The various types of weft knitting machines

8.1 Fabric machines and garment-length machines

Weft knitting machines may be broadly grouped according to end product as either:

- *circular machines*, knitting *tubular fabric* in a continuous uninterrupted length of constant width, or
- *flat* and *circular machines*, knitting *garment-length sequences*, which have a timing or counting device to initiate an additional garment-length programming ('machine control') mechanism. This co-ordinates the knitting action to produce a garment-length structural repeat sequence in a wale-wise direction. The garment width may or may not vary within the garment length.

The difference between fabric and garment-length knitting is best understood in terms of hand flat knitting. If the knitter merely traverses the cam carriage backwards and forwards across the needle bed, a continuous fabric length will be knitted. However, if the knitter counts the traverses and alters the cam box settings at predetermined traverses, a garment-length sequence can be knitted.

Underwear may be knitted either in garment-length or fabric form, whereas *knitwear* is normally in garment-length form, usually knitted in machine gauges coarser than E 14. *Jersey wear* is cut and made-up from fabric usually knitted on large circular machines (26-inch or 30-inch diameter), although there are larger and smaller diameter machines used. Generally, gauges are finer than E 14.

8.1.1 Fabric machines

Large diameter, circular, latch needle machines (also known as *yardgoods* or *piece goods*, machines) knit fabric, at high speed, that is manually cut away from the machine (usually in roll form) after a convenient length has been knitted. Most fabric is knitted on circular machines, either single-cylinder (*single jersey*) or cylinder and dial (*double jersey*), of the revolving needle cylinder type, because of their high speed and productive efficiency.

Circular machines employing bearded needles are now obsolete. Although sinkerwheel and loopwheel frames could knit high quality speciality fabrics, their production rates were uncompetitive.

Unless used in tubular body-width, the fabric tube requires splitting into open-width. It is finished on continuous finishing equipment and is cut-and-sewn into garments, or it is used for household and technical fabrics. The productivity, versatility and patterning facilities of fabric machines vary considerably. Generally, cam settings and needle set-outs are not altered during the knitting of the fabric (see also Chapter 13, *The production of weft knitted fabric*).

8.1.2 Garment-length machines

Garment-length machines include straight bar frames, most flats, hosiery, legwear and glove machines, and circular garment machines including *sweater strip* machines, producing knitwear, outerwear and underwear. On these machines, the garment sequence control with the timing/counting device, collectively termed '*the machine control*', automatically initiates any alteration to the other facilities on the machine needed to knit a garment-length construction sequence instead of a continuous fabric.

This machine control may have to initiate correctly-timed changes in some or all of the following: cam-settings, needle set-outs, feeders and machine speeds. It must be able to override and cancel the effect of the patterning mechanism in rib borders and be easily adjustable for different garment sizes.

Also the *fabric take down* mechanism must be more sophisticated than for continuous fabric knitting. It has to adapt to varying rates of production during the knitting of the sequence and, on some machines, be able to assist both in the setting-up on empty needles and the take away of separate garments or pieces on completion of the sequence.

Garments may be knitted to size either in tubular or open-width; in the latter case more than one garment panel may be knitted simultaneously across the knitting bed. Large-diameter circular machines and wide V-bed flat machines can knit garment blanks that are later split into two or more garment widths (*blanket-width* knitting) (see also Chapter 20, *Circular garment-length machines*).

8.2 Knitting welts and rib borders

Garment-length knitting sequences vary considerably. The simplest circular garment machines knit repeat sequences of rib borders and body panels in a continuous structure at high speed. This structure requires cutting into garment lengths and seaming to produce a secure welt edge.

Most garment machines knit some form of secure welt edge at the start of the garment sequence and either a 'knitted-in' separation course (draw-thread or dissolving thread) or 'press-off' separation between each garment piece. In the latter case, the machine must be capable of commencing knitting of the next garment length on empty needles.

Shaping of flat garment panels is either in the form of cut edges or in the form of knitted selvedges (in the case of reciprocating knitting on a flat machine). The amount of shape introduced into the garment also varies; in some cases this is achieved entirely by the cutting and making-up operation, in others it is by stitch shaping, stitch length variation, loop transfer and fashioning, held stitches or reciprocation.

8.3 Integral knitting

Whereas garments cut from fabric are completely assembled during seaming, others require varying amounts of making-up. *Integrally knitted* articles or '*whole garments*' are completely assembled on the knitting machine and require no further making-up operations off the machine.

Some V-bed glove knitting machines are of this type, as are some hosiery machines with integral toe-closing facilities. Some V-bed flat machines can knit complete garments in tubular form [1].

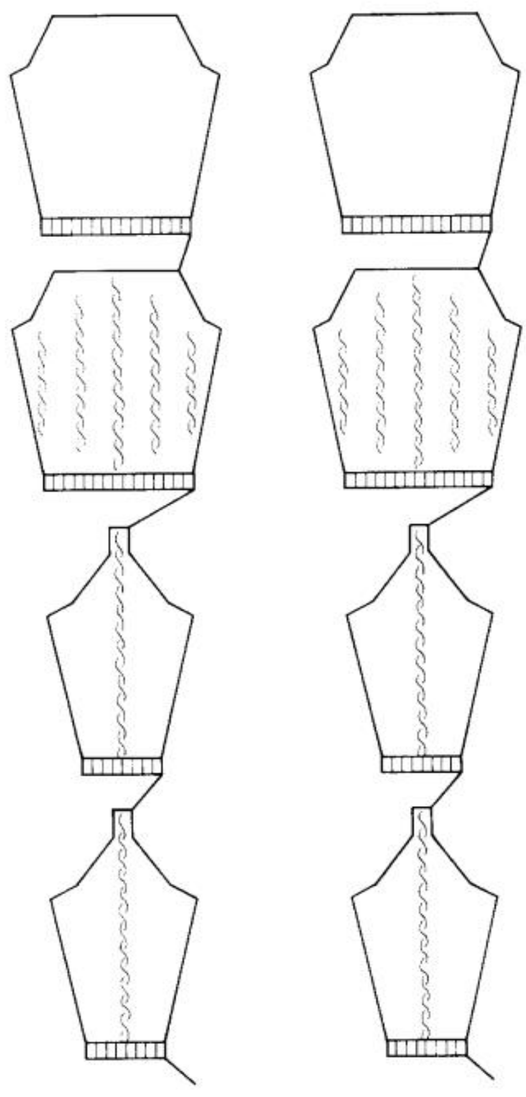

Fig. 8.1 Sequential knitting.

The advantages of this technique include savings in making-up machinery, space and labour, and reductions in the production sequence. Disadvantages include increased costs and complexity of the knitting machine and a possible reduction in its versatility and flexibility.

Certain electronically-controlled straight bar and V-bed flat machines can now be programmed to carry out a sequence of knitting a front, a back and two sleeves in turn thus using the same yarn and stitch lengths. Programming *sequential knitting* requires adequate computer memory and gives the advantages of quick response, less work in progress and better matching of component panels (Fig. 8.1).

8.4 The three classes of weft knitting machines

The three main groups of weft knitting machinery may broadly be classified as either straight bar frames, flats, or circulars, according to their frame design and needle bed arrangement.

8.4.1 Straight bar frame machines

Straight bar frames are a specific type of machine having a vertical bar of bearded needles whose movement is controlled by circular engineering cams attached to a revolving cam-shaft in the base of the machine. The length of the machine is divided into a number of knitting heads ('*sections*' or '*divisions*') and each head is capable of knitting a separate but identically-dimensioned fashion-shaped garment panel.

The needles press their beards against a fixed pressing edge; loop formation prior to intermeshing is achieved by individually horizontally-moving loop-forming sinkers, and knock-over occurs when the needles descend below the knock-over bits.

At either edge of each knitting head, a group of rackably-controlled points transfer loops to fashion shape the garment panel at the selvedges by widening or narrowing the knitting width. On completion of the garment panel, it is *pressed-off* the needles.

As straight bar frames have a single needle bar, they are unable to knit rib welts. A few rib frames (with a horizontal as well as a vertical needle bar) were built, but they were too slow and complex to become accepted. The same situation arose with the *rib-to-plain frame*, which had an auxiliary needle bed and was designed to knit a rib border after which only the vertical needle bar continued knitting for the plain knit body panel.

The welt and border sequence at the beginning of the panel was achieved by one of the two following methods:

1 Knitting a rib border fabric and welt on a separate V-bed flat machine, running it onto the empty needles of the frame and then commencing to knit the body panel onto the rib.
2 Employing a welt-turning device on the frame to produce a double thickness plain fabric. This method is more popular in the USA. It is the only method of knitting welts on fully-fashioned stockings.

Straight bar frames are long, capital-expensive machines that, because of their multi-sections and in spite of their intermittent knitting action, are highly productive in a very narrow sphere of garment manufacture. The knitting width is rather restricted and fashion tends not to encourage full exploitation of the fashion shaping and stitch-transfer patterning potential of the machines.

The machines are noted for their production of high-quality garments as a result of the gentle knitting action, low fabric tension and fashion shaping, which reduces the waste of expensive yarn during cutting and is emphasised on the garments by carefully-positioned fashion marks.

The straight bar frame is the only bearded needle weft knitting machine that is still commercially viable, although it now faces serious competition from electronically-controlled V-bed flat machines

8.4.2 Flat machines

The typical flat machine has two stationary beds arranged in an inverted V formation. Latch needles and other elements slide in the tricks during the knitting action. Their butts project and are controlled as they pass through the tracks formed by the angular cams of a bi-directional cam system. It is attached to the underside of a carriage that, with its selected yarn carriers, traverses in a reciprocating manner across the machine width (Fig. 8.2).

The machines range from hand-propelled and -manipulated models to automated, electronically-controlled, power-driven machines.

The classes of flat machines are:

1 the V-bed flat machines, which form by far the largest class;
2 the flat-bed purl machines, which employ double-headed needles;

Fig. 8.2 Mechanically controlled flat knitting machines. 1 = jacquard power flat; 2 = hand flat; J = jacquard selection steels; P = paste board movement cards.

3 machines having a single bed of needles, which include domestic models and a few hand-manipulated intarsia machines; and
4 the unidirectional, multi-carriage ('Diamant') machines, which are no longer built.

As with all knitting machines, there is a separate cam system for each bed; the two systems are linked together by a bow, or bridge, that passes across from one needle bed to the other. The systems for each needle bed are symmetrically arranged so that knitting, and in some cases loop transfer, may be achieved in either direction of carriage traverse.

The intermittent action of the carriage traverse and its low number of knitting heads (one to four) and cam systems (often only two to six, with a maximum of eight) reduces productivity but enables major cam changes to occur when the carriage is clear of the active needles.

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

Articles knitted on flat machines range from trimmings, edgings and collars, to shaped panels, integrally-knitted garment pieces, integrally-knitted complete garments and other articles.

8.4.3 Circular machines

The term 'circular' covers all those weft knitting machines whose needle beds are arranged in circular cylinders and/or dials, including latch, bearded, or (very occasionally) compound needle machinery, knitting a wide range of fabric structures, garments, hosiery and other articles in a variety of diameters. Circular garment-length machines are either of body size or larger (Fig. 8.3), having a cylinder and dial arrangement, single cylinder or double cylinder, as is also the case with small diameter machines for hosiery (Fig. 8.4).

During the last 200 years, numerous inventors have assisted the development of circular weft knitting technology towards its present state of sophistication and diversity [2]. Whilst *Decroix's* patent of 1798 has been considered to be the first for a circular frame, *Marc Brunel's* 'tricoteur' of 1816 is probably the first practical working example of such a frame. Efforts were concentrated during the subsequent 30 years on improving the knitting action of this frame, with its revolving dial of fixed bearded needles radiating horizontally outwards and having their beards uppermost.

In 1845, *Fouquet* applied his '*Stuttgarter Mailleuse*' wheels to the frame and their individually moving, loop-forming sinkers provided the sinker frame with the capability of knitting high-quality fabric, a possibility later exploited by *Terrot* who improved the frame's patterning facilities and marketed it throughout the world.

Fig. 8.3 Mechanically controlled circular knitting machines. 1 = plain cylinder and dial fabric machine; 2 = rib jacquard machine; 3 = double cylinder purl garment length machine.

Fig. 8.4 Mechanically controlled hosiery machines. 1 = seamless hose machine; 2 = double cylinder half-hose machine.

In 1849, *Moses Mellor* produced a revolving circular frame with vertically-arranged bearded needles facing outwards from the needle circle; this later developed to become the loopwheel frame. In the same year, *Matthew Townsend* patented uses for the latch needle and by 1855, *Pepper* had produced a commercial machine with a single set of movable latch needles and two feed points. This was soon followed by *Aiken's* circular latch needle rib machine of 1859, which also contained movable needles. *Henry Griswold* took latch needle knitting a stage further by moving the needles individually and directly via their bent shanks in his world-famous, hand-operated, revolving cam-box, small-diameter sock machine of 1878 (Fig. 4.4).

The first small-diameter, revolving-cylinder machine appeared about 1907 but there was still much strenuous effort required by machine builders and needle manufacturers before circular latch needle machines could seriously begin to challenge bearded needle straight and circular machines in the production of consistently high-quality knitted articles.