10

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.

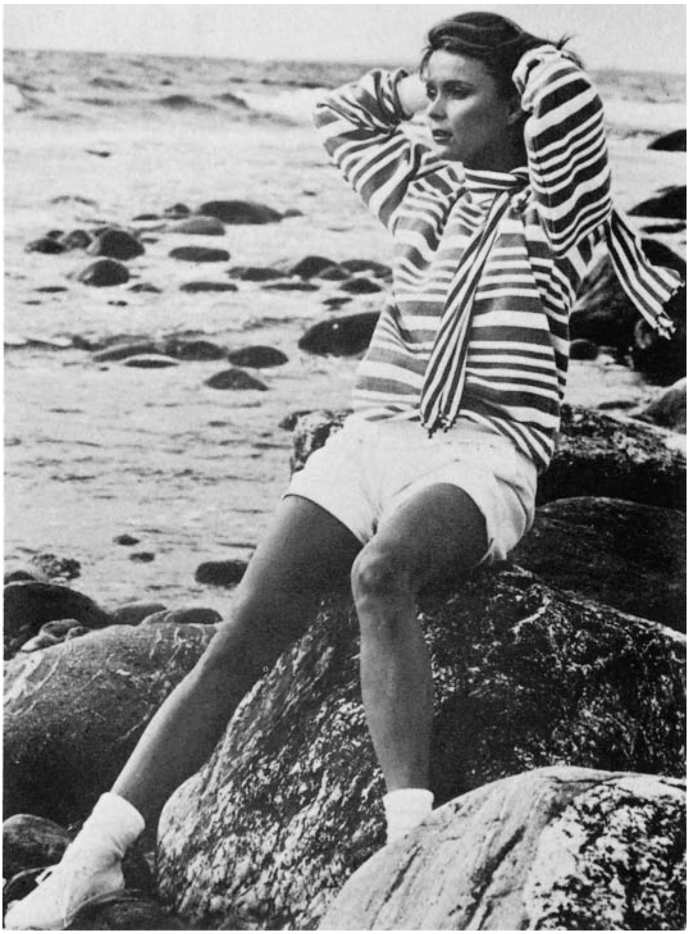


Fig. 10.1 An attractive use of horizontal striping [International Institute for Cotton].

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

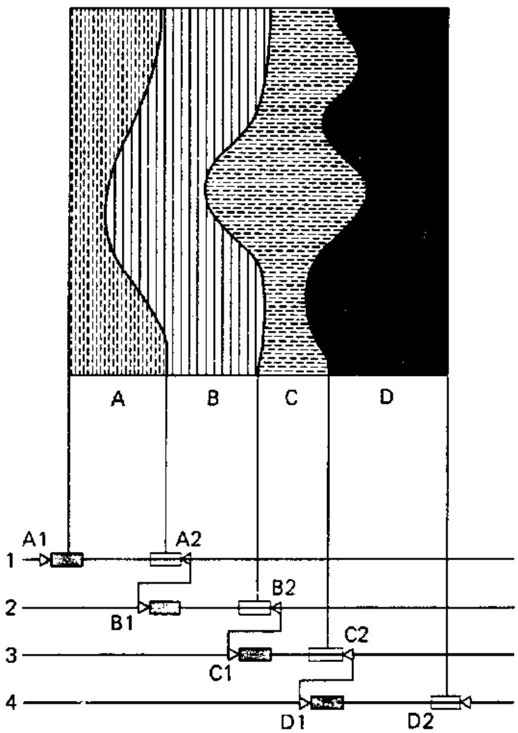


Fig. 10.2 Yarn carrier positioning for intarsia. Four zones are illustrated. Each colour (A, B, C and D) is supplied by its own yarn carrier, which travels only between its own carrier stops (which are capable of being repositioned). All carriers traverse in the same direction at a particular course. 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 [Shima Seiki].

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 camtrack 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 (see Chapter 11).

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

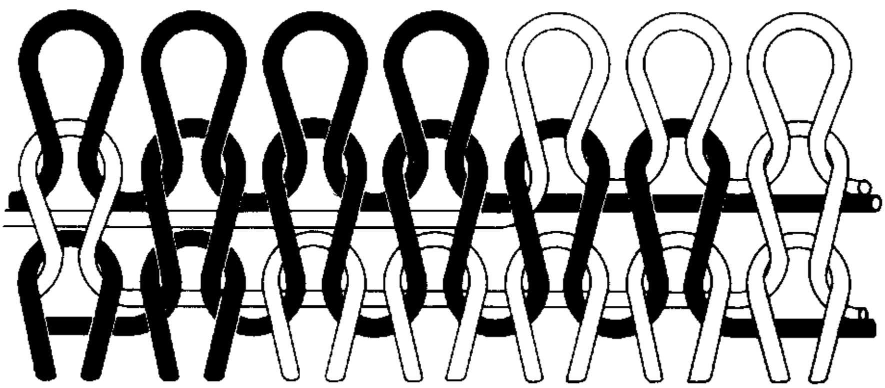


Fig. 10.4 Single jersey jacquard.

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

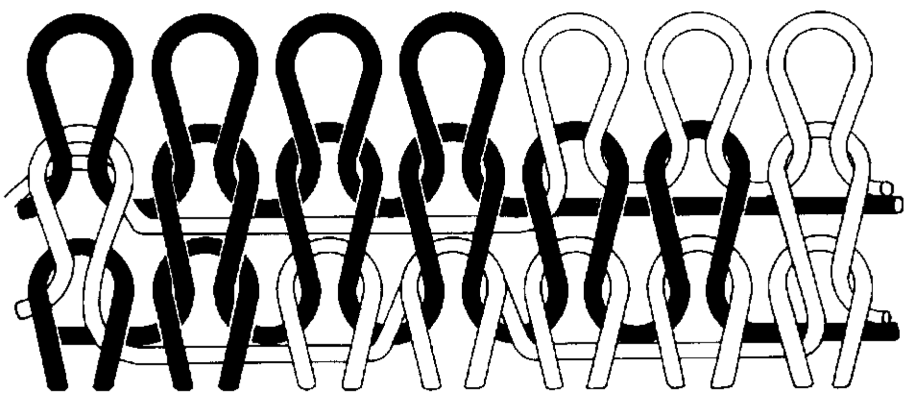


Fig. 10.5 Accordion fabric.

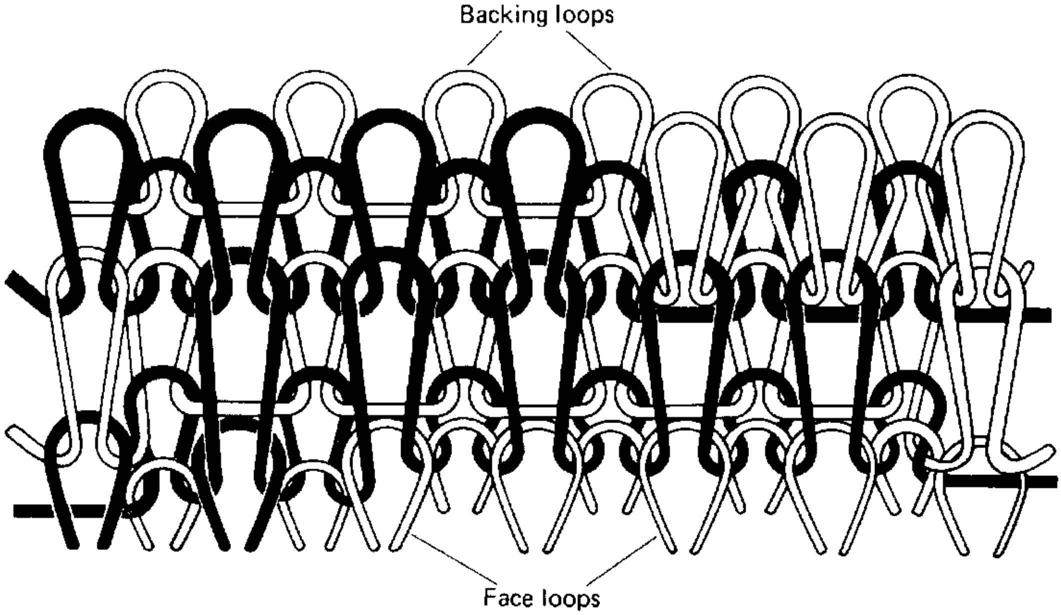


Fig. 10.6 Rib jacquard.

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-

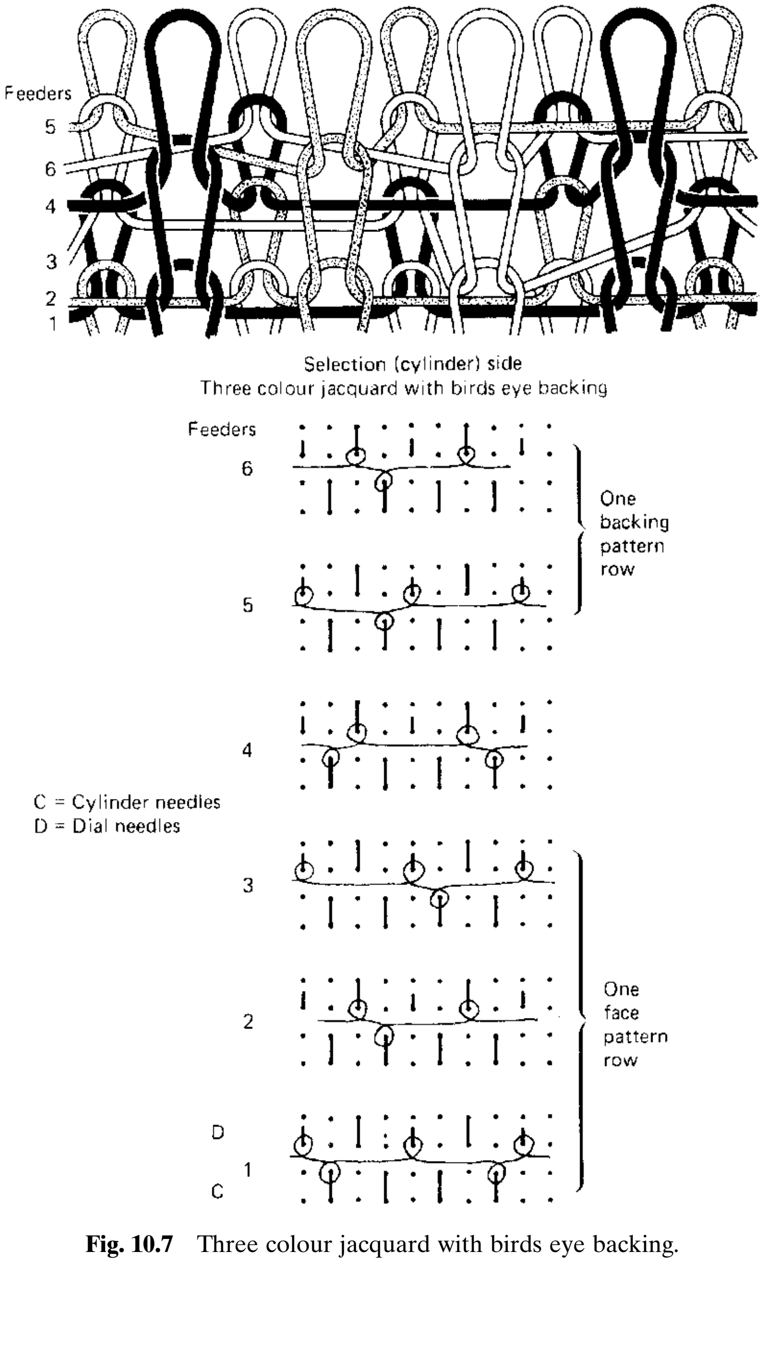


Fig. 10.7 Three colour jacquard with birds eye backing.

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).

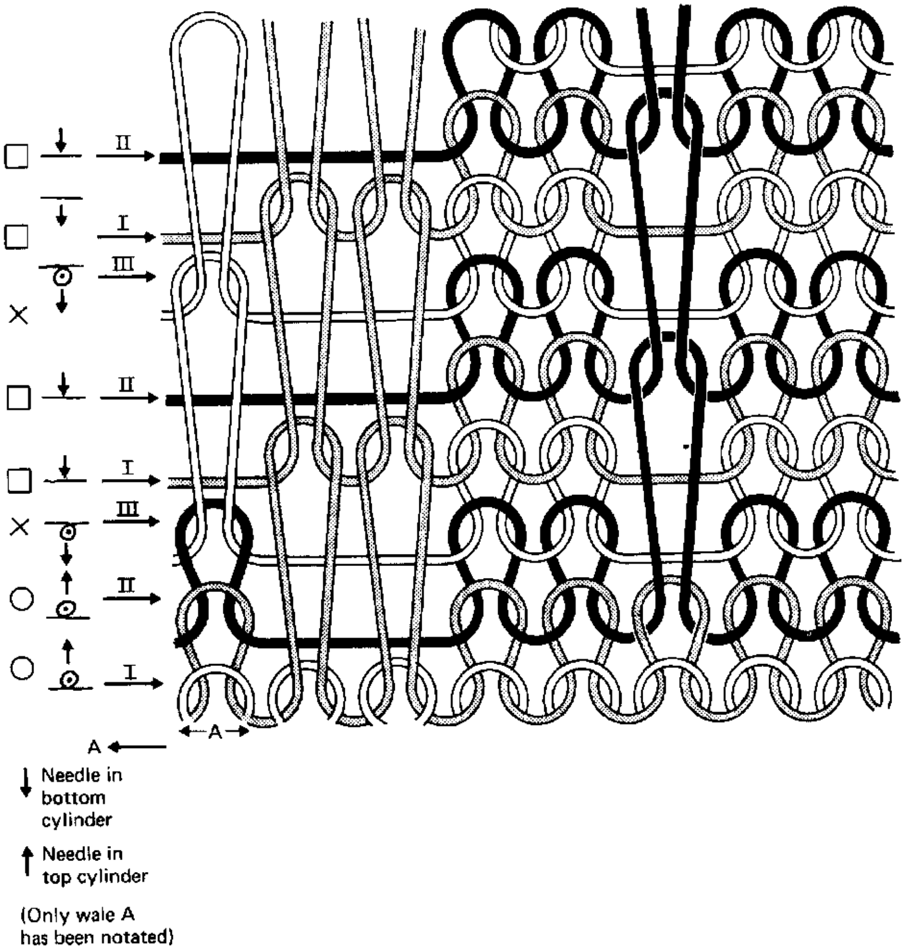


Fig. 10.8 Combined links-links and three colour float jacquard.

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.

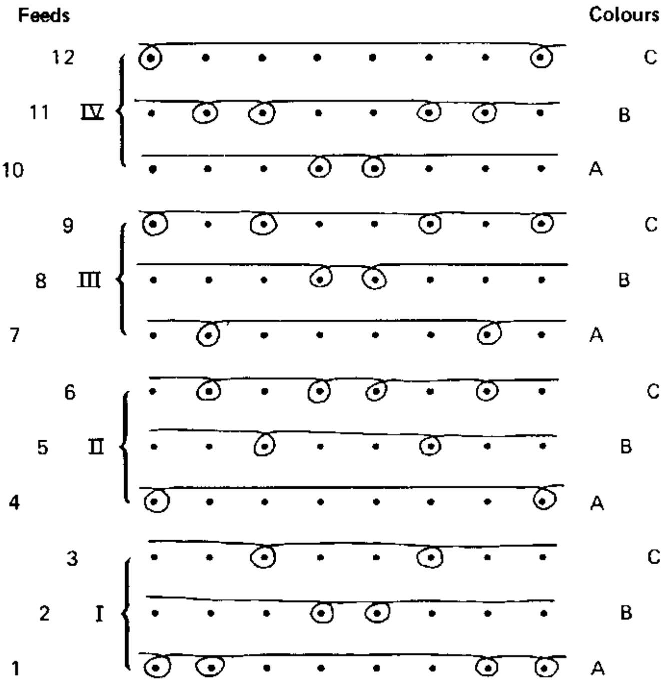
Using the running thread notation, provide:

(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.

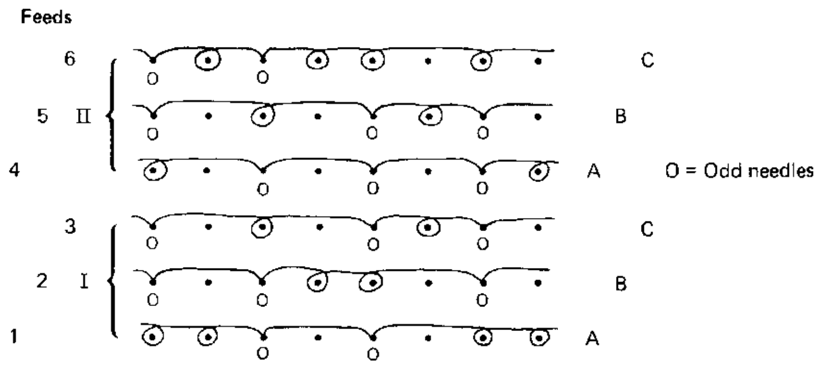
Face pattern rows								
IV		B	B	A	A	B	B	
III		A		B	B		A	
II	A		B			B		A
I	A	A		B	B		A	A

Eight face wales

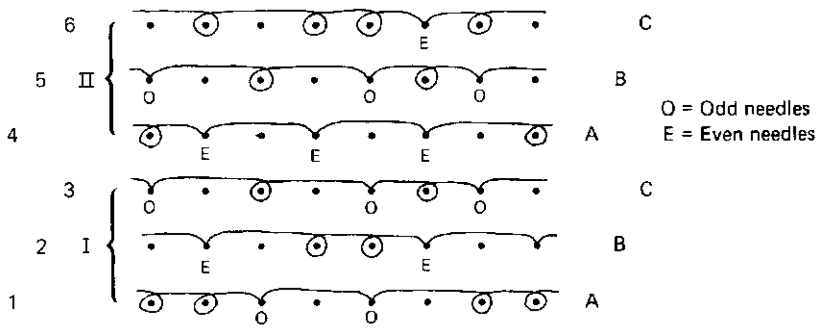
☐ = Colour C



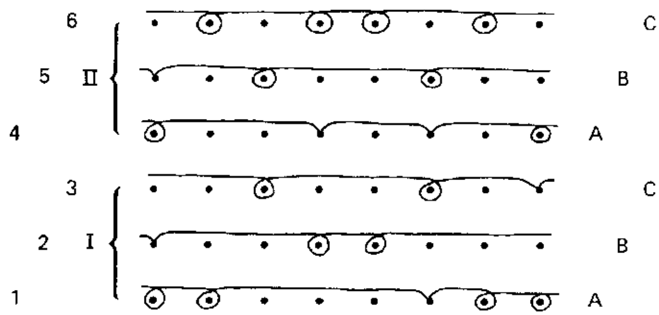
(a) Single jersey knit/miss Jacquard



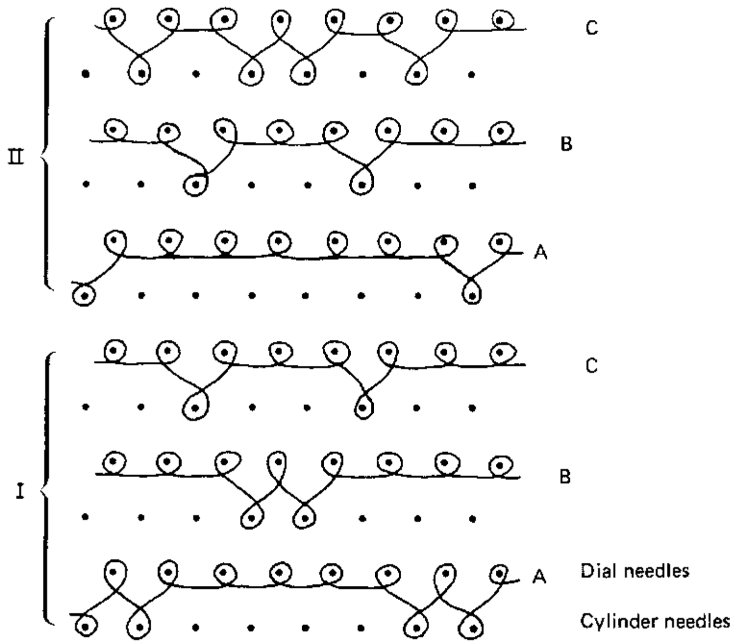
(b) (i) **Straight accordion** (tucking on non-knitting odd needles)



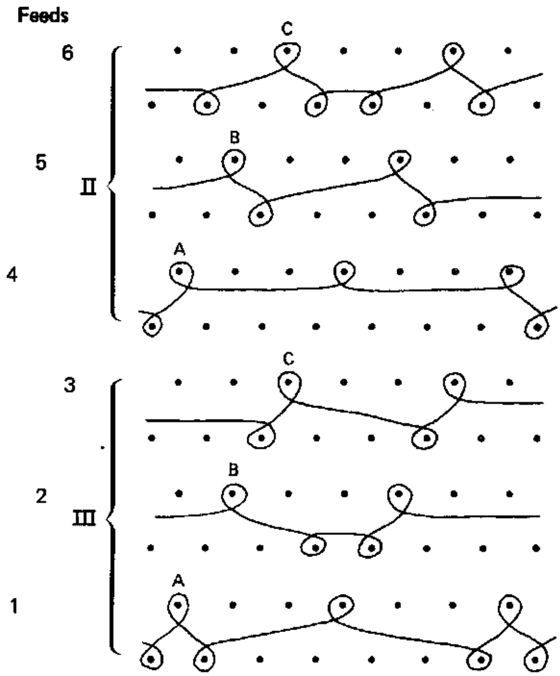
(b) (ii) **Alternate accordion** (tucking on odd needles at odd feeders and even needles at even feeders when non-knitting)



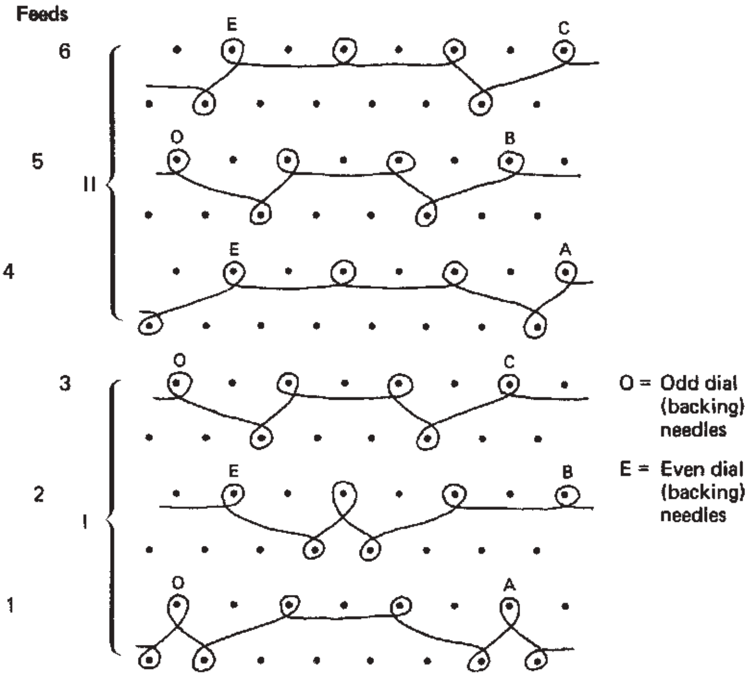
(b) (iii) **Selected accordion** (tucking only on carefully selected non-knitting needles)



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



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



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

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11

Pattern and selection devices

11.1 Weft knitted patterns

Generally, patterns are produced in weft knitted structures either in the form of selected colours for face stitches or surface relief patterns based on a choice of different types of stitch. As illustrated in Fig. 3.4, the height to which a latch needle is lifted in its trick determines which stitch will be knitted. If all needle butts are in the same position on the needle stems and they pass over the same cam profile, a plain fabric will be knitted, with all stitches having the same intermeshed loop structure. Patterning is therefore determined by selection of needle butts – for example, either to pass onto a raising cam to knit or to miss the cam profile and not be lifted.

The width of the pattern in wales is determined by how many needles can be selected separately, independently of each other. The pattern depth in courses is dependent upon the number of feeds with selection facilities and whether the selection can be changed during knitting.

Simple patterning and quick rib changes (during garment-length knitting) can be achieved in a limited width repeat when element butts are at one of a range of lengths or positions associated with particular raising cam arrangements.

The cam arrangement and element butt repeat set-out will determine the pattern area. Popular simple methods employ different butt lengths and cam thicknesses and/or different butt positions and cam tracks.

11.2 Different lengths of butt

Whereas 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 may not reach into the track and will thus pass across the face of the cam and be unaffected by its profile (Fig. 11.1).

The same principle is employed when cams are withdrawn into their cam-plate

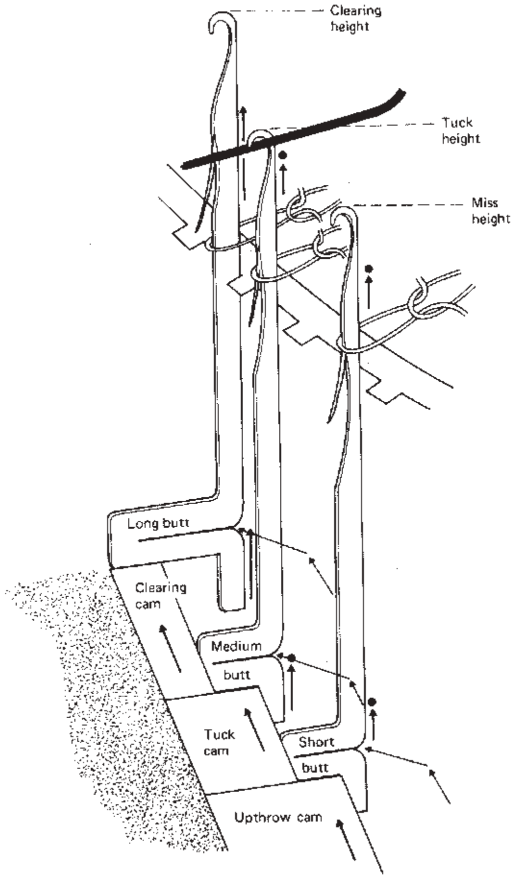

Fig. 11.1 Miss, knit and tuck using different butt lengths.

or the elements are depressed into their tricks, thus reducing the effective length of their butts.

The principle of butt lengths is that the element with the longest butt is always contacted first as a cam is brought into operation and the shortest butt is affected only when the cam is fully in action.

For example, a tuck cam might be partly in action, raising long and medium butt needles but allowing short butt needles to pass across at miss height, whilst the succeeding clearing cam is set to raise only long butt needles, leaving medium butt needles at tuck height. If short, instead of long, butt needles are required to be lifted, it is necessary to contact and lower the long butt needles before they reach the raising cam that is placed fully in action to lift the short butt needles remaining in line with it.

Separately butted and cam-controlled elements known as *push-jacks* may be placed below the needles in their tricks. As their butt set-out need not correspond to that of the needles, a greater selection potential is available than through the set-out of the needle butts alone. Long butt jacks can thus be used to positively lift short butt needles. Jack butt set-outs are particularly suitable for obtaining predetermined rib set-outs in garment length sequences.

11.3 Different butt positions

The principle of different butt positions is employed in the interlock cam system, where two cam tracks are used (Section 7.4.2). In *single-jersey multi-camtrack (raceway)* machines, needle butts may be positioned in one of between 2 and 5 cam tracks that, at every feed position, have fixed but exchangeable knitting, tucking or missing cams. In some machines (e.g. jacquard machines), a common top butt is controlled by a stitch cam-track, whereas in high-speed machines the exchangeable cams also incorporate the stitch and guard cam shape and are located on a common slide for stitch length adjustment (Fig. 11.2).

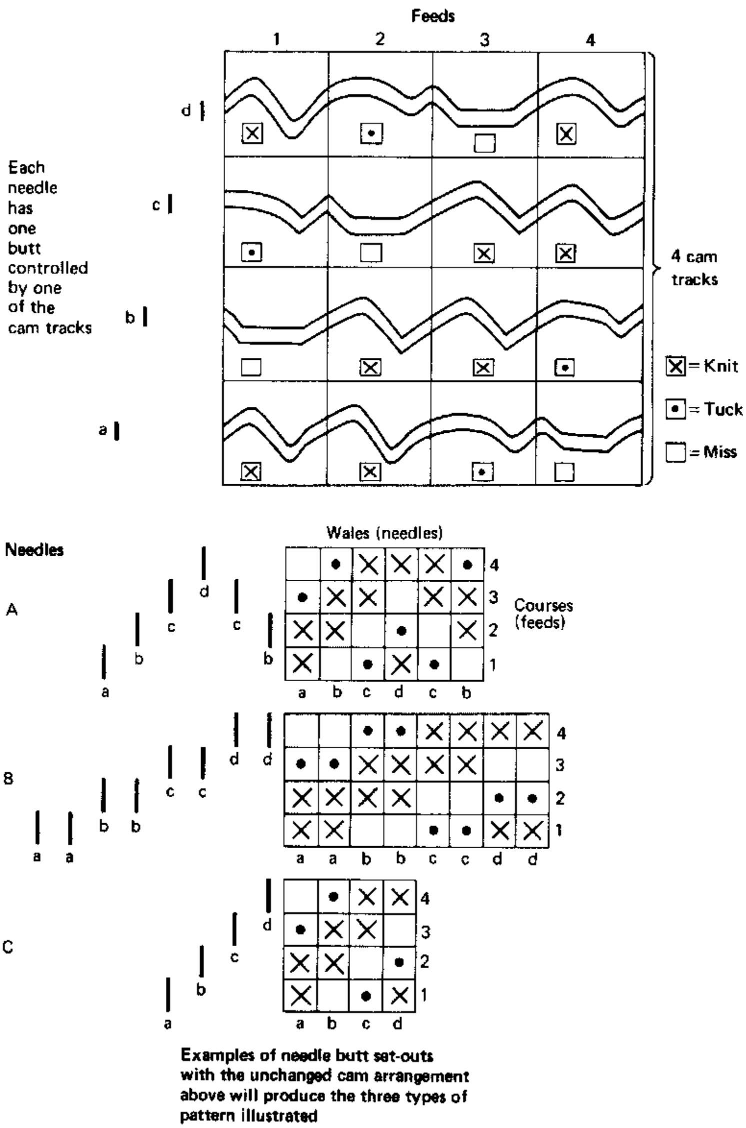

Fig. 11.2 Multi-cam track needle butt control.

11.4 Multi-step butt set-outs

Although some selection devices, including pattern wheels, operate onto element butts of one height position, many patterning arrangements involve the use of a single selection butt for each element, placed at one of a choice of height positions. The total number of different heights often directly influences the width repeat in wales. It is generally most convenient to arrange and retain a butt set-out that is a factor of the needle bed, so that the pattern widths exactly repeat into it.

The two most common geometrical butt set-outs are straight and mirror repeats, although combinations of the two are possible.

A *straight* (*diagonal*, *echelon*, or *up-and-up*) *butt set-out* is arranged in an ascending order in the direction of knitting (Fig. 11.2). Each butt position is used once only in the set-out repeat, so the pattern width is equal to the number of available pattern butt positions.

A *mirror repeat* (*reflex chevron*, *up-and-down*, or *geometric*) *butt set-out* is a mirrored continuation of the straight set-out, with the butts descending in sequence after the highest position (see Fig. 11.3). The top and bottom butts are not used in the descending sequence as the former would produce two identical adjacent wales in the same repeat and the latter would produce two identical adjacent wales with the first wale of the next repeat. This set-out thus produces a symmetrical design width about a common centre wale, with the right side identically mirroring the left side.

With geometric selection, the top butt position is used only in mirror repeats so that these are exactly twice the width of straight set-outs and both mirror repeats and straight set-outs are a factor of the number of cylinder needles.

For example, an E 18, 30-inch diameter machine with 1728 cylinder needles, using a small-area fixed selection, might have 24 butt positions (and pattern comb teeth) for a straight set-out repeating 72 times around the cylinder, and an extra top butt and tooth used only for mirror repeat set-outs, making 25 up and 23 down, giving a width of 48 butts that repeats 36 times around the cylinder.

11.5 Selection devices

Selection devices vary considerably in their facilities and their pattern-changing and pattern-area capabilities.

A *selection device* is positioned to operate in advance of a raising cam system (usually associated with a knitting feed position) to select the path that the element operating butts will follow as they pass through that system. Each possible path will cause the element to be moved in a different manner, resulting in the knitting of a different type of stitch. Usually, a selection decision determines the choice of two butt paths.

11.6 Element selection

Element selection involves three aspects:

1 The *initiation and presentation* of the selection decision, usually as a *YES* or *NO*, by the presence or absence of a tooth, a peg, a punched hole or an electronic

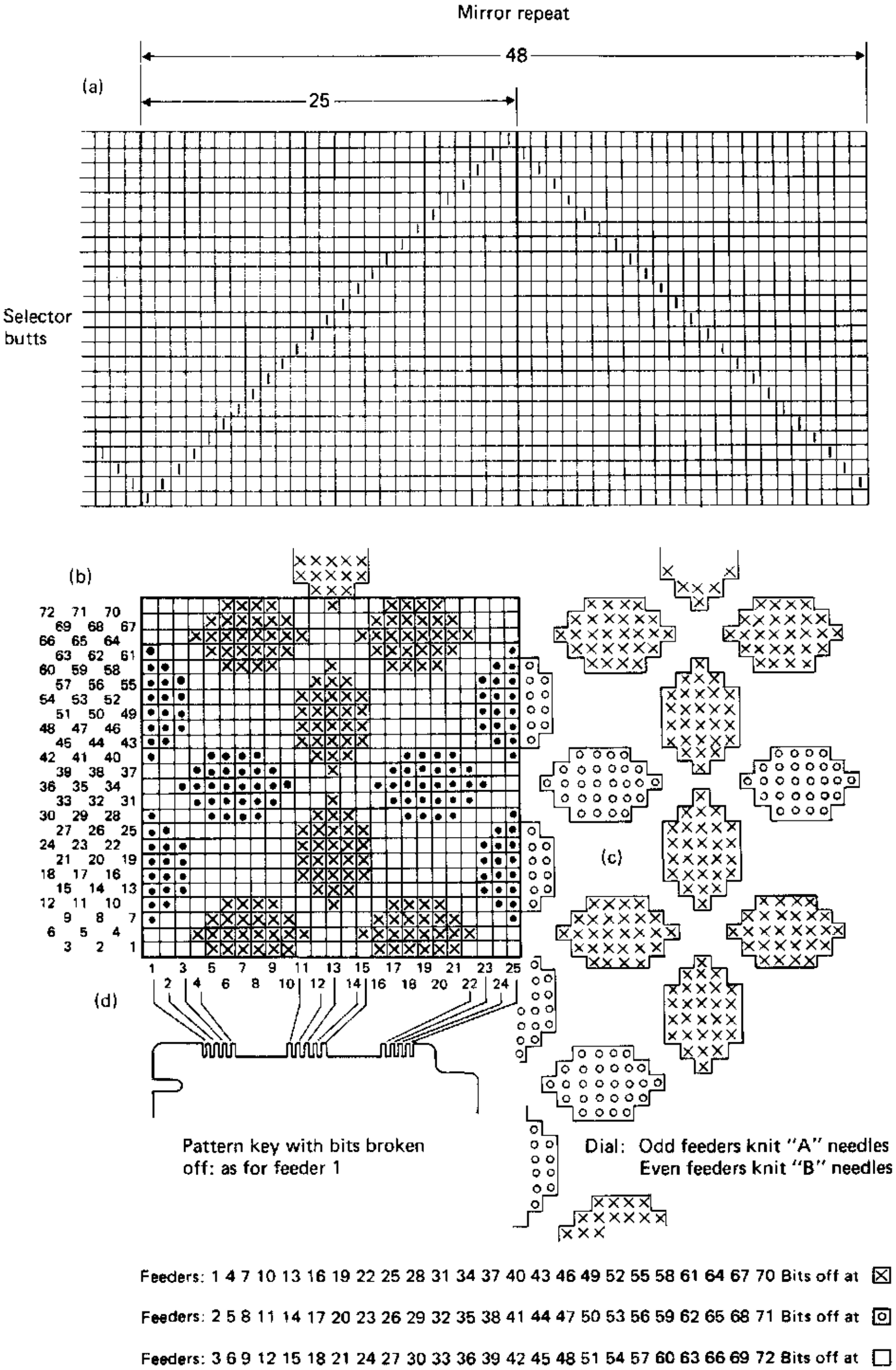

Fig. 11.3 Mirror repeat needle selection.

impulse. Normally, there is a selection in advance of a raising cam, with each feeder course being associated with a particular selection device.

2 The *transmission of the selection decisions* from the device and their reception by elements in each trick of the needle bed. One of three methods is normally employed for this task:
   (a) Employing *individual raising cams*, when required, for each element raising butt (pattern wheel selection).
   (b) *Selectively pushing* the elements upwards in their stationary tricks to align their raising butts into action with the path of the traversing or rotating cam systems (full mechanical jacquard selection).
   (c) *Selectively retracting* the elements into the interior of their tricks so that their raising butts no longer project out into the path of the cams. This method is widely used for mechanically- and electronically-initiated selection on circular and flat machines, especially when employing geometric multi-butt set-outs of selection butts. Raising butts may be selected to miss a complete raising cam or only the final upper section (e.g. between tucking and clearing height).
3 The *translation of the selection decision into a knitting movement*. With the exception of linear-motor drive of needles, this is still a completely mechanical action of a raising butt following, or failing to follow, the profile of a raising cam and thus causing an element to be lifted, or not lifted, in its trick during a stitch formation cycle.

Normally, all selection devices of one circular machine will hold an equal number of width selections and an equal number of depth selections. When each device is aligned to commence selection at the same starting trick (wale), equal widths of selection will occur at each feeder course and will be aligned into rectangular selection areas exactly framed by the courses and wales of the fabric (Fig. 11.4).

11.7 Selection area arrangement

Dependent upon the type of device, four arrangements of the selection areas around the fabric tube are possible:

1 *Full jacquard selection* can produce a selection area of theoretically unlimited depth and a width equal to the number of needles in the cylinder, so that the design exactly surrounds the fabric tube without repeating.
2 *Pattern wheels* have a circumference selection that is not an exact factor of the number of cylinder needles, so that their selection areas follow the spiral path of the feeder courses around the fabric tube. In the starting wale of each machine revolution, the base of the areas will thus have risen by the number of feeder courses knitted in one machine revolution compared with its position in the same starting wale at the previous machine revolution (X in Fig. 11.4a).
3 *Fixed geometric selection devices* (step jack devices) provide only one selection width at each device, which is unchanged from one machine selection to the next (Fig. 11.4b). Machines employing this type of device are termed *small-area* or *intermediate jacquards*; although their pattern area potential is limited, they have

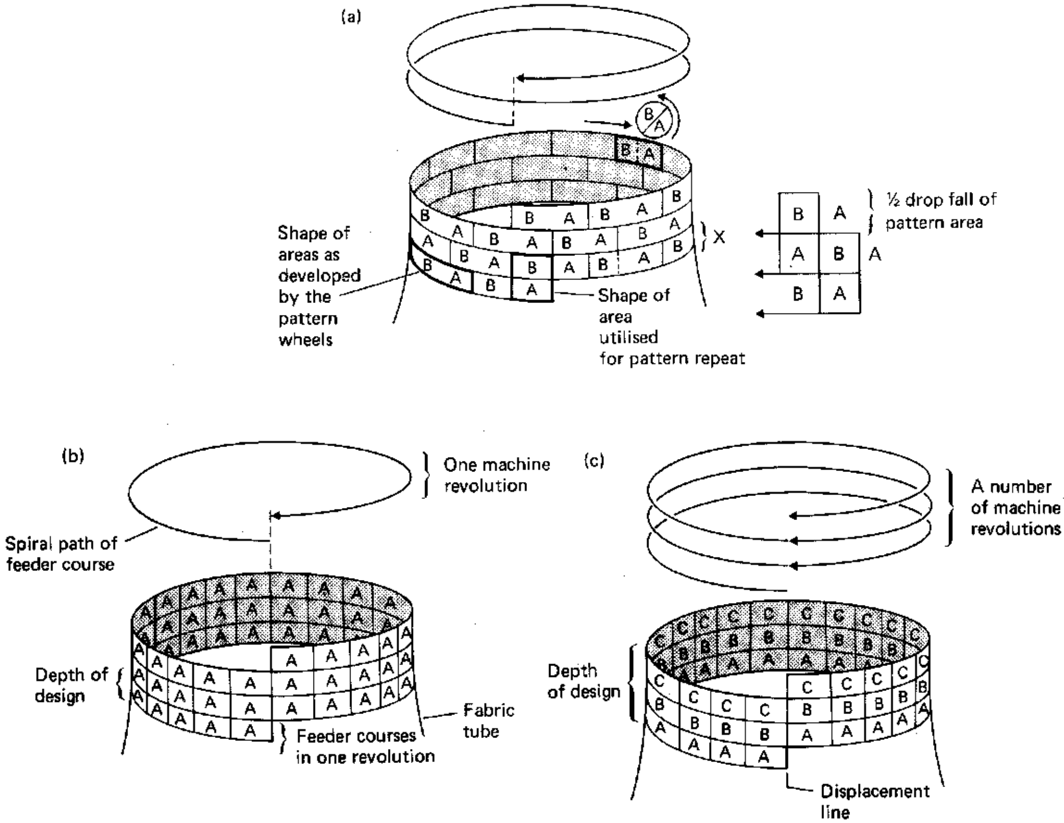

Fig. 11.4 The development of design areas using selection devices.

sufficient feeders and speed to be employed in the production of single colour and plain structures as well as jacquards.

A complete design depth is thus produced at each machine revolution, composed of the number of active feeder courses, so that the base of the design will have risen by that number of courses each time it is recommenced in the starting wale, but no displacement of design is noticeable between the adjacent finishing and starting wales of the fabric tube.

4 *Non-fixed geometric selection devices* hold a limited number of different selection widths so that a new selection width may be presented, commencing in the starting wale of each machine revolution (Fig. 11.4c). Single-jersey and rib machines using non-fixed selection are termed *large-area jacquards*. A design depth is thus developed that is a multiple of the number of machine revolutions in the sequence of selection presentations. These devices produce a displacement line between the starting and finishing wales of the tube in the form of a rise by the number of feeder courses in one revolution. Usually, the tube is split open along this line during finishing.

The potential depth of non-fixed selection devices is increased by the ability to dwell (retain) a selection for a number of machine revolutions, and to rack the selection sequence forwards or backwards by one or two steps.

Only in the case of full jacquard selection on machines with stationary needle bed tricks (certain flat machines and revolving cam-box circular machines) can a successive row of selection decisions be kept in permanent alignment with each trick. On other revolving cam-box machines and flat machines, the selection devices pass across the tricks with their associated cam-sections or, in the case of revolving cylinder machines, they remain with their cam-sections as the cylinder revolves past them.

Pattern wheels or discs turn in continuous alignment but in the opposite direction to the cylinder, so that each trick in turn receives a decision from the selection sequence around the wheel periphery. The element butts being selected may be set-out at the same height. Although the selection is in a fixed set-out in a pattern wheel, the pattern depth is spirally developed over a number of machine revolutions. On machines with selector wheels, a tape may rearrange the selection set-out for the next machine revolution, or a different disc selection may be switched into operation.

With multi-butt selection, the selection butt at each trick can be placed at one of a number of different heights, usually in a geometric set-out, which together will determine the pattern width (Fig. 11.4). As either the selection device or the needle cylinder is revolving, the selection is transferred from the device by a bank of spring-loaded plates or electronically-controlled selectors that pivot across to contact any selection butts at that height as they pass (Fig. 11.5).

Instead of one pattern key (comb) at each selection, it is possible to have four different selection keys on a spindle so that, when the machine has a pattern

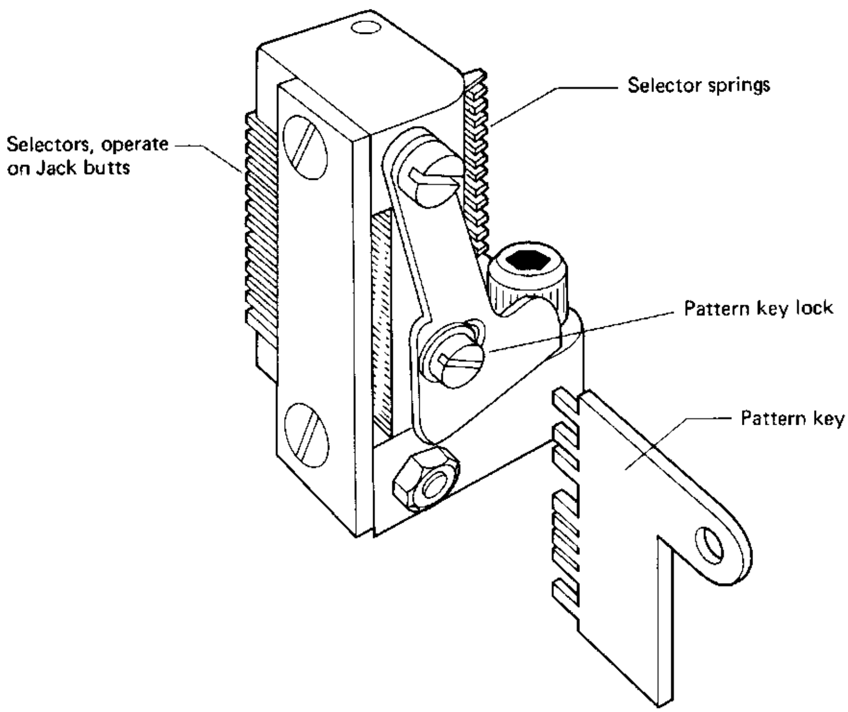

Fig. 11.5 Fixed pattern key selection.

change, the spindle is turned at each feed to introduce a new pattern-selection key.

On mechanical selection devices, a vertical row of selection teeth or pegs at each station pushes the respective height plates towards the needle bed. With non-fixed selection, a different selection row may be aligned at the start of each machine revolution at each device in turn.

11.8 Full jacquard mechanical needle selection

Full jacquard mechanical needle selection provides the possibility of independent selection over the full width of the stationary needle bed in a simultaneous movement for all needles on flat machines or onto blocks of adjacent needles on revolving cam-box circulars. Theoretically, it offers unlimited depth in traverses or revolutions dependent upon the number of jacquard steels or the length of the jacquard rolls. Each column of holes is allocated to a particular needle, with a new selection being presented by each part turn of the prism or roller.

The arrangement was widely applied to flat machines. It has also been employed on rib jacquard and garment-length purl machines produced by the *Wildman Jacquard Company* (see previous editions of this book). Pattern changing was time-consuming and expensive (just one design row of two-colour jacquard around the machine involved 2 × 1344 separate punched hole positions). In addition, low production speeds, a limited number of feeders, and coarse gauge restricted its use. Full mechanical jacquard selection has now been replaced by electronic jacquard selection on both V-bed flats and on circular machines.

11.9 Multi-step geometric needle selection

Multi-step geometric selection has developed from the *Brinton* trick wheel of 1926, which first employed single butted depressible selectors beneath the cylinder needles rather than in an intermediate drum. Figure 11.6 illustrates a device, used on *Wildt Mellor Bromley* machines of the RTR range, for either rib jacquard or rib loop transfer selection on circular garment-length machines with revolving cam systems. The pattern drums move with their associated cam sections and have a circumference of 40 vertical rows of selection. As each drum passes the garment control mechanism, it may be caused to single or double rack forwards, or single rack backwards, or be bluffed to dwell and retain the same selection for the next machine revolution. Thus, within the pattern depth, 40 different feeder courses are possible for each pattern drum.

Each vertical column around the drum has a height of either 24 or 36 selection positions, depending upon the model. This depth corresponds to the pattern width repeat. The drums are either drilled with holes to receive push-in metal pegs or are equipped with grooved tricks for the insertion of pattern jacks whose butts are snipped off according to the pattern. The latter arrangement is generally preferred as the jacks can be prepared in a less laborious operation whilst the machine is knitting another design.

A bank of spring-loaded selector plates, corresponding in height to the possible selection heights, works with each drum to transmit the selection to the cylinder.

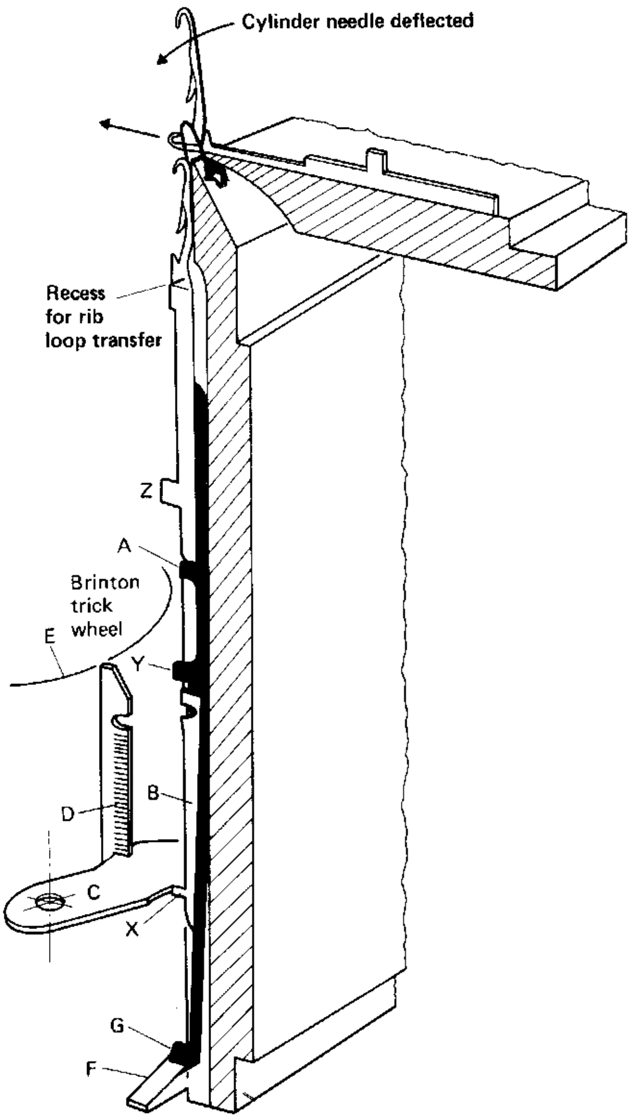

Fig. 11.6 Geometric selection using Brinton trick wheels.

The tail of each cylinder needle is supported by the upper edge (A) of a spring-tailed lifting jack. A selector presser (B) is placed in front of each jack in a trick. The presser has a complement of 24 or 36 pattern butts corresponding to the width repeat; all except one butt (X) are removed so that a chevron or echelon pattern butt set-out is arranged around the needle cylinder.

The tail of the lifting jack is sprung outwards, so that its raising butt (G) is in line with the raising cam (F) (F may be either a clearing cam or a rib loop transfer cam). If butt (G) follows the profile of cam (F), the jack will lift its cylinder needle to either knit or transfer its loop, depending on the cam position and shape.

The selection is indirect, requiring a decision for non-movement of the needle.

When a pattern bit (D) is placed in the vertical row of the drum directly facing the cylinder at the same height as the pattern butt (X) of a needle jack presser, the spring-loaded plate (C) at that height will be pivoted towards the cylinder so that it presses against butt (X) as it passes by. This causes the tail of the jack to be depressed into the cylinder so that its butt (G) goes behind the raising cam (F) and the needle is not lifted.

Needle butt (Z) is used to lower the needle and this, in turn, lowers the jack ready for selection at the next cam system. The effect of the selection may be cancelled (for example, in the rib border of a garment length) by introducing a raising cam to lift all jacks by means of butts (Y).

11.10 Needle selection by disc

The *Mellor-Bromley* rib jacquard (RJ) system uses revolving stacks of discs at each feed selection position. The replaceable disc stacks are rotated in unison with the machine drive. On 72-feeder machines, the stacks are accommodated at two alternately staged heights. When a disc tooth contacts the bottom half-butt of a presser (X in Fig. 11.7), it causes the jack tail (Y) which 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.

Presser half-butts are of two types: those with an upper half-butt (X in Fig. 11.7) are placed in odd cylinder tricks, and those with a lower half-butt are placed in even tricks.

A selection disc is actually composed of a pair of discs, the teeth of the upper one selecting odd needles by means of the upper half-butt and the teeth of the lower one selecting even needles by means of the lower half-butt (O in Fig. 11.8). As each only selects alternate needles, their teeth are cut twice as coarse as the machine gauge and are centred for these needles. 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.

The height control of the pressers is achieved through their identically arranged and carefully-spaced guide butts, of which each may have as many as 10, depending upon the height of the disc stacks. During each cylinder revolution, two of these butts are in contact with a guide channel that surrounds the cylinder so that the pressers are held at a constant height. Three bolt cams, situated at a short break in the channel, provide the choice of serially lifting, lowering or retaining (bluffing or dwelling) the pressers at the same height for the next cylinder revolution. Introduction or withdrawal of each cam is controlled by separate tracks on a punched-hole film that racks once per cylinder revolution and thus has a major effect on the pattern depth.

Fig. 11.8 illustrates the change of presser height (S) at each of eighteen cylinder revolutions so that its half-butt obtains the selection from every disc (D) in the stack. Notice that, during the revolutions whilst the presser is being lifted, its guide butts occupy position (A) in the guide.

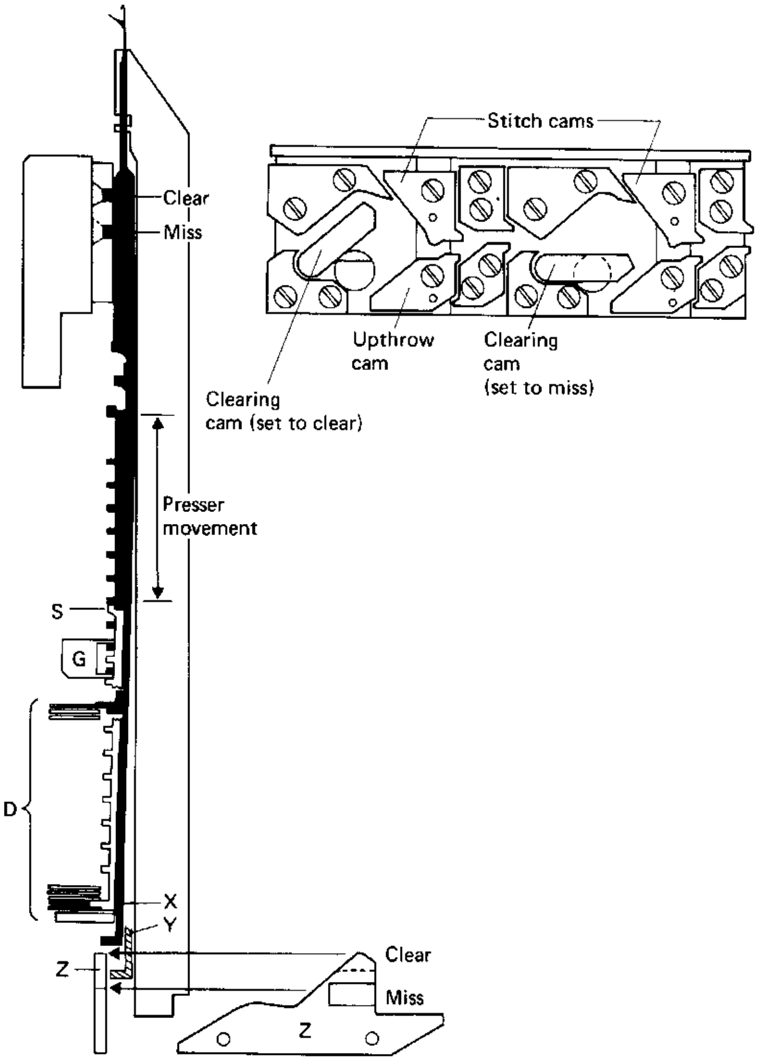

Fig. 11.7 Disc selection.

11.11 The pattern wheel

The pattern wheel is a cheap, simple device occupying little space, and is unique in employing separate raising cams, in the form of pattern bits, to select and move individual elements, if necessary, to three different positions in their tricks (Fig. 11.9). It is most popular in single-jersey machines, either as an inclined wheel for needle or point selection, or as a horizontal wheel for plush sinker selection. The pattern set-out, which is unchanged during knitting, uses bits which are either re-usable and are inserted into the tricks, or are break-off teeth on pre-prepared discs.

The wheels, tricked to the same gauge as the revolving cylinder needles, are driven continuously in the opposite direction, either by the needle butts meshing with their tricks or by gearing from the cylinder.

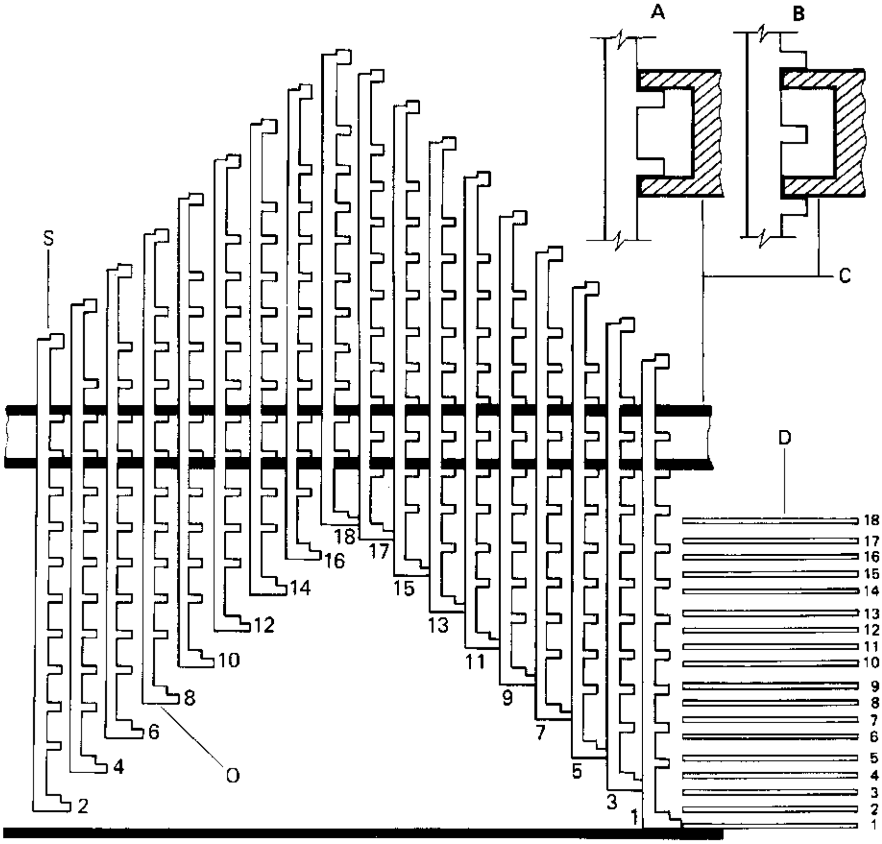

Fig. 11.8 Change of presser position from one revolution to the next.

The wheels are of the gain or loss type so they do not produce an exact number of complete turns in one machine revolution. The design areas can have a depth greater than the number of feeds, but are built up in a spiral manner, compared with the courses around the fabric tube.

The inclined pattern wheel, like all selection devices, is normally placed at each feeder. It is set at an angle of 20–40 degrees in place of the solid raising cam so that, as it turns, it lifts any element whose butt rests on a pattern bit. The needles will all have a butt of the same size in the same position.

With a three-position wheel (Fig. 11.9), a needle entering an empty trick will remain at miss height (3), a needle supported by a low bit will be lifted to tuck (2), and a needle supported by a high bit will be lifted to clear (1). Needles left at miss height are lowered by a wing cam (X) to ensure that they do not inadvertently receive yarn.

Some machines have four-finger striping selection available at each feeder wheel, which considerably increases the pattern depth and scope. Another mechanism often used in conjunction with striping is a pattern placer, tuck bar, or pattern-cancellation device, which is a moveable raising cam, usually acting onto a butt at a level lower than the pattern wheel. When the cam is raised into action, it causes

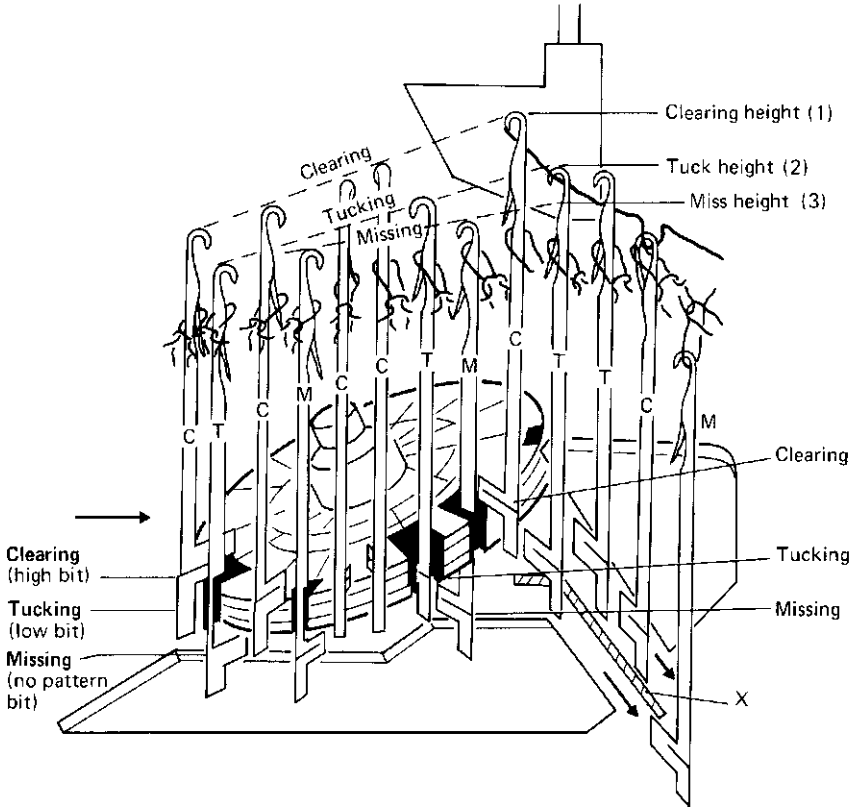

Fig. 11.9 Three-step needle selection using a pattern wheel.

all needles to be lifted to knit and thus cancels the selection for a number of courses so that alternating bands of design and plain single colour may be produced.

Alternative methods of needle selection with higher productivity, less restrictive pattern areas, and quicker pattern-changing facilities have replaced the pattern wheel as the most popular method of pattern selection.

11.12 Pattern wheel design areas

The principles governing design areas apply to all wheel selections, including sinker-wheels with plush and plain plating sinkers, provided that their set-out remains unchanged during knitting (Fig. 11.10). The wheels are generally of the same size and gauge on the same machine. The needle producing the starting wale of the design is marked and, as the cylinder turns during the first revolution, it will align with the marked starting trick of each wheel in turn, to ensure that their selections commence above each other in the same wale. As the widths will be of the same size and similarly arranged in each wheel, they will be built-up into a pattern depth, each exactly aligned with the previous one, commencing with the first feeder selection. They will therefore be arranged as columns of pattern widths around the fabric tube.

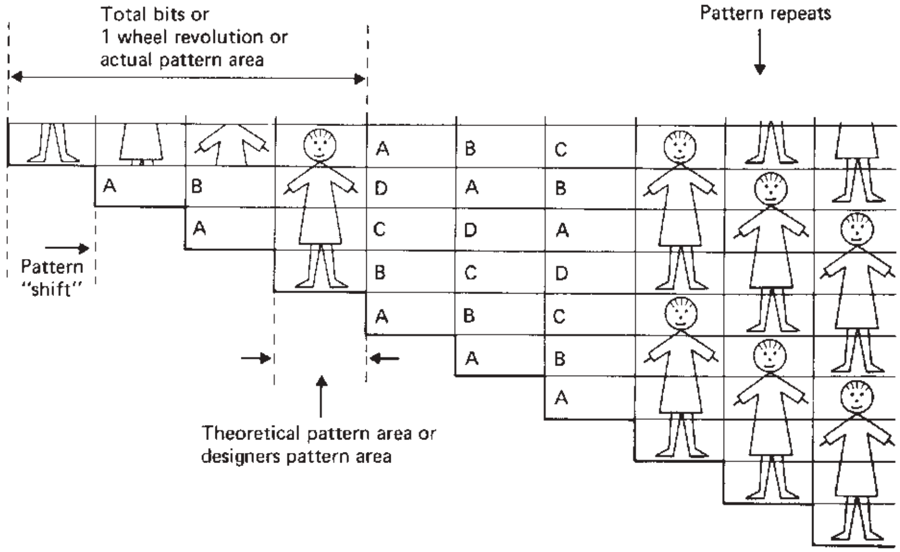

Fig. 11.10 The building of pattern areas over a number of machine revolutions using pattern wheel selection.

A rectangular design area is developed if the chosen width (W) is the highest common factor (hcf) of the cylinder needles (wales in the fabric tube) (N) and the tricks in one wheel (T).

A non-spiral design area, showing no fall (f) in courses from one pattern width to the next across the fabric, is produced when T is an exact factor of N, so that $W = T$. In one machine revolution, the wheels will make an exact number of turns and their starting tricks will re-align with the starting needle in the cylinder, thus completing the pattern depth.

The number of pattern width columns around the fabric tube (P) = N/W. The pattern depth (D) in feeder courses = Feeders (F) × depth per feed or number of pattern widths in one wheel (d).

To convert the number of courses to pattern rows, it is necessary to divide them by the number of colours (C) in the design.

Example: If $N = 1400$, $T = 140$, $F = 36$, $C = 2$.

Calculation: $W = 140$ (hcf of N and T)

$P = N/W = 10$

$d = T/W = 1$

$D = F \times d = 36$ Therefore depth in pattem rows $= 36/C = 18$.

With a design area of 140 wales by 18 pattern rows, it is too wide and too shallow for most designs.

Spirally-developed designs are used because they provide a greater pattern depth but, as a consequence, they also produce a fall between one pattern area and the next one adjacent to it. They are produced when T is not an exact factor of N (i.e. $N = nT + RT$) where n = a number of whole turns of the wheel and R is a fraction of a turn.

At the second revolution, the starting tricks in the wheels will not re-align with the starting needle in the cylinder, and the continuous selection of the wheels will have 'shifted' or 'moved on' compared to the cylinder needles. Each wheel can be set-out with more than one width ($d > 1$) and W will be a factor of R, so that a different width selection will be produced in the first column of design and in all the others in turn at the next machine revolution, as a result of the shift of the wheels.

The pattern depth will therefore be increased by a multiple of d and it will be built up during d revolutions of the machine, after which the starting tricks of the wheels will again re-align with the starting needle in the cylinder because, by then, they, as well as the cylinder, will have completed an exact number of turns.

The disadvantage of spirally-developed designs is that each wheel is producing a number of different pattern width selections in adjacent columns along the same feeder course and, as these are for different courses in the pattern depth, the pattern areas will appear to fall from one column to the next.

The fall (f) is expressed by the difference between the two adjacent widths in courses in the direction of knitting, which is towards the right in fabric produced on machines with clockwise revolving cylinders. It must be understood that each wheel has shifted sideways by the same amount, so that its width selections are placed exactly above those of the first wheel and are in the correct sequence for the depth. Therefore, although the areas show a fall or drop, the courses are always correctly placed within the pattern depths.

Half-drop design areas occur when $N = nT + 1/2T$ so that $W = 1/2T$ and $d = 2$. It will take two machine revolutions to develop the pattern depth in the starting pattern column but the wheels will, as they turn, place the selection for their second width in the adjacent column and thus produce a half-drop of the pattern area. Using the previous machine data as guide, $N = 1400 + \frac{1}{2}T = 1470$; W = hcf of N and $T = 70$; $N/T = 10\frac{1}{2}$; $P = 21$, $D = F \times 2 = 72$. The wheel of the first feeder will make course width 1 and $(F + 1)$. As the two widths will occur in adjacent columns, the fall will be 36 courses in a total depth of 72 courses.

(Calculations for other types of pattern drops are included in previous editions of this book but are no longer in general use.)

11.13 Electronic needle selection

Electro-magnetic needle selection is now available on many types of knitting machines; this was first commercially used on circular rib jacquard machines (Fig. 11.11). The electronic impulse that energises an electromagnet is usually assisted by the field of a permanent magnet, and the minute selection movement is then magnified by mechanical means.

If all the needles, or a block of needles, were to be simultaneously selected, each would require its own actuator. It is much cheaper to select the needles at a single selection position in serial formation, using between one and six actuators, although the time interval between each selection impulse is shorter.

Many of the modern electronic selection units are now *mono-system*, i.e. the selection butt position for each needle is at the same height, so the time interval between each selection impulse is the time between one needle and the next passing the selection position. The selection speed can be as fast as 6000 needles per second. These selection units are very compact and can now be fitted into the dials of

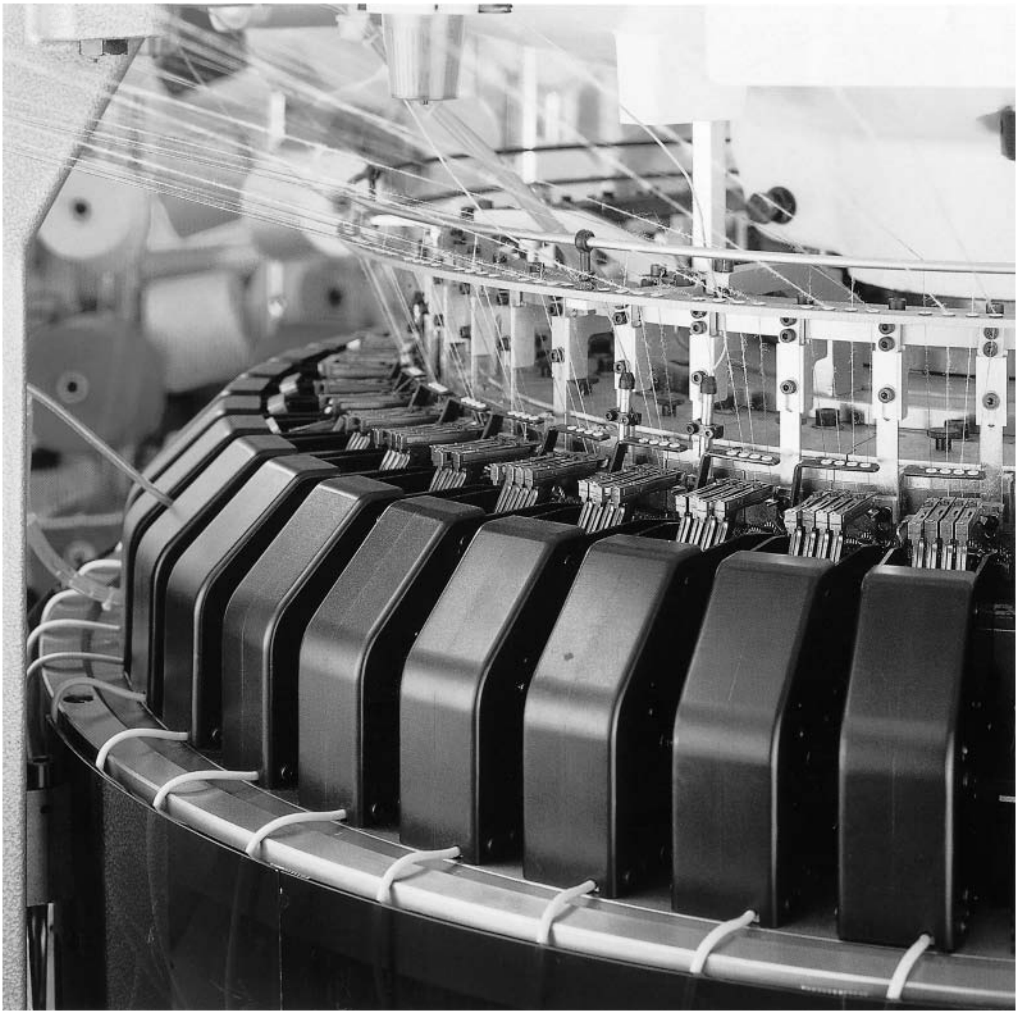

Fig. 11.11 Piezo-electronic rib jacquard machine with three-way selection and four-colour stripers [Terrot].

large-diameter circular machines for dial needle selection in addition to cylinder needle selection [1].

The *Moratronic* was one of the earliest machines and was first exhibited in 1963 (Fig. 11.12). 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 energise a coil and thus neutralise 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.

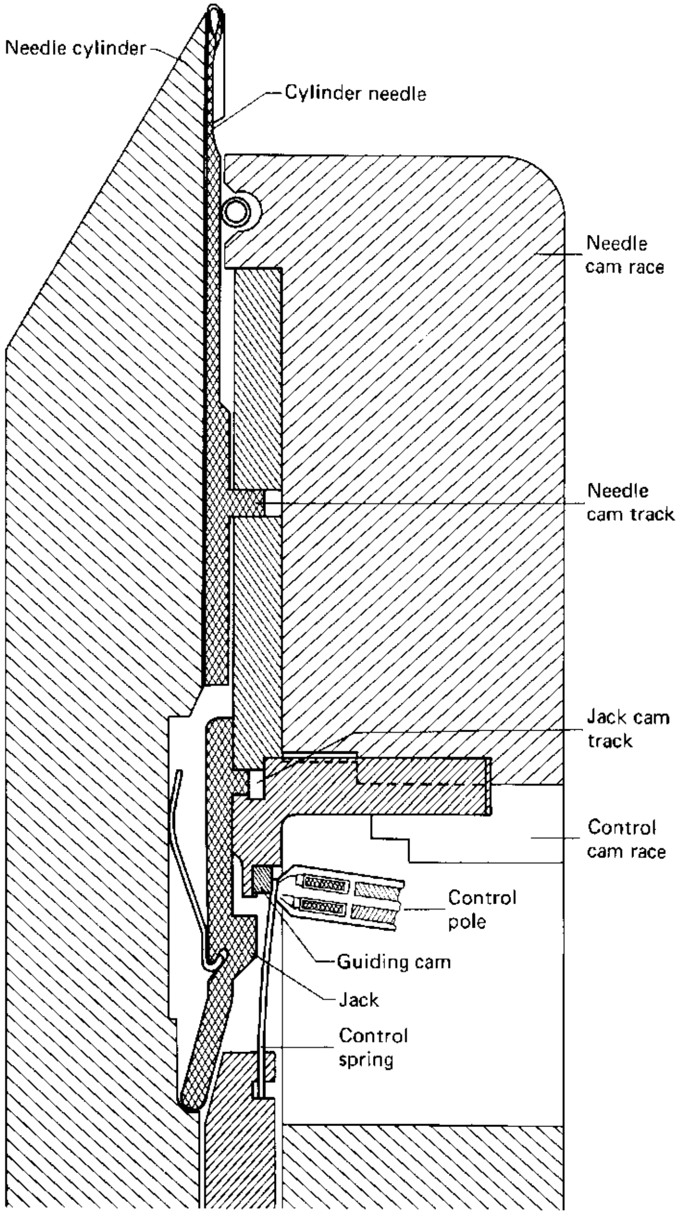

Fig. 11.12 Moratronic needle selection.

As the cam presses onto the spring, it depresses the jack into a deep recess of the trick so that the jack butt is pushed away from the cylinder raising cam and the needle supported by the jack is not lifted to knit. If no impulse is generated, the control magnet can hold the spring so that it passes in a bent position on the near side of the control cam and is held away from its jack, which stays out of its recess with its butt remaining on the raising cam to lift the needle above to knit.

The film is driven in phase with the needle cylinder to make a selection in

0.5 milli-seconds. Twelve million selections are possible – enough for a full-width selection 1564 pattern rows of three-colour design deep.

Reference

1. BOCKHOLT, K., Changes in needle selection, *Knit. Int.*, (1998), May, 51.

12

Electronics in knitting

12.1 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.

12.2 The disadvantages of mechanical programming

Mechanical pattern and programming data for controlling knitting machines is stored in the form of punched cards, chains, rack-wheels, peg drums, and element 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.

12.3 The advantages of electronic control and programming

Electronics offer the decisive advantages of convenient power-supply, compatibility with existing mechanical components, micro-miniaturisation of circuitry, and economical data storage. In addition, electronic systems do not require to be of a size proportionate to their task or to operate on a one-to-one relationship with it.

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

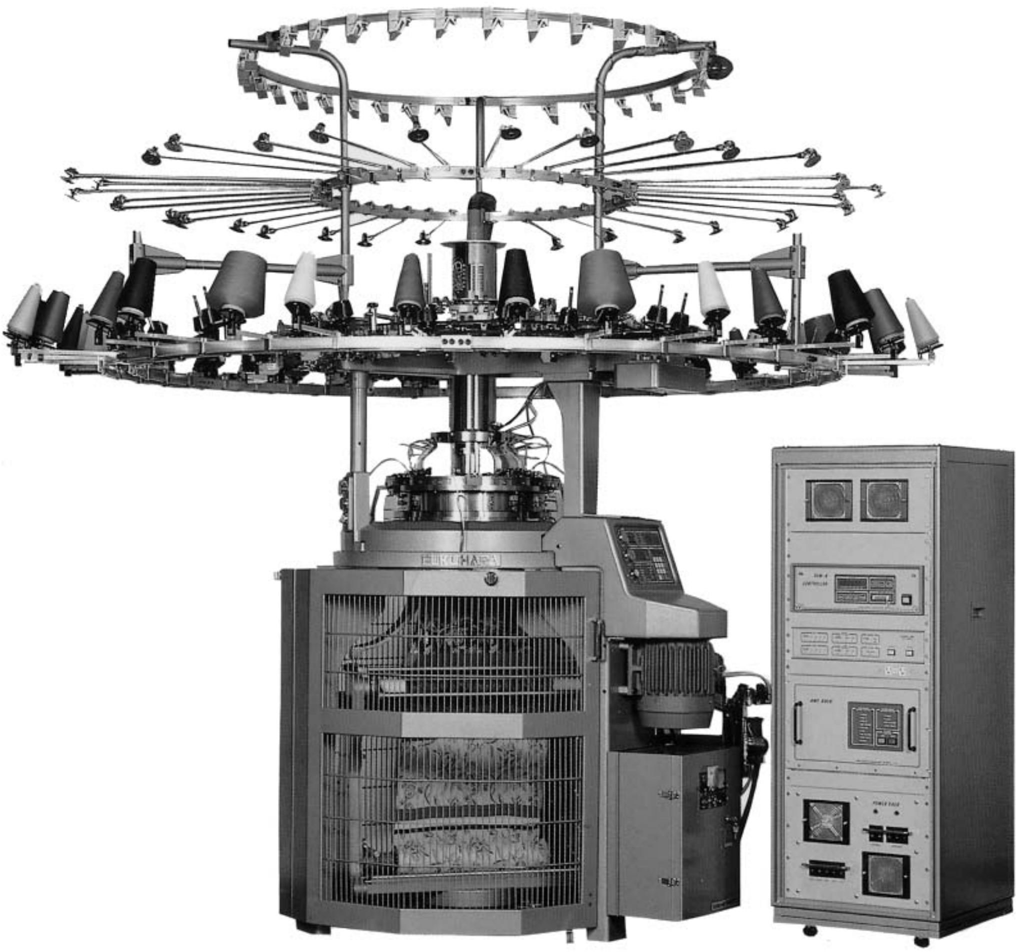

Fig. 12.1 Electronic sampling machine [Monarch].

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 (Fig. 12.1).

12.4 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 binary digits can be arranged in the form of a programme where they can be encoded and converted into symbols to compose, for example, a knitting design or a machine programme.

12.5 Microprocessors and computers

The most important use of electronics is in microprocessor and computer systems. A computer can receive, store, retrieve, and communicate enormous quantities of information at phenomenal speeds. It can also manipulate, rearrange, select, and transform this information. It performs arithmetical or logical processes accurately at high speed after receiving the instructions (programme) and values (data) without the need for further intervention by the operator.

Flexibility in processing of data occurs because the system can be programmed to produce *YES* or *NO* decisions, based on the result of comparing and testing monitored data, that then determine the choice of two alternative courses of action in the program of the system. These alternative courses within the main program sequence may include counted loop sequences, branching or jumping out of the main sequence, and selection of stored sub-routines.

It is these facilities that give electronically-controlled knitting pattern preparation and needle selection their extensive capabilities as compared with previously available methods. Inputs include switches, sensors on knitting machines, keyboards, light pens, tapes and discs; and outputs include actuators on knitting machines, lights, digital and graphical displays, tapes, and printers. Outside the system, the digital impulses may be changed from parallel to serial, or even analogue, form, or may be converted into light, sound, radio or carrier waves, or mechanical movements.

Although it is possible to directly program a system using switches, a matrix board, a keyboard or another input device, the processor (and probably the knitting machine) will be held waiting during this time-consuming operation. It is therefore preferable to record the program and data in an auxiliary memory store such as a tape or disc. Its contents can be rapidly inputted electronically into internal memory, as required, whilst using a direct input keyboard or switches for minor amendments or alterations during the running of the programme.

Some systems are programmed to interact with the operative who is thus able, within specified and guided limits, to change values of data, with the effects of the amendments being visually indicated by the system.

12.6 The computerised knitting machine

Although knitting is still a mechanical action between the yarn and the knitting elements, the design of tomorrow's machines will be increasingly influenced by the facilities offered by electronics (Fig. 19.13). Thus, whereas on mechanically-controlled knitting machines nearly all the mechanical movements are linked to, and are triggered by, the revolution of the machine or traverse of the cam carriage, electronic controls can be dispersed and separately operated.

In addition, their operation can be smoothly introduced in a series of gradual steps and not in a restricted number of large steps, as is the case with mechanical drive systems.

The electronically-controlled knitting machine can be part of a network of management communication links. A single control unit can control a complete bank of machines if necessary.

Unlike the mechanically-controlled machine, which is passively operated, stands alone and has no means of receiving and transmitting electronically generated data,

Fig. 12.2 Knitting patterns and programmes are quickly generated using automatic routines. These are checked and can be transmitted on-line to the CMS knitting machine. Simultaneous monitoring of production can also be achieved [Stoll SIRIX].

the increasing automatic monitoring and adjustment facilities provided by microprocessor control on modern machines obviates the need for continual manual attention (Fig. 12.2).

Perhaps electronics has had its greatest impact in V-bed flat knitting, as a major factor in the successful development of shaping techniques (Chapter 19).

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.

12.7 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 (Fig. 12.3).

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.

Fig. 12.3 The simulated knit package is mapped onto an image of a model to simulate the appearance of the final product. This image can also be used for evaluation and sales promotion purposes [Shima Seiki].

Generally, an input device is employed that can be moved by hand in the direction of either axis, with its location and movement over the screen being indicated by a special character symbol termed a cursor. The physical movement of input devices such as digitizers, joysticks, and trackballs is converted by the system into the series of numbers, whereas a light pen detects the presence of light whose position is being generated on the screen.

Computer 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, coloured, 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. Recognised 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 *Quantel Paintbox* has established the standard for an interactive computer graphic design system. It consists of a digitising table, a pressure-sensitive stylus, an interactive computer with integral software, a digital frame store, hard disc storage and a colour monitor that communicates commands via menus displayed on the screen.

Selections include colour, brush size, paint mode, and the automatic drawing of various shapes and structures. Enclosed areas of the design may be filled in with a colour (if this facility is available) and the locations of the colours may be exchanged. Stored sub-routines may also be recalled to assist with the development of the design.

By relating the co-ordinate points of the design to other co-ordinate points within the design area, the design can be rapidly modified, with motifs being multiplied in number or geometrically transformed. Each transformation may occur separately or as a combined effect: for example, a motif may be reflected (mirror imaged) across the width (the X axis) or the depth (Y axis) of the design area. It can be translated (moved in a straight line without altering its appearance), rotated (moved in a circular path around a centre of rotation), and scaled (increased or decreased in size along the X or Y axis or along both axes). Graphic capabilities are obviously dependent upon the type of system and its software. Electronic pattern preparation thus provides the designer with an immediate visual representation of the design as it is being conceived, amended, and edited, without recourse to the knitting of trial swatches (Figures 12.3 and 12.4). The grading of sizes [1] and the introduction, manipulation and placing of shapes and colours, is achieved with the minimum of effort and the elimination of all tedious and repetitious actions.

The program can be structured to guide and assist the designer and thus ensure that the resultant design is compatible with the knitting machine and the end-use requirements. Once a satisfactory design is achieved, a permanent record may be outputted onto hard copy and/or onto a carrier acceptable for controlling the knitting machine.

Not only is a programme required for knitting the fabric structure, one is also required for knitting the garment-length sequence, and a further programme is required for shaping. Many automatic modules are already installed that can be quickly recalled and ‘seamlessly’ co-operate with each other. The technician is

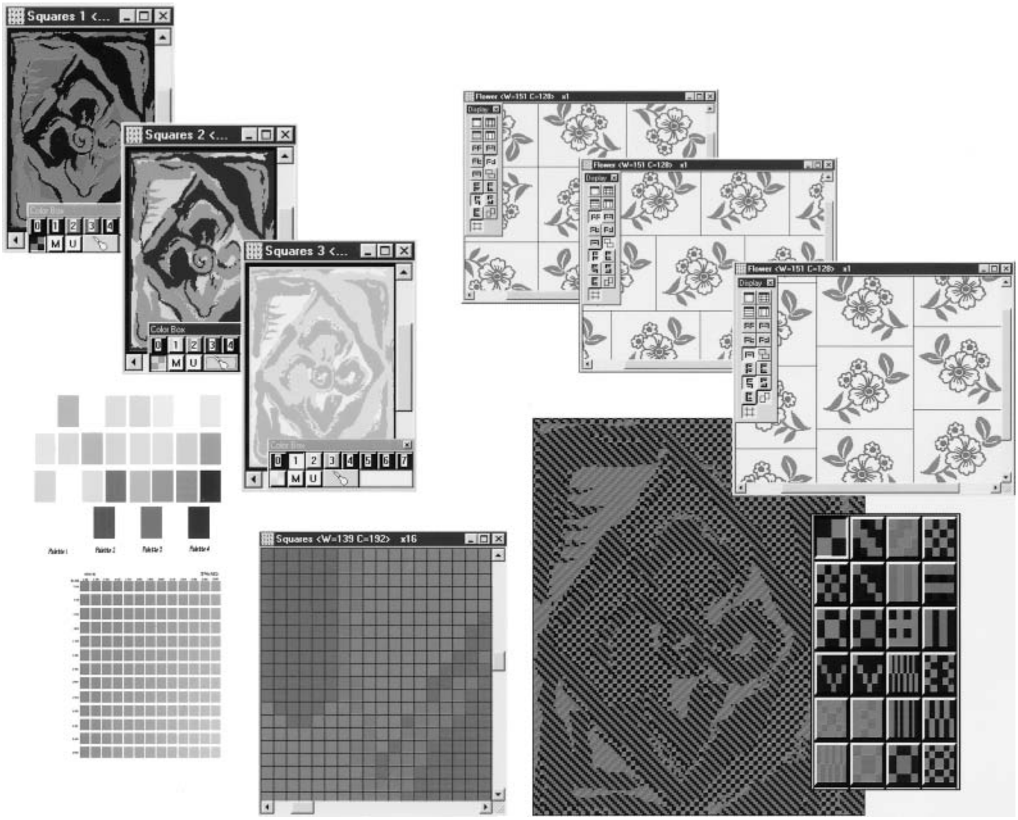

Fig. 12.4 MKS knitting system for Windows [Monarch].

guided throughout his programming by software that recognises the constraints imposed by the fabric and the technical specification of the knitting machine.

12.8 The Stoll CAD pattern preparation system

The *Stoll SIRIX* is a complete design, patterning and programming system originally specially developed from *Apple II* PC software. It caters for every application in V-bed flat knitting. It uses icons and windows to graphically support the generation and development of knitting programmes for *Stoll CMS* electronic flat machines. *SIRIX* has a hierarchy of files holding folders. These can be opened by a double click of the mouse on an icon. 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 multi-tasking facility permits simultaneous operation of a wide variety of programmes. These are controlled via the graphically-oriented user interface. Patterns can be designed using jacquard colours and the *Sintral* programming language, or directly by defining stitches and modules. These can then be transformed automatically into a knitting programme simply by pressing a button. *Sintral* is the text editor, which facilitates the creation of knitting programmes using plain language instructions. Designs or programmes are analysed, processed and tested, then automatically translated into *Sintral*, then presented to the monitor or loaded into the machine.

The *design programme* is a 'Paint' programme that provides a palette of colours, shades, brush shapes and sizes, and design tools.

Using the *yarn programme*, yarn types, shades, and textures can be generated and stored to closely simulate knitted panels, in advance of the knitting process.

Sophisticated colour printers can produce realistic images of the garment which, it is hoped, will reduce the time-consuming process of swatching and sample development on the knitting machine. Once the design is completed, a model can be called-up onto the screen whose three-dimensional appearance simulates the wearing of a garment made from the design.

A recognition that designers and technicians require different information as the sample is developed has led to the provision of two separate but linked and constantly up-dated screen windows. The *technical window* presents the developing design in the form of running thread notations and technical data, whereas the *design window* shows the design as a knitted structure. Each can be displayed as and when required, and changes on one are automatically up-dated on the other (Fig. 12.5).

The *grid* or *raster programme* works with peripheral input devices including scanners and cameras, or any programme containing an image. It adjusts images to the correct size for the number of wales and courses in the required design. An automatic *colour reduction programme* reduces the number of shades to the number of yarn colours to be used in the jacquard design.

The *jacquard programme* takes over after the grid programme, and has an extensive tool and colour palette (Fig. 12.6). The pattern field and stitch size are selected and the pattern motif is drawn onto a grid. Patterns can be depicted in the form of colours, stitch icons, or *Sintral* symbols. Stored designs can be called up. Shapes and areas can be re-scaled, manipulated, rotated, flipped, multiplied, deleted, or interchanged. Whilst a motif is being moved, it becomes transparent, so that the background can be seen through it, thus making it easier to accurately position.

Structure patterns are drawn using stitch icons that graphically depict stitch appearance. Pattern elements, such as cables, Aran and lace, are available in modules to build into the programme. The computer translates into machine language other relevant information that can be inputted by the designer, such as *yarn carrier allocation* and *knitted stitch sizes*.

The *intarsia programme* enables complex programmes for the production of intarsia designs to be generated almost completely automatically, based on following the rules of intarsia knitting. The pattern sketch is converted into an intarsia design in several stages. Intarsia designs are drawn using intarsia stitch icons for colours, structure and, if required, ladder backing. From the intarsia motifs on the screen, the *SIRIX* generates individual colour fields that are allocated to individual yarn feeders. The programme step '*Yarn Feeder*' works out the best starting point for the yarn feeder and inserts the lines necessary to position it. From the intarsia pattern needle selection, feeder paths and, if required, ladder backing on the rear bed is generated.

In the *shaping (fully-fashioned) programme*, the shape of the panel, e.g. sleeve, back, or front with a V-neck, is superimposed graphically over the ground pattern.

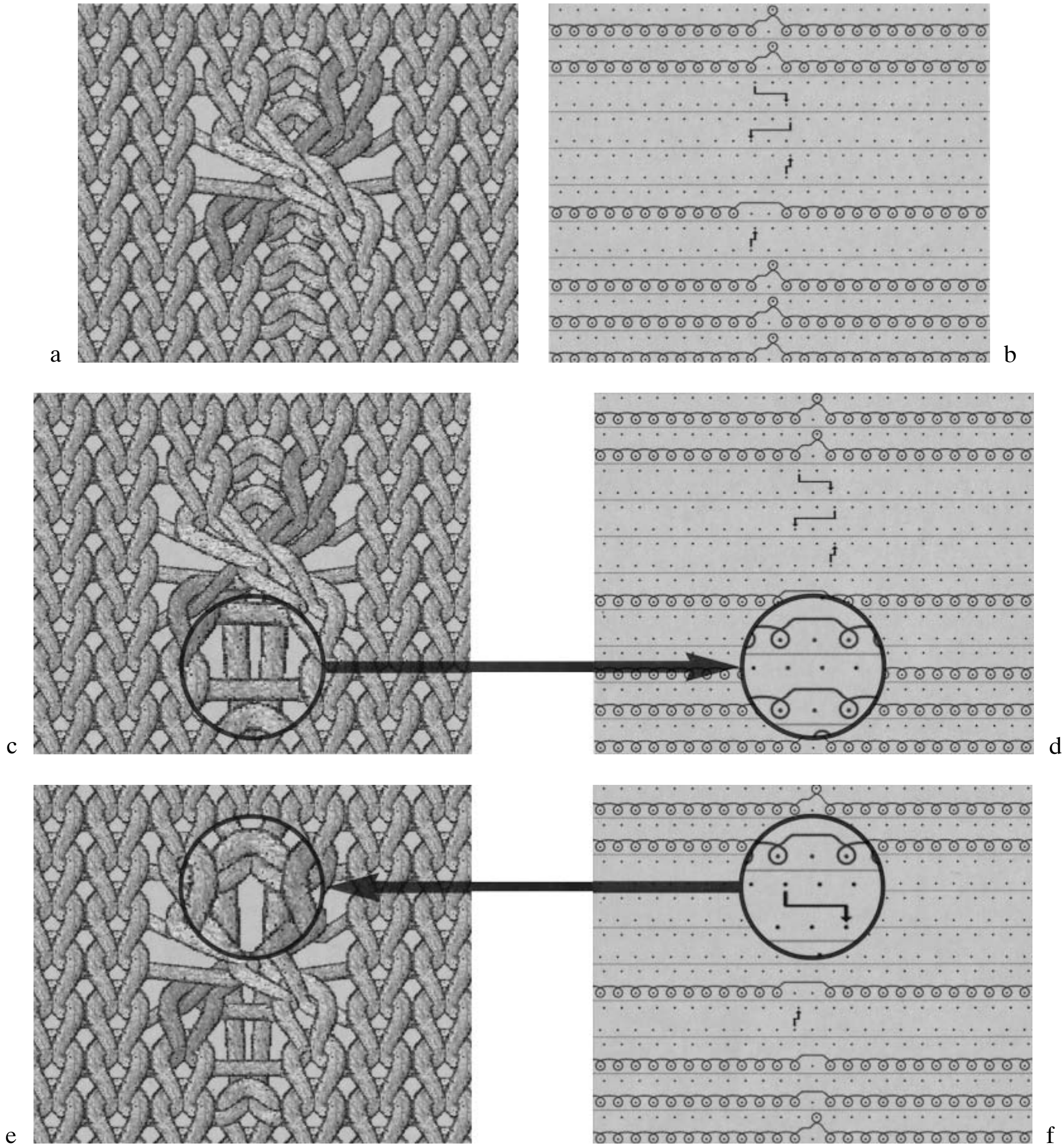

Fig. 12.5 Linked windows options of fabric view and technical view [Stoll].

Cables and Aran motifs are automatically faded-out at the selvedges. A complete automatic-knitting programme is generated from a drawn shape (Fig. 12.6).

A garment shape is selected from the file, inserted in the form of an area over the jacquard, and positioned where required. The width of the selvedge area can be varied and different stitch structures selected. The shape is cut out of the jacquard.

Narrowing modules are automatically inserted to give the required shape. The *FF programme* generates the *Sintral* programme that contains all the necessary data

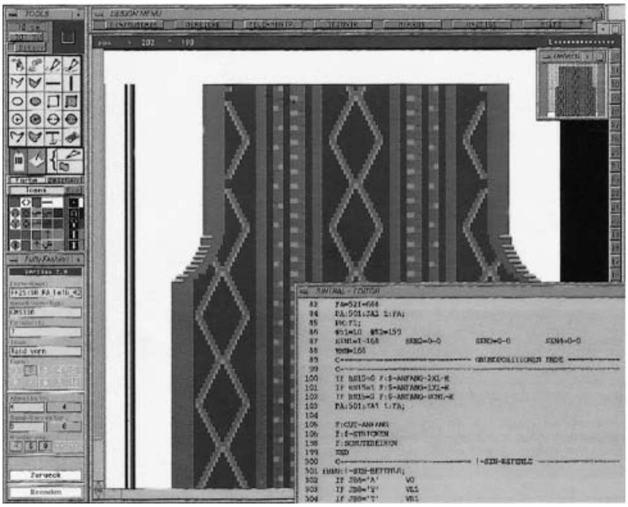

Fig. 12.6 The FF programme inserts the control columns and, using the existing jacquard, generates the Sintral programme, which contains all the necessary data for machine control [Stoll].

for machine control. The *module programme* breaks the modules down into complete knitting sequences. Stitch transfers can be programmed automatically.

The programme *Sirix Auto-Sintral* automatically generates the complete *Sintral* knitting programme. Starts and repeats for size changes can be selected. Once one size has been knitted, the CMS machine automatically changes-over to producing the next size.

The *analyse programme* tests the knitting programme, line-by-line, using an internal analysis routine, simulating without involving the knitting machine. Knitting information such as needle selection, yarn feeders, racking, etc. are carried in a programme log and can be assessed at any time. The *selection programme* presents the *analyse* data, course by course, in notation form, permitting rapid checking of pattern accuracy.

The *DIM 3 programme* permits the three-dimensional representation of knitted fabric on the screen. This can be enlarged, rotated and manipulated, from the face or reverse, at any angle. The fabric can be appraised as a whole or in fine detail.

On-line generates a direct connection to all the machines in the plant. Knitting programmes are transferred, on-line, to and from the knitting machines on the network, and production sequences are centrally controlled. Data on machine stoppages and reasons, as well as on production progress can be collected.

Tele-Service provides long-distance data transmission of knitting programmes as well as remote diagnosis of CMS flat knitting machines and *SIRIX* pattern-preparation systems.

On the CMS machine, the touch control screen displays pictogram symbols providing information on the progress of knitting production such as knitting speeds, settings of cams, yarn feeders and fabric take-down. Patterns and garment programme sequences can be read into the machine memory, either from floppy discs or directly on-line from the pattern-preparation unit.

12.9 The Shima total design system

Since developing the *Micro SDS* pattern preparation system, *Shima* have introduced a series of systems with improved hardware and software according to industry's needs.

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 *KnitPaint* 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, *KnitPaint* 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 *loop 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, crewe neck, cardigan, etc) for which the mesh grids are ready-made is available.

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Further information

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SCHLOTTERER, H., Sirix – A user-friendly pattern development system, *Knit. Tech.*, (1995), 1, 18–20; 2, 81–3.