

# Basic mechanical principles of knitting technology

## 4.1 The sinker

The sinker is the second primary knitting element (the needle being the first). It is a thin metal plate with an individual or a collective action operating approximately at right angles from the hook side of the needle bed, between adjacent needles. It may perform one or more of the following functions, dependent upon the machine's knitting action and consequent sinker shape and movement:

*Loop formation*

*Holding-down*

*Knocking-over*

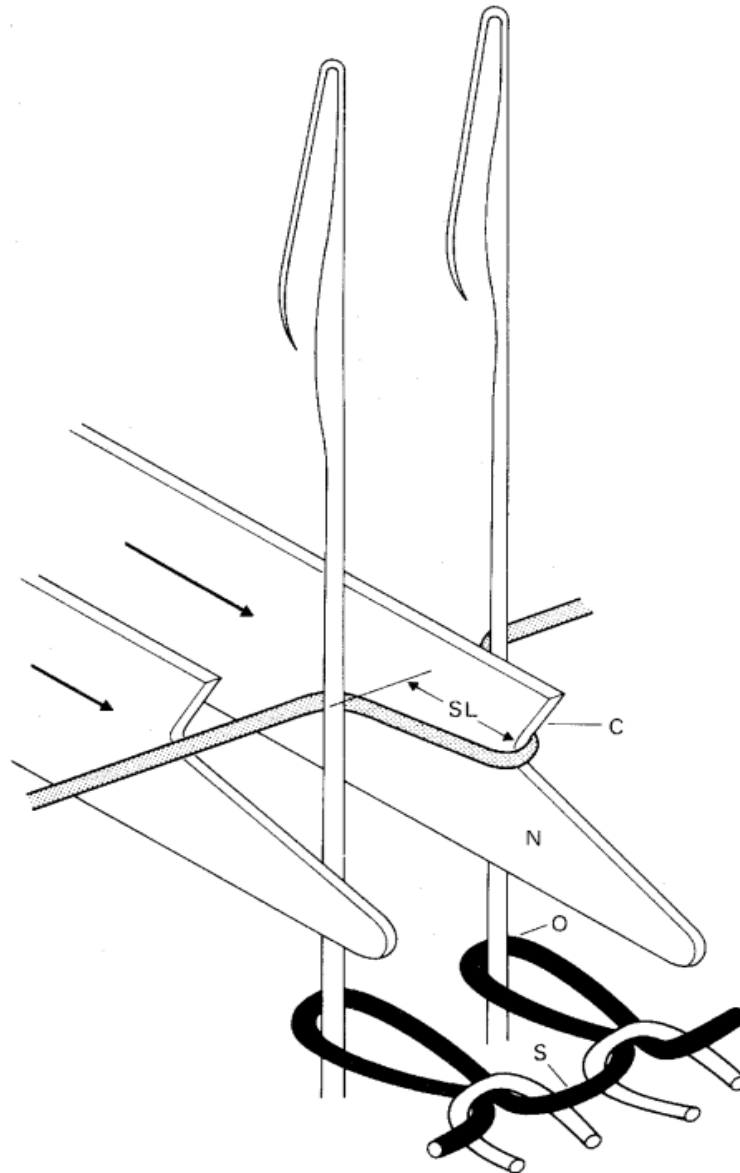
(It is always advisable to use one or more of the above terms as adjectives when referring to a sinker, in order to avoid confusion.)

On bearded needle weft knitting machines of the straight bar frame and sinker-wheel type (as on Lee's hand frame), the main purpose of a sinker is to *sink* or kink the newly laid yarn into a *loop* (Fig. 4.1) as its forward edge or catch (C) advances between the two adjacent needles. On the bearded needle loopwheel frame, the blades of burr wheels perform this function, whereas on latch needle weft knitting machines (Fig. 4.2) and warp knitting machines (Fig. 4.3), loop formation is not a function of the sinkers.

(NB: On the European mainland, particularly in Germany, the term *couliering* is used to describe the presentation of a yarn, the kinking of it into a needle loop and the knock-over of the old loop. Also the term 'sinker' often refers confusingly to a jack or other element (that can be sunk into a trick so that its butt is no longer in action.)

The *second* and more common function of sinkers on modern machines is to *hold down the old loops* at a lower level on the needle stems than the new loops that are being formed, and to prevent the old loops from being lifted as the needles rise to clear them from their hooks.

In Fig. 4.1, the protruding *nib* or *nose* of sinker (N) is positioned over the sinker

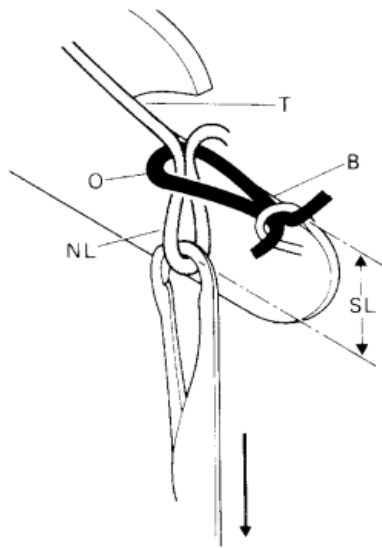


**Fig. 4.1** Action of the loop-forming sinker.

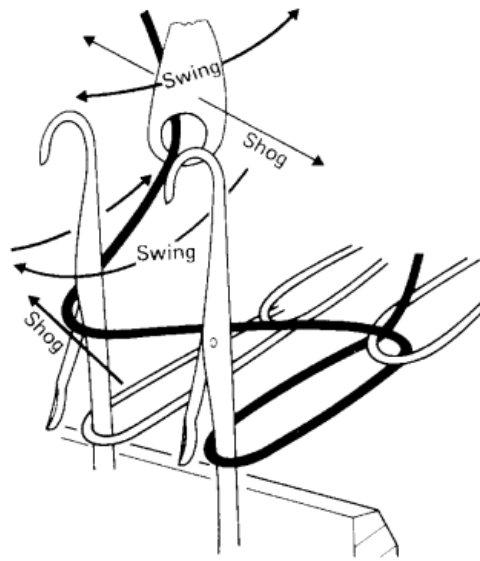
loop of the old loop (O), preventing it from rising with the needle. On tricot warp knitting machines and single bed weft knitting machines, a *slot* or *throat* (T in Fig. 4.2) is cut to hold and control the old loop.

The sole function of the sinker may be to act as a *web holder* or *stitch comb* as on the raschel warp knitting machine, in which case only the underside of the nose performs this function. On single cylinder latch needle weft knitting machines the holding-down sinkers have a rectangular gap cut into their upper surface, remote from the nose, into which the *sinker cam race* fits, to positively control the sinker's movement.

Holding-down sinkers enable tighter structures with improved appearance to be obtained, the minimum draw-off tension is reduced, higher knitting speeds are



**Fig. 4.2** Action of the knock-over sinker.



**Fig. 4.3** Loop forming by warp guides.

possible and knitting can be commenced on empty needles. Holding-down sinkers are often unnecessary when knitting with two needle bed machines as the second bed restrains the fabric loops whilst the other set of needles moves. However, if single bed knitting or held loop structure is knitted, a form of holding-down element may still be required (as is the case with some V-bed flat knitting machines).

The *third function* of the sinker – as a *knock-over surface* – is illustrated in Fig. 4.2 where its upper surface or *belly* (B) supports the old loop (O) as the new loop (NL) is drawn through it. On tricot warp knitting machines the sinker belly is specially shaped to assist with *landing* as well as knock-over. On raschel warp knitting machines, many V-bed flats, and cylinder and dial circular machines, the verge or upper surface of the trick-plate (V in Fig. 3.4) serves as the knock-over surface.

On some machines, the knock-over surface moves in opposition to the descent of the needle (see *Relanit*, Chapter 13; and *Shima* contra sinkers, Chapter 19).

## 4.2 The jack

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

## 4.3 Cams

All needles have a reciprocating action either *en masse* or serially (except on now obsolete bearded needle sinkerwheel and loopwheel frames, where the circle of fixed bearded needles merely revolves). Cams are the devices which convert the rotary machine drive into a suitable reciprocating action for the needles and other elements. The cams are carefully profiled to produce precisely-timed movement and

dwell periods and are of two types, *engineering cams* and *knitting cams*. The movements may be represented in the form of a time-displacement graph.

#### 4.3.1 Engineering cams

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

In warp knitting machines, four types of cam drive have been employed: single acting cams, cam and counter cam, box cams and contour cams. The first type requires a powerful spring to negatively retain the cam truck or follower in contact with the cam surface, where bounce and excessive wear occur at speed. The cam and counter cam arrangement provides a cam and its follower in each direction of movement, but is obviously more expensive to manufacture. The box or enclosed cam employs a single cam follower, which is guided by the two cam races of a groove on the face of the cam. However, change of contact from one face to the other causes the follower to turn in the opposite direction, producing wear which cannot be compensated. The contour, ring or pot cam is the reverse of the box cam as the cam profile projects out from one face of the cam in the form of a lip with a cam-follower placed on either side of it. This is a popular and easily adaptable arrangement. Although cams are comparatively cheap, simple and accurate, at speeds above 800 courses per minute they are subject to excessive vibration. For this reason, at speeds in excess of that, eccentric drive is now employed.

The *eccentric* is a form of crank which provides a simple harmonic movement with smooth acceleration and deceleration. Its widespread use is the result of adapting this simple motion and modifying it to the requirements of the warp knitting machine, so that even dwell (stationary periods) in the element cycle can be achieved. On the *FNF compound needle machine*, the movements of two eccentric drive shafts, one turning twice as fast as the other, were superimposed on each other. Now, however, the simpler, single eccentric drive is successfully driving element bars at speeds in excess of 3000 courses per minute.

#### 4.3.2 Knitting cams

The other type of cam, the angular *knitting cam* (see Fig. 3.4), acts directly onto the *butts* of needles or other elements to produce individual or serial movement in the tricks of a latch needle weft knitting machine.

Two arrangements exist:

- (a) Revolving cylinder machines – the needle butts pass through the stationary cam system and the fabric hanging from the needles revolves with them.
- (b) Reciprocating cam-carriage flat machines or rotating cam-box circular machines – the cams with the yarn feeds pass across the stationary needle beds.

In weft knitting, the yarn feed position is fixed in relation to the cam system (Fig. 3.4). The yarn feed moves with or remains stationary with the cam system, as do the

yarn packages and tackle (except in the case of flat machines where the cam-carriage only reciprocates away from and towards the stationary yarn packages and does not revolve).

In the past, most *garment-length* knitwear and underwear machines have had revolving cam boxes because changes to the cam settings during the garment sequence can be initiated from a single control position as the cam-boxes pass by; also the garment lengths are stationary and may be inspected or removed whilst the machine is knitting. Now, most new electronically-controlled garment-length machines are of the revolving cylinder type as electronics have removed the need for the complex arrangement of rods and levers found, for example, on mechanically-controlled half-hose machines (Fig. 21.3.)

All hosiery machines and all fabric-producing machines are revolving cylinder machines because the weight of revolving multi-feeder yarn packages and tackle creates inertia problems that reduce efficiency and knitting speeds.

*Knitting cams* are attached, either individually or in unit form, to a cam-plate and, depending upon machine design, are fixed, exchangeable or adjustable. In the last case, on garment-length machines this might occur whilst the machine is in operation. Elements such as holding-down sinkers and pelerine (loop-transfer) points are controlled by their own arrangement of cams attached to a separate cam-plate.

At each yarn feed position there is a set of cams consisting of at least a raising cam, a stitch cam and an upthrow cam (Fig. 3.4.), whose combined effect is to cause a needle to carry out a knitting cycle if required. On circular machines there is a removable cam section or door so that knitting elements can be replaced.

The *raising cam* causes the needles to be lifted to either tuck, clearing, loop transfer or needle transfer height, depending upon machine design.

The *swing cam* is fulcrummed so that the butts will be unaffected when it is out of the track and it may also be swung into the track to raise the butts.

The *bolt cam* can be caused to descend into the cam track to control the element butts or be withdrawn out of action so that the butts pass undisturbed across its face; it is mostly used on garment-length machines to produce changes of rib set-outs.

The *stitch cam* controls the depth to which the needle descends, thus controlling the amount of yarn drawn into the needle loop; it also functions simultaneously as a *knock-over cam*.

The *upthrow* or counter cam takes the needles back to the rest position and allows the newly-formed loops to relax. The stitch cam is normally adjustable for different loop lengths and it may be attached to a slide together with the upthrow cam, so that the two are adjusted in unison. In Fig. 3.4 there is no separate upthrow cam; section X of the raising cam is acting as the upthrow cam.

The *guard cams* are often placed on the opposite side of the cam-race to limit the movement of the butts and to prevent needles from falling out of track.

Separate cam-boxes are required for each needle bed or associated element bed and they must be linked together or co-ordinated. If the cam-box itself is moving from right-to-left, the needle butts will pass through in a left-to-right direction.

On circular fabric machines, the cams are designed to act in only one direction, but on flat and circular leg-wear machines, the cams are symmetrically arranged to act in both directions of cam-box traverse, with only the leading edges of certain cams in action. All cam systems are a compromise between speed, variety, needle control and selection systems [1].

#### 4.4 The two methods of yarn feeding

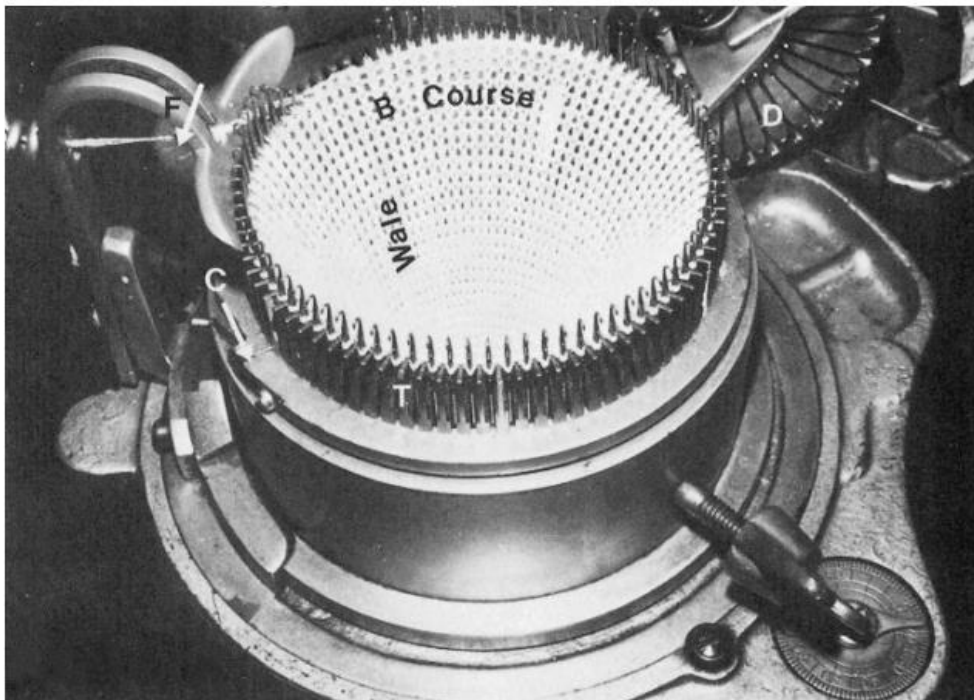
As mentioned in Section 4.3.2, yarn feeding involves either (a) moving the needles past the stationary yarn feed or (b) moving the yarn past the stationary needle bed.

When the yarn moves past the needles, the fabric will be stationary because the loops hang from the needles. This arrangement exists on all warp knitting machines, and on weft knitting machines with straight beds and circular machines with stationary cylinders and dials.

On straight machines of both weft and warp type, the yarn-carrier or guide has a reciprocating traversing movement that takes it towards and away from a suitably-placed yarn supply. On stationary cylinder and dial machines, however, the yarn supply packages must rotate in order to keep with the continuously revolving yarn feeds.

Because the latch needle beds of these flat and circular weft knitting machines are thus stationary, it is necessary to reciprocate the cam-carriage and revolve the cam-boxes so that the needle butts of the stationary tricks pass through. The needles are thus reciprocated to rise and receive the yarn at the exact moment when the traversing yarn feed is passing by (Fig. 4.4).

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



**Fig. 4.4** Simple hand-turned Griswold type machine

T = stationary needle tricks; C = revolving cam-box; F = revolving feeder; D = replaceable dial and needles; B = technical back of plain fabric.

## 4.5 The three methods of forming yarn into needle loops

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

- 1 (Fig. 4.1) – by sinking the yarn into the space between adjacent needles using loop forming sinkers or other elements which approach from the beard side. The action of a straight bar frame is illustrated. (Other obsolete circular bearded needle machines such as the sinkerwheel and loopwheel frame employ the same technique.) The distance SL, which the catch of the sinker moves past the beard side of the needle, is approximately half the stitch length,
- 2 (Fig. 4.2) – by causing latch needles to draw their own needle loops down through the old loops as they descend, one at a time, down the stitch cam. This method is employed on all latch needle weft knitting machines. The distance SL that the head of the latch needle descends below the knock-over surface (in this case, the belly of the knock-over sinker) is approximately half the stitch length, and
- 3 (Fig. 4.3) – by causing a warp yarn guide to wrap the yarn loop around the needle.

The lapping movement of the guide is produced from the combination of two separate guide bar motions:

- A swinging motion which occurs between the needles from the front of the machine to the hook side and return.
- A lateral shogging (or racking) motion parallel to the needle bar on the hook side and also on the front of the machine.

The swinging motion is fixed, but the direction and extent of the shogging motion may or may not be varied from a pattern mechanism. This method is employed on all warp knitting machines and for wrap patterning on weft knitting machines (when a fixed wrapping movement is used). The length of yarn per stitch unit is generally determined by the rate of warp yarn feed.