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(54) **Circular knitting machine of the type having two needle beds for knitting rib patterned tubular fabrics.**

(57) In a circular knitting machine of the type having two needle beds or needle-carrying structures (1,8) for knitting plain and purl stitches, the lower needle-carrying structure (1) comprises a cylinder and the upper needle-carrying structure (8) has a substantially bell-like shape and needle tricks (11) of arcuate shape for correspondingly arcuately bent needles (13). The arcuately bent needles (13) are controlled by selecting jacks (12), in turn controlled by cams (18) arranged around the substantially bell-like structure (8). Such a machine can have the same number of needles (3,13) on both needle-carrying structures (1,8), and accordingly, a higher fineness for a given diameter than traditional cylinder and dial machines. It also enables knitting loops to be transferred between all of the needles (3,13) in the two structures (1,8), both from the purl stitch side to the plain and from the plain stitch side to the purl, thus enabling the knitting of various types of rib pattern, such as 1:1, 2:2, etc., without requiring any jack replacement.

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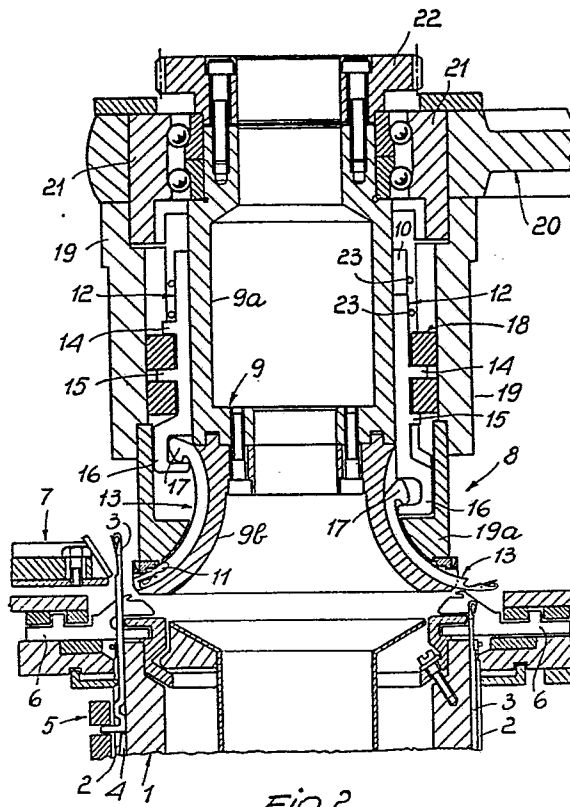


FIG. 2

This invention relates to a circular knitting machine of the type having two needle beds or needle-carrying structures for knitting plain and purl stitches, in particular rib patterned tubular fabrics.

5 For knitting the above type of knitted fabric, either a double cylinder or cylinder and dial machine is generally employed. Double cylinder machines, while affording good rib pattern knitting capabilities with the possibility of passing from a type of rib pattern
10 to another, are of complex construction, difficult to adjust, comparatively slow, and expensive. The cylinder and dial machines, by contrast, are much more simple construction-wise, faster, and less expensive, but do not allow the rib pattern type to
15 be changed at will, and where the diameters are small, cannot be manufactured for quite the same fineness as double cylinder machines of comparable diameter. In fact, the radial arrangement of the dial needles in respective needle tricks imposes
20 limitations on the mechanical implementation of the needle tricks. It follows that in small diameter machines, as used primarily for knitting stocking articles, the number of the dial needles is at all times equal to one half the number of the needles
25 in the cylinder. This definitely limits the types of rib pattern knitworks attainable on such machines; as an example, rib patterns of the 1:1, 1:3 and 1:5 types can be knitted but not of the 2:2, 2:4, types, nor is it possible to switch from
30 one type to another.

It has been proposed of overcoming said limitations by providing a machine with two needle-carrying structures, whereof the lower structure comprises a conventional needle cylinder and the upper structure comprises a dial having needle tricks of arcuate shape, in which tricks arcuately bent needles are movable having their hooks and latches arranged on the concave side. Representative of such a machine is the one disclosed in German Patent No. 667,499. The arcuate needle tricks in the dial are arranged such that the needles, which are moved along a circular path over an arc of about 90°, come out of the dial in a substantially radial direction to knit similarly to the needles of a traditional needle dial. The arcuately bent needles are provided with a butt each for engagement with a respective tilting jack, in turn controlled by a respective overlying slider, which is driven in a substantially radial direction by means of cams. The slider movements result, with the intermediary of the tilting jacks, in the needle operative movements being performed accordingly.

The arrangement of the arcuately bent needles also allows small diameter machines to be produced which have a considerable fineness, owing to the needles extending no longer radially and linearly toward the dial center, but from a substantially radial direction at the outward edge of the dial being deflected to follow a direction substantially parallel to the machine axis, while remaining

at a fair distance away from said axis. Thus, even with small diameters, it becomes possible to provide in the upper needle-carrying structure the same number of needle tricks as can be formed in the
5 lower needle-carrying structure. This enables the knitting of different types of rib patterns, in that with the assistance of transfer sliders associated with the dial needles and cylinder needles, respectively knitting loops can be transferred from one structure
10 to the other in either directions.

The necessity of providing the tilting jacks and respective control sliders for the arcuate needles complicates, however, the construction with respect to traditional dials and increases the
15 overall size thereof, such that it is in practice impossible to provide it in sizes below a certain limit and the improved dimensional features to be afforded by the arcuate needles are nullified. Moreover, the presence of transfer sliders for both the
20 cylinder and dial needles disallows diametrical dimensions below a given value, again to the detriment of the advantages that the arcuate configuration of the needles could otherwise secure.

25 To obviate in part such limitations, it has been proposed of driving the arcuate needles directly through the cams, as described in German Patent No. 675,210. In the latter instance, the needles extend over an arc of about 180° and are
30 each provided, at the opposite end to the knitting

end, with a butt for engagement with the cams, which
cams are also arcuately shaped in cross-section. The
missing of the tilting jacks and respective control
sliders affords a degree of constructional

5 simplification, but the cams, as well as the needles,
become much more difficult to manufacture, while
it is impossible to arrange movable cams for
needle selection.

It has been further proposed (refer to German
10 Patent No. 687,914) that a double cylinder machine
be designed such that the upper needle cylinder has
a smaller diameter than the lower needle cylinder
and a bottom end which flares out, thereby the
straight needle tricks in the upper cylinder are
15 caused to become arcuate at the bottom portion
thereof. The needle tricks accommodate straight
needles which have each an elastic wire-like
shank portion enabling the needle to adapt itself
to the shape of the respective arcuate trick.
20 Thus, the needles are caused to move out of the
upper cylinder in more or less radial directions to
co-act with the needles in the lower cylinder. At
the opposite end to the hook one, the upper cylinder
needles are each provided with a butt portion for
25 engagement with control cams arranged around the
upper cylinder.

The partly elastic needles, besides their
difficult construction, exert, however, a continuous-
ly applied pressure on the bottoms of the respective
30 arcuate tricks during the needle movements, which

results in premature wear of the upper cylinder and considerable stress in the control cams. Moreover, the movement of the needle hooks outside of the upper cylinder is accompanied by vibration, as
5 caused by the elastic nature of the needle shanks, so that it is not always possible to ensure a correct formation of the stitches.

This invention sets out to provide a knitting machine of the type with arcuately bent needles as
10 mentioned in the preamble, which has none of the drawbacks affecting conventional machines and is more simply constructed, has no wear problems, and affords a wide selection of the arcuate needles.

Within the above general aim, it is possible
15 to arrange that the knitting machine according to this invention is suitable for knitting in plain and purl stitch to any desired rib pattern without involving the presence of transfer sliders associated with the needles of the two needle-carrying structures.

20 According to one aspect of the present invention, there is provided a circular knitting machine of the type having two needle beds or needle-carrying structures for knitting plain and purl stitches, in particular rib patterned fabrics,
25 wherein the lower needle-carrying structure comprises a needle cylinder and the upper needle-carrying structure comprises a needle dial having arcuate needle tracks in the outer top surface thereof, wherein arcuately bent needles are slidable

having the respective hooks and latches arranged on the concave side thereof, said needle tricks being arranged such that the work ends of the arcuately bent needles are moved in a substantially radial direction to the machine and the arcuately bent needles extending substantially over an arc of 90° and being controlled by selecting jacks, the machine being characterized in that said selecting jacks are movable along respective straight and preferably vertical portions of the needle tricks in said needle dial and hingedly associated with the respective needles, said selecting jacks having each at least one control butt for engagement with control cams.

15 A machine so constructed only requires one selecting jack for controlling a respective needle, and the jacks moving along a straight trick portion can be conveniently controlled by cams located externally to the dial and requiring no arcuate cross-sectional configuration. Thus, movable cams can be readily arranged radially to the machine, thereby to achieve a desired selection of the jacks and consequently of the needles. The hinged engagement of the arcuate needles with their related jacks results in a movement of the two elements which is practically free of stress and wear induced in the dial.

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Further details and advantages of the invention will be more readily apparent from the following

detailed description of two preferred embodiments thereof, given herein by way of example only and being illustrated in the accompanying drawings, where:

5 Figure 1 is an axial section through a circular knitting machine according to the invention, illustrating a first embodiment thereof;

Figure 2 shows a fragmentary axial section through another embodiment of the inventive machine
10 which is especially suitable for knitting rib patterns of various types;

Figures 3a and 3b are developed views of the cam ring controlling the needles and selecting jacks of the machine of Figure 2, each figure showing a
15 respective half of said cam ring;

Figures 4,5,6 and 7 are respective detail views of one jack and one needle of the upper needle-carrying structure and one needle and one jack of the cylinder in the machine of Figure 2;

20 Figures 8a, 8b, and 8c illustrate the steps of transferring knitting loops from the purl side to the plain one, the initial and final steps being shown as viewed from the needle sides, and the intermediate steps being shown as viewed from the
25 needle fronts;

Figures 9a, 9b, and 9c illustrate reverse transfer steps, in the same sequential order as Figures 8a, 8b, and 8c above;

Figures 10 and 11 show schematically the
30 respective arrangements of the lower and upper

selecting butts of the jacks in both needle-carrying structures where the rib pattern is a 1:1 (Figure 10) and 2:2 (Figure 11) pattern.

With initial reference to Figure 1, a circular
5 knitting machine according to the invention comprises two needle beds or needle-carrying structures 61 and 62, in overlying relationship one above the other, the lower structure 62 comprising a conventional needle cylinder and the upper
10 structure 61 having a substantially bell-like shape.

In the cylinder 62, there are formed in a manner known per se needle tricks 63, wherein the needles 64 are movable which knit plain stitches, the needles being controlled by selecting jacks 65
15 which are selected through selecting means of conventional design. The cylinder 62 is carried rotatably by a stationary structure 66, 67, 68 of the machine and is rotatively driven by machine motive means, not shown, through a bevel gear pair,
20 also not shown, as is normal with single-cylinder knitting machines. The reference numeral 69 designates sinkers of conventional design, which are slidably accommodated in a rotating ring carrier or support 70 and controlled through a fixed control
25 ring 71, the whole assembly being in accordance with known and accepted practices. For completeness sake, a feed unit 72 including yarn feeding fingers 73, of a known type, is also shown. The machine further comprises means for controlling the needles

64 and jacks 65, which comprise conventional cams for controlling the movements of the needles 64 and jacks 65.

The upper needle-carrying structure 61 comprises
5 a substantially bell-like body 74 being grooved with needle tricks 75 formed in its outward portion in a lengthwise direction. The needle tricks 75 include an arcuate portion 75a each, located at the bottom portion of the bell-like body 74, and a
10 substantially straight portion 75b each, preferably extending in a vertical direction, and spanning the remaining portion of the bell-like body 74. At their lowermost point, the portions 75a are substantially tangent to a horizontal plane. Movable in the
15 portions 75a are respective needles 76 of arcuate shape, the radius of curvature being equal to that of the portion 75a, which needles have their bottom ends provided with hooks and latches facing the concavity of the arcuate shape and top ends
20 configured for engagement in hinged relationship with respective upper jacks 77. That engagement is preferably implemented through a hook-up type of association, the needles 76 having a top hooked end 76a each, and the jacks 77 having a bottom
25 hooked end 77a each. The engagement and configuration of the hooks are such as to allow the needles 76 to be pulled and pushed by the respective jacks 77 and a free movement of the needles 76 and jacks 77 in their respective trick portions 75a and 75b.

30 Each selecting jack 77 is provided with at

least one control butt 77b adapted to follow control
cams 78 which constitute means for controlling the
needles 76 and are arranged on the outside of the
substantially bell-like structure 61. Advantageously,
5 the cams 78 are supported on a fixed structure 79
of substantially hollow cylindrical shape, which
structure is supported on the portion 80 of the
machine stationary frame. The bell-like body 74 is
rotatably supported by that same portion 80 through
10 bearings 81, and is rotated through a gear wheel 82
attached to the top of the bell-like body 74 and
rotatively driven by the machine motive means at
the same rpm as the cylinder 62, as is normally the
case with the needle dial.

15 At 83, there is indicated a saw cutter of
known design, which is carried by the structure 79
and is adapted to cut in a known manner the yarns
after they have been knitted.

Advantageously, the needles 76 extend
20 substantially over an arc of about 90°. It will be
appreciated how, under the influence of the
rectilinear movement of the jacks 77, as produced
by the cams 78 in accordance with the machine
knitting program, the needles 76 are moved along an
25 arc of a circle between a position whereat their
hooks and latches move out of the bell-like body
74, as shown in Figure 1 for the right-hand needle
76, and a position whereat both the hooks and latches
are located within the bottom periphery of the
30 bell-like body 74, as shown in Figure 1 for the

left-hand needle. It will be further appreciated how the useful movement of the hooks and latches of the needles between the two positions is not substantially different from the conventional one, 5 it occurring mainly in a horizontal and radial direction at the knitting loop formation area. Thus, knitting is also carried out in a conventional manner and will require no further explanation.

The arcuate lay of the needle tricks 75 makes 10 available in a troublefree way a number of needle tricks 75 equal to the number of needle tricks 63 in the cylinder 62, even with small diameter machines. This affords the possibility of greatly increasing the machine fineness, and accordingly of 15 the product to be obtained thereon for a given cylinder diameter.

Advantageously, the bell-like body 74 may be made open at the top, to thus allow the product to be discharged from the top, that is in an inside 20 out condition, which is known to favor the final operations to be carried out on the product, and especially so in the instance of stockings articles. Of course, the gear 82 will also be open at the center. It is apparent that such a configuration 25 also allows the fabric to be pulled upwards during the knitting thereof, there being provided for this purpose equivalent means to those employed in the upward pull double cylinder machines.

The machine of Figure 2 comprises, as the lower 30 needle-carrying structure, a cylinder 1, in the

needle tricks 2 whereof there are slidably arranged,
in a manner known per se, latch needles 3
whose features will be described more completely
hereinbelow. Underneath the needles 3, there are
5 arranged respective selecting jacks 4 which are
controlled, like the needles 3, by cams of a cam
ring 5, as will be explained hereinafter. The
numeral 6 designates the sinkers, of a known type,
whilst the numeral 7 designates a yarn feed unit.

10 The upper needle-carrying structure 8 comprises
a substantially bell-like body 9 formed in two parts,
namely a cylindrical top part 9a and a bottom part
9b substantially in the shape of a hyperbolic
hyperboloid. The two parts have on their outward
15 surfaces needle trick grooves 10, respectively 11,
which are aligned together and equal in number to
the needle tricks 2 on the cylinder 1 and
accommodating jacks 12 and needles 13, respectively.
The needle tricks 11 on the part 9b are of arcuate
20 shape and substantially tangent to the bottom plane
of the part 9b. The needles 13, of the latch type,
are also of arcuate shape and extend substantially
over an arc of a circle corresponding to one quarter
of a circle. Each jack 12 has selecting butts 14, 15
25 arranged on at least two levels and having different
lengths. The jacks 12, moreover, have bottom ends
16 in the form of hooks open in a radial direction
for hinged connection to hooked ends of
the needles 13, the configuration and arrangement of
30 the hooked ends 16, 17 being such as to allow the

needles 13 to be pushed and pulled by the jacks 12, as well as a freedom of relative movement between the needles 13 and jacks 12 in a radial direction. Thus, the movements of the jacks 12 and needles 13

5 can practically occur without involving any adversely affecting stresses and wear of the needle tricks in the structure 8.

The jacks 12 are controlled by cams in a cam ring 18 arranged about the bell-like body 9, in a
10 pattern which will be described hereinafter. The cams of the cam ring 18 are attached to a fixed part 19 which embraces, at least in part, the bell-like body 9 and is in turn secured to a stationary structure 20 of the machine. The bell-like body 9 is rotatably
15 carried in this same stationary structure 20 through bearings 21 and is rotatively driven, at the same rpm as the cylinder 1, through a gear wheel 22 rigid with the bell-like body 9. A part 19a, attached to the fixed part 19, encloses the area of the needles
20 13 and is configured to cover with rotary clearance the tricks 11 of the part 9b. The jacks 12 are held in their tricks 10 by snap rings 23.

Advantageously, the arcuate tricks 11 of the part 9b are made non-tangent to the straight tricks
25 in the cylindrical part 9a, and are caused to partly retract at the passage area between consecutive portions of the tricks 10 and 11. It has been found, in fact, that such an arrangement affords a more linear movement of the needles 13, between the cited
30 two limit positions, since those portions of the

tricks 11 in the part 9b in front whereof the hooked ends 16 of the jacks 12 move are on the average vertical, and the stroke length of the hooked ends 17 of the needles 13 in a horizontal direction is reduced.

5 The tricks 11 and tricks 2 are slightly offset angularly, such as to allow the overlying needles 3 and 13 to move out without any interferences.

As shown in detail in Figures 4 and 5, the hooks and latches of the needles 13, as well as the hooked
10 ends 17, are facing the concave sides of the needles, whereas the hooked ends 16 of the jacks 12 are facing the opposite side to the butts 14 and 15, that is the inward portion of the machine with the jacks 12 installed in the machine.

15 The needles 3 are each provided with a protrusion 24 facing outwards on their shanks, below the latch, and adapted for transporting the loops toward the needles 13 in the upper needle-carrying structure 8, as will be explained hereinafter. Advantageously,
20 they are also provided with a lateral recess 25, located slightly below the protrusion 24, the function whereof will be described hereinafter. The needles 3 are also provided, in a manner known per se, with bottom control butts 26 for engagement with
25 determined cams in the cam ring 5, as explained hereinafter. Advantageously, the hooks of the needles 3 may be slightly deflected outwardly with respect to the vertical inner corners of the needles, in accordance with a well known practice.

30 The jacks 4 controlling the needles 3 are

provided with patterning butts, two of which, as indicated at 27 and 28, are located at different height levels and preferably adjacent each other, and serve selection purposes for the knitting loop transfer described hereinbelow. The jack selection for patterning purposes (including loop transfer) is effected by means of selection devices S1, S2, S3, S4 of a known type, as discussed here below. Moreover, the jacks 4 are provided, in a manner known per se, with a top control butt 29 and bottom control butt 30 for the movement of the jacks 4 under the influence of the cams of the cam ring 5.

With particular reference to Figures 3a and 3b, the cam ring 5 of the cylinder 1 and cam ring 18 of the upper needle-carrying structure 8 are configured, by way of example, to bring to knitting the needles 3 and 13 at two yarn feeds F1 and F2, and to complete the loop transfer both from the needles 13 to the needles 3 and from the needles 3 to the needles 13. The needles 3, 13, along with their respective jacks 4, 12, are moved in the direction of the arrow R. For clarity of illustration, the upper cam ring 18 is shown as overlaid on the lower cam ring 5 and plan developed such that to each generatrix of the lower cam ring 5 there corresponds the same generatrix (i.e. one lying in the same axial plane) of the upper cam ring 18, albeit the latter has a slightly shorter circumferential length than the former, owing to the different diameters of the two cam rings, as may be seen in Figure 2.

With the yarn feeds F1 and F2, there are associated associated in the upper cam ring 18, a pair of overlaid push-out cams 31, respectively 32, and a pair of overlaid knitting cams 33, respectively 34, the
5 upper cams in each pair being adapted to interfere with the top butts 14 of the upper jacks 12, and the lower cams of each pair being adapted to interfere with the lower butts 15 of the jacks 12. With those same feeds F1 and F2, there are associated, in the lower
10 cam ring 5 and in a manner known per se, raising cams 41, respectively 42, and knitting cams 43, respectively 44, for the needles 3, as well as raising cams 51, respectively 52, for the lower jacks 4.

In the upper cam ring 18, there are further
15 provided, downstream of the cams 34, a pair of overlaid push-out cams 35, the topmost one whereof is adapted to interfere with the upper butts 14 and the lowermost one with the lower butts 15 of the jacks 12, and a following push-in cam 36 adapted to act on
20 the lower butts 15 of the jacks 12, the cams 35 and 36 being effective in the transferring of the loops from the needles 13 to the needles 3, as will be explained hereinafter. Downstream of the cams 35 and 36, there are also provided in the upper cam ring 18,
25 a push-out cam 37 and push-in cam 38 for transferring the loops from the needles 3 to the needles 13, both these cams being operative to act on the upper butts 14 of the jacks 12.

Furthermore, there are provided in the lower cam
30 ring 5, sequentially in this order, a lowering cam

46 for withdrawing the needles 3 after the transferring of the loops from the needles 13 to the needles 3, a raising cam 47 for raising the needles 3 to transfer the loops from the needles 3 to the needles 13, and a
5 pair of consecutive lowering cams 48,49 for withdrawing the needles 3 upon completion of the loop transfer. For the jacks 4, there are also provided in succession raising cams 55 and 57, respectively for raising at the area of loop transfer from the needles 13
10 to the needles 3 and for raising at the area of loop transfer from the needles 3 to the needles 13. The jacks 4 are lowered, after they have been caused to climb the cams 51,52,55, and 57, in a known manner, respectively from the portions 53,54,56, and 58 of
15 the ring 59.

As may be noted in Figures 3a and 3b, the raising cam 47 is arranged, as viewed in the direction R of rotation of the needles 3 and 13, at least in part before the push-out cam 37, and the lowering cam 48
20 is arranged, again in the direction of rotation of the needles 3 and 13, at least in part before the push-in cam 38.

The cams 31,32,35,37, as well as the cams 47 and 48, are cams arranged to be movable independently of
25 one another in a radial direction relatively to the respective needle-carrying structures, the movement being imparted by the machine main drum to carry out the necessary selections of the jacks 12, as will be apparent hereinafter. These movable cams may receive
30 support in a conventional manner, and conventional

may also be their operation.

It is now assumed, for a clearer illustration of the capabilities of the machine according to this invention, that it is desired to switch from one
5 type of rib pattern knitwork to another, that the machine is preset for 1:1 and 2:2 rib pattern operation with the possibility of switching at will from one type to the other. In this case, the lower selection butts 15 of adjacent jacks 12 would be
10 alternately short and long butts, whilst the corresponding lower jacks 4 would alternately have an available lower selection butt 28, where underlying an upper jack 12 with a short lower butt 15, and a missing one, where underlying an upper jack
15 12 with a long lower butt 15, as is shown diagrammatically in Figure 10, wherein the small circles identify the missing lower selection butts. The upper selection butts 14 of adjacent upper jacks 12 would instead be arranged in pairs, with alternating
20 short and long ones, whilst the upper selection butts 27 of the corresponding lower jacks 4 would be alternately available and missing, in pairs, again such that to the long upper butts 14 there corresponds a missing upper selection butt 27, and to the short
25 upper butts 14 there corresponds an available upper selection butt 27, as shown diagrammatically in Figure 11, wherein small circles represent the missing upper selection butts.

During the knitting of the 1:1 rib pattern
30 knitwork, the upper movable cams 31 and 32, as well

as the cams 35 and 37, are withdrawn, and the lower movable cams 31 and 32 are in a position such that they only act on the long lower butts 15. The related jacks 12 follow, along with these long butts, the track A, thereby the associated needles 13 will be all knitting at the feeds F1 and F2, in a manner known per se. The other jacks 12, having short lower butts 15, will follow the track B with these butts, and accordingly do not bring the associated needles 13 into knitting. Therefore, the needles 13 will be knitting in alternating sequence at each feed F1 and F2. The needles 3 of the cylinder will also be alternately knitting, as selected by the selecting devices S1, S2, in a manner known per se, thereby those needles 3 which are positioned underneath the knitting needles 13 are left inoperative, and those needles 3 which are positioned underneath non-knitting needles 13 are driven to knit. The knitting needles 3 follow with their butts 26, in a known manner, the track C, and the non-knitting needles 3 follow the track D with their butts 26. The selecting devices S3 and S4, during normal knitting operation, are effective to hold all of the jacks 4 low at the cams 55 and 57.

If it is now desired to switch from the 1:1 rib pattern to the 2:2 rib pattern, the lower cam 35 is driven into the operative position, thereby all the jacks 12 with a long lower butt 15, corresponding to the needles 13 which have been knitting, are lowered such that their butts 15 follow the track E, while

the related needles 13 are brought to the outside of the body 9b with the last yarn loop 60 in their hooks (Figure 8a). Immediately thereafter, the underlying needles 3 are raised, following an appropriate
5 selection by the selecting device S3, which causes only those jacks 4 to climb the cam 55 which have no butts 28 and whereto there correspond, as mentioned hereinabove, the needles 13 which have been knitting. The corresponding needles 3, which had not been
10 knitting, are raised to a height level such that their open latches do not lie higher than the needles 13 (Figure 8b). The butts 26 of these needles 3 follow the track F. Thereafter, the needles 13, which are pushed out to a sufficient
15 extent to bring the knitwork loops to beyond their latches, are withdrawn under the action of the cam 36 which acts on the long lower butts 15 of the respective jacks 12, while the yarn 60 closes again the latches (on the right in Figure 8b), to remain
20 between the hook and latch of an adjacent needle 3. The latter is then lowered by the cam 46 and picks up the yarn being delivered from the needle 13 (Figure 8c).

In this manner, all the needles 13 have no
25 knitwork loops thereon and have the yarn 60 caught in their hooks. At this point, the machine is set for 2:2 rib pattern knitting.

Now, the selecting device S4 drives onto the
cam 57 the jacks 4 of all those needles 3 which
30 are not to knit plain stitches, i.e. only those jacks 4

which have no upper selection butt 27, or in other words the jacks which are represented by small circles in the diagram of Figure 11. All the other jacks 4 remain instead low, and the respective
5 needles 3 are, therefore, set to continue in the plain stitch knitting mode. These are needles which alternate in pairs.

The needles 3 raised by the jacks 4 follow with their butts 26 the track G. Their raising movement
10 is completed on the cam 47, and are raised to a much larger extent than upon the purl to plain knitting transition just described. During the raising movement, they pick up the yarn 60 in the recess defined by the protrusion 24 and take that yarn to
15 above the hooks and latches of the respective needles 13 (Figure 9a). The position reached is such that the recess 25 of the needles 3 is substantially level with the needles 13. Through the cam 37 being brought into its operative position, all those jacks
20 12 are engaged which are provided with long upper butts 14, that is, two alternately consecutive jacks, in accordance with the diagram of Figure 11. These jacks will follow, with their long upper butts 14, the track H, and the corresponding needles 13 will be pushed
25 out of their respective tricks 11 to insert themselves between the yarn 60 brought up by the adjacent needles 3 (Figure 9a and left side of Figure 9b). Advantageously, the recess 25 favors a correct insertion of the needles 13 under the yarn 60,
30 because it allows the needles 13 to arrange themselves

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very close to the vertical plane of symmetry of the needles 3. The needles 13 are pushed out to an extent such that their open latches do not exceed the needles 3.

5 At this point, the needles 3 begin to be withdrawn (right side of Figure 9b) under the influence of the cam 48, while the yarn 60 remains in the hooks of the respective needles 13. Since the latches of the needles 3 are located above the protrusion
10 24, upon the needles 3 being lowered, the respective latches are closed (Figure 9c) and the needles 3 release the yarn 60 which is left on the overlying needles 13. These too are in the meantime withdrawn by the cam 38. Thus, the loop transfer is completed,
15 and the machine is made ready to knit a 2:2 rib pattern, having alternately two plain knitting needles and two rib knitting needles, with the yarn in their respective hooks.

For knitting in the 2:2 mode, the upper cams
20 31 and 32 are operated and the lower cams 31 and 32 drawn out of operation as are the cams 35 and 37, the selection for knitting of the needles 3 being effected through the selection devices S1 and S2 in a conventional manner.

25 It will be appreciated that, based on the same principle as just described for transferring the knitting loops from the needles 13 to the needles 3, the loops can now be returned to all the needles 3 in the cylinder, and hence, by placing two cams,
30 equivalent to cams 37 and 38, under the latter, the

1:1 mode be resumed, if desired, by utilizing -
after having carried out a suitable loop transfer
selection - the same principle described above for
transferring the loops from the needles 3 to the
5 needles 13. It will be apparent, moreover, how by
providing the upper jacks 12 with butts at three or
more levels and having three or more lengths, one
can increase the number of the rib pattern types
attainable without any jack replacement requirements.
10 Furthermore, the jacks 12 may be selected for loop
transfer by means of drum-type selection devices,
similarly to the jacks 4 of the cylinder 1, to thus
obtain a variety of rib pattern types in a desired
sequence.
15 It should be also noted that to bring in the
movable cams of the cam ring 18, the long butts, both
lower ones 15 and upper ones 14, of the jacks 12
are actually in part longer and in part shorter
thereby the cams can be brought in two stages, as
20 is common practice.

Advantageously, the knitting or stitch forming
cams 33 and 34 of each pair may be displaceable
parallel together in a vertical direction, such as
to change the length of the purl stitches. They may
25 be supported and controlled for this purpose
similarly to the corresponding cams of a double
cylinder knitting machine.

It will be apparent from the foregoing that
the invention enables different types of rib pattern
30 fabrics to be obtained on a machine which is more

simple, can operate at a higher rate, and is less expensive, than a double cylinder machine or a machine having arcuate needles of the type described in the preamble, with considerable attendant advantages of an economic nature. It may be seen that the machine requires no transfer sliders in association with the needles, as do instead the arcuate needle machines described in the preamble.

The knitting machine, as described hereinabove, is susceptible to many modifications and variations without departing from the purview of the instant inventive concept. Thus, as an example, the machine may be equipped with stationary cylinder and bell-like needle-carrying structure and rotary cams. Instead of the hook connection between the needles 76 and jacks 77, a clevis pin type of engagement may be provided, e.g. like the one between the shank of the needles and the respective latches.

Of course, a machine as herein described and illustrated need not be set up of necessity for knitting stockings articles, and could be of a larger size, there being no limitations from the inventive concept in this respect. Similarly, it is not necessary that the tricks be provided in the same number on both needle-carrying structures, and the upper needle-carrying structure may have, for example, one half the number of needles provided in the cylinder.

As a further example, it is well within the capabilities of an expert to change the arrangement

of the long and short butts on the jacks 12 to produce, for instance, 2:4, 2:6 or other types of rib patterns. Moreover, it is obviously possible to reverse the arrangement of the lower

5 butts 15 and upper butts 14, as well as of the selection butts 27 and 28, by appropriately adjusting the arrangement and operation of the related cams or selection levers therefor. The machine could also comprise a single feed or more

10 than two yarn feeds. The upper jacks 12, as mentioned hereinabove, may have more than two butts and be selected by means of selection drums. Naturally, the protrusion 24 on the needles 3 is not strictly required to be in the form of one

15 continuous widening down to the bottom thereof, as illustrated, but may have a more limited height extension.

CLAIMS

1 1. A circular knitting machine of the type
2 having two needle beds or needle-carrying structures
3 for knitting plain and purl stitches, in
4 particular rib patterned fabrics, wherein the lower
5 needle-carrying structure comprises a needle
6 cylinder (1,62) and the upper needle-carrying
7 structure comprises a needle dial (18,61) having
8 arcuate needle tricks (11,75a) in the outer
9 top surface thereof, wherein arcuately bent needles
10 (13,76) are slidable having the respective hooks
11 and latches arranged on the concave side thereof,
12 said needle tricks (11,75a) being arranged such that
13 the work ends of the arcuately bent needles (13,76)
14 are moved in a substantially radial direction to
15 the machine and the arcuately bent needles (13,76)
16 extending substantially over an arc of 90° and being
17 controlled by selecting jacks (12,77),
18 characterized in that said selecting jacks (12,77)
19 are movable along respective straight and preferably
20 vertical portions (10,75b) of the needle tricks in
21 said needle dial (8,61) and hingedly associated with
22 the respective needles (13,76), said selecting jacks
23 (12,77) having each at least one control butt (14,
24 15;77b) for engagement with control cams (18,78).

1 2. A machine according to Claim 1, characterized
2 in that said arcuately bent needles (13,76) are each
3 provided with a hooked top end (17,76a) in removable
4 engagement with a hooked bottom end (16,
5 77a) of a respective one of said jacks (12,77),

6 said hooks (16,17,76a,77a) being configured for a
7 push-pull type of engagement between said jacks
8 (12,77) and said arcuately bent needles (13,76).

1 3. A machine according to Claim 2, characterized
2 in that said hooked end (16) of said upper jacks (12)
3 is open in a radial direction to allow for a relative
4 movement between said jacks (12) and said needles (13)
5 in a radial direction.

1 4. A machine according to one or more of
2 Claims 1 to 3, characterized in that said upper jacks
3 (12) each have selection butts (14,15) arranged on
4 at least two levels, and in that the needles (3)
5 of the lower needle-carrying structure (1) are
6 each provided with a protrusion (24) facing outwards
7 on the shank thereof and being located below the
8 latch thereof, for transporting knitting loops to
9 the arcuately bent needles (13) in the upper needle-
10 carrying structure (8), and are controllable to bring
11 said protrusion (24) at least to the level of the
12 hooks of the arcuately bent needles (13) in the
13 upper needle-carrying structure (8).

1 5. A machine according to Claim 4, characterized
2 in that said protrusion (24) defines a recess for
3 accommodating the yarn (60).

1 6. A machine according to either Claim 4 or 5,
2 characterized in that, below said protrusion (24),
3 the needles (3) in the lower needle-carrying structure
4 (1) each have a lateral recess (25) adapted for receiving
5 the respective needles (13) of said upper needle-
6 carrying structure (8) while knitting loops are being
7 transferred from the needles (3) of the lower needle-
8 carrying structure (1) to the needles (13) of the

9 upper needle-carrying structure (8).

1 7. A machine according to one or more of the
2 preceding claims, characterized in that said upper
3 jacks (12) are each provided with selection butts
4 (14,15) having different lengths.

1 8. A machine according to Claim 7, characterized
2 in that said upper jacks (12) can be selected by
3 means of at least partly movable cams (18) acting
4 on said butts (14,15).

1 9. A machine according to Claim 8, characterized
2 in that said cams (18) for selecting said upper jacks
3 (12) comprise overlaid push-out cam pairs (31,32),
4 the cams (31,32) in each pair being movable
5 independently of each other in a radial direction
6 to the respective needle-carrying structure (8).

1 10. A machine according to either Claim 8 or 9,
2 characterized in that said cams (18) for selecting
3 said upper jacks (12) comprise stitch forming cam
4 pairs (33,34) movable parallel together in a
5 vertical direction to change the length of the purl
6 stitches.

1 11. A machine according to one or more of Claims
2 4 to 10, wherein the needles (3) in the lower
3 needle-carrying structure (1) can be selected by
4 means of lower jacks (4), characterized in that said
5 lower jacks (4) have each selection butts (27,28)
6 arranged at different levels for selecting the
7 needles (3) of the lower needle-carrying structure
8 (1) in order to transfer knitting loops between
9 the needles (3) in the lower needle-carrying structure

- 30 -

10 (1) and the needles (13) in the upper needle-
11 carrying structure (8).

1 12. A machine according to one or more of
2 Claims 4 to 11, wherein with said needle-carrying
3 structures (1,8) there are associated cam rings (5,18)
4 for controlling the needles (3,13), characterized in
5 that said cam rings (5,18) comprise at least one
6 raising cam (47) configured to raise selected needles
7 (3) of the lower needle-carrying structure (1)
8 to a loop transferring position and at least one
9 push-out cam (37) to push out selected needles
10 (13) of the upper needle-carrying structure (8)
11 to a loop transferring position, said raising cam
12 (47) being positioned, relative to the direction of
13 rotation of the needles (3,13), at least partly
14 ahead of said push-out cam (37), said cam rings (5,
15 18) comprising also at least one lowering cam (48)
16 for said needles (3) selected in said lower needle-
17 carrying structure (1) and at least one push-in
18 cam (38) for said needles (13) selected in said
19 upper needle-carrying structure (8), said lowering
20 cam (48) being positioned, relative to the direction
21 of rotation of the needles (3,13) at least partly
22 ahead of said push-in cam (38).

1 13. A machine according to Claim 12,
2 characterized in that said push-out cam (37) is
3 configured to bring said selected needles (13) of
4 said upper needle-carrying structure (8) to a pushed
5 out position whereat the latches thereof
6 do not exceed said selected needles (3) or said

7 lower needle-carrying structure (1).

1 14. A machine according to Claims 1 to 4,
2 characterized in that said upper needle-carrying
3 structure (8) is formed in two parts, an upper part
4 (9a) of substantially cylindrical shape accommodating
5 said upper jacks (12), and a lower part (9b) of
6 substantially hyperbolic hyperboloidal shape
7 accommodating said needles (13) of said upper
8 needle-carrying structure (8), the tricks (11) of
9 said lower part (9b) being recessed with respect to
10 the tricks (10) of said upper part (9a) at the
11 transition area between said two parts (9a,9b).

1 15. A machine according to one or more of the
2 preceding claims, characterized in that the tricks
3 (10,11) in said upper needle-carrying structure (8)
4 are slightly offset angularly with respect to the
5 tricks (2) in said lower needle-carrying structure
6 (1).

1 16. An arcuate latch needle for a circular
2 knitting machine, characterized in that it has a
3 hooked end (17,76a) for engagement with a selection
4 jack (12,77).

1 17. A selection jack for a circular knitting
2 machine, characterized in that it has a hooked end
3 (16,77a) for engagement with an arcuate needle
4 (13,76) according to Claim 16.

FIG. 1

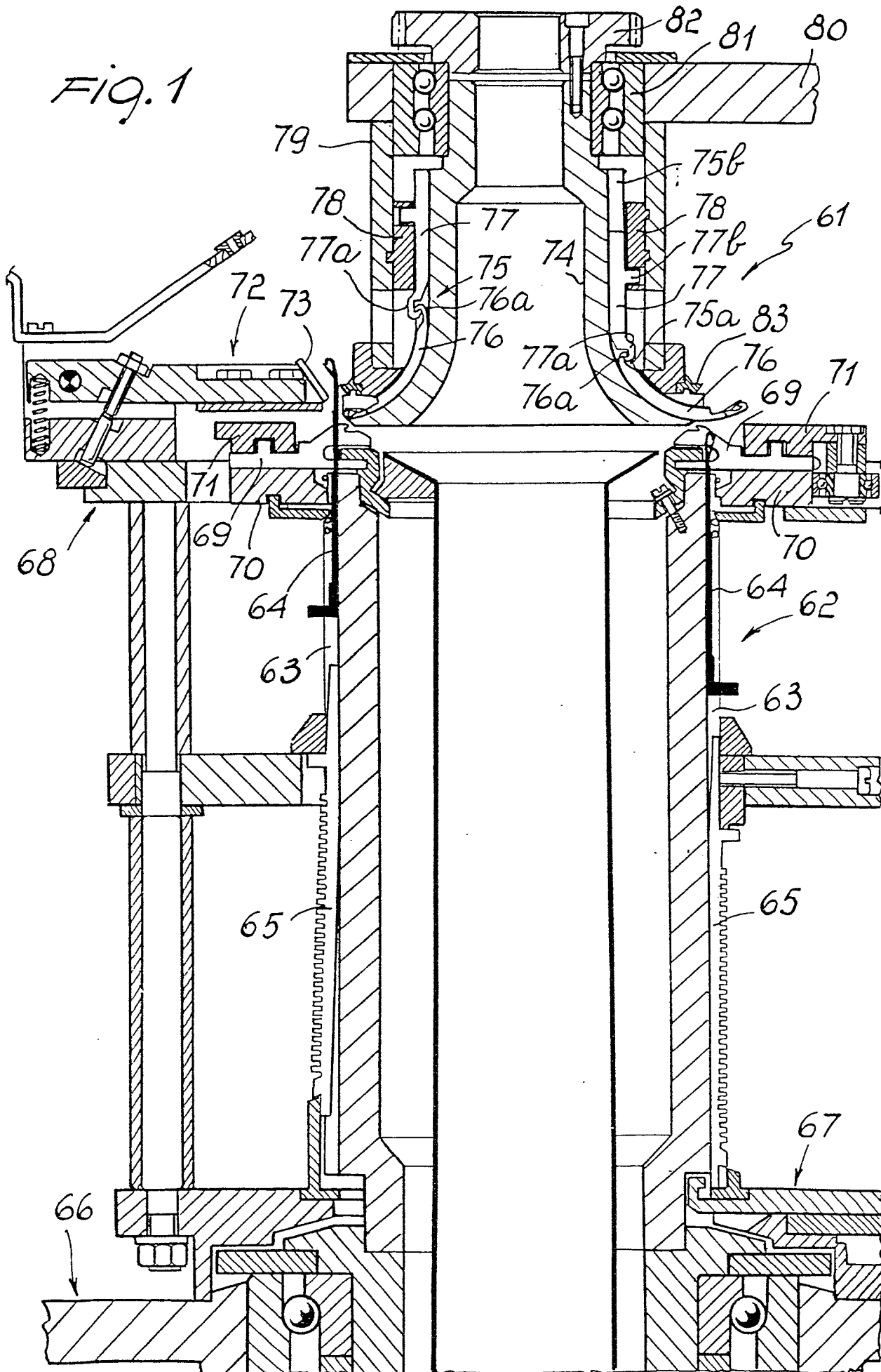




Fig. 2

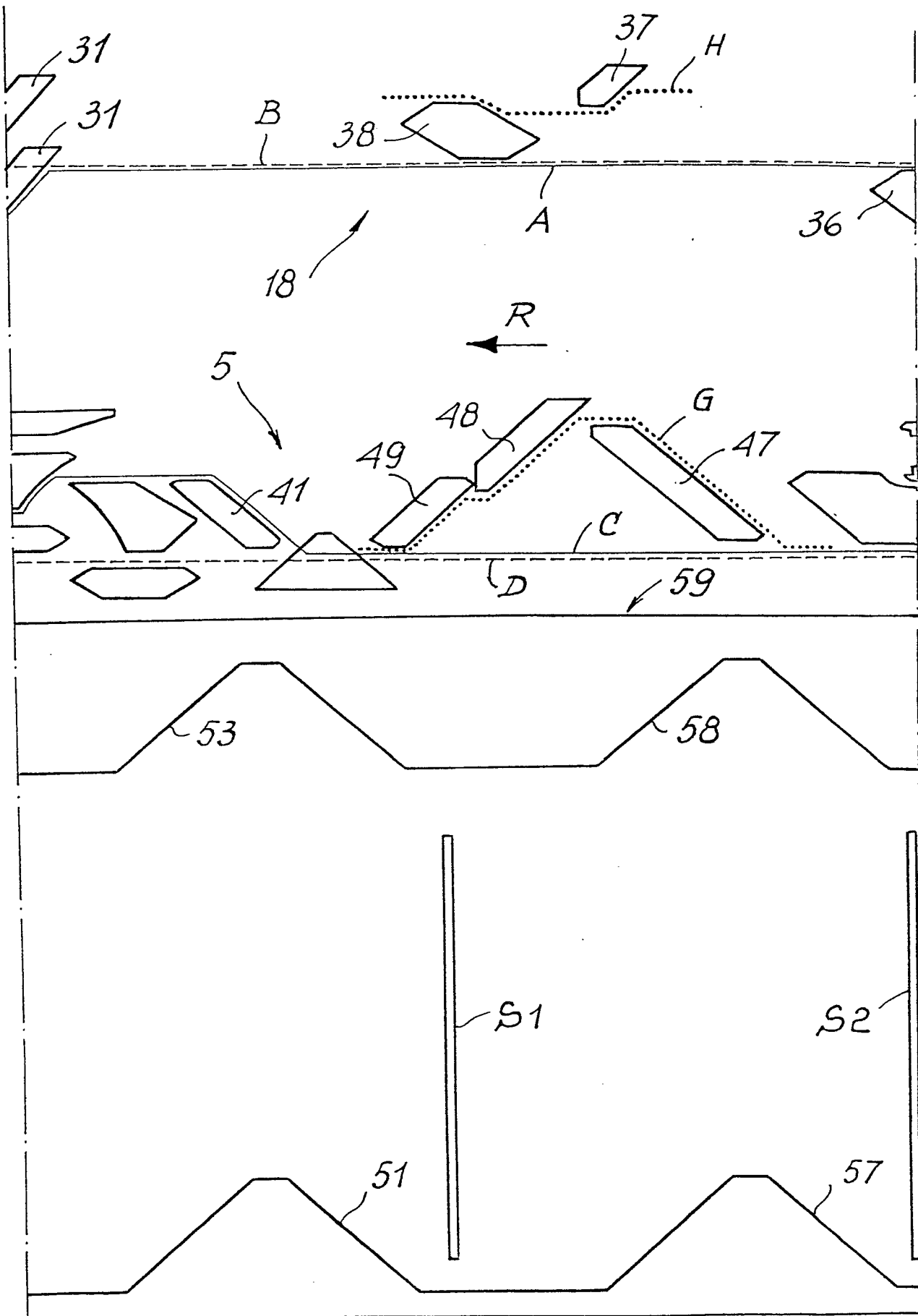


Fig. 3a

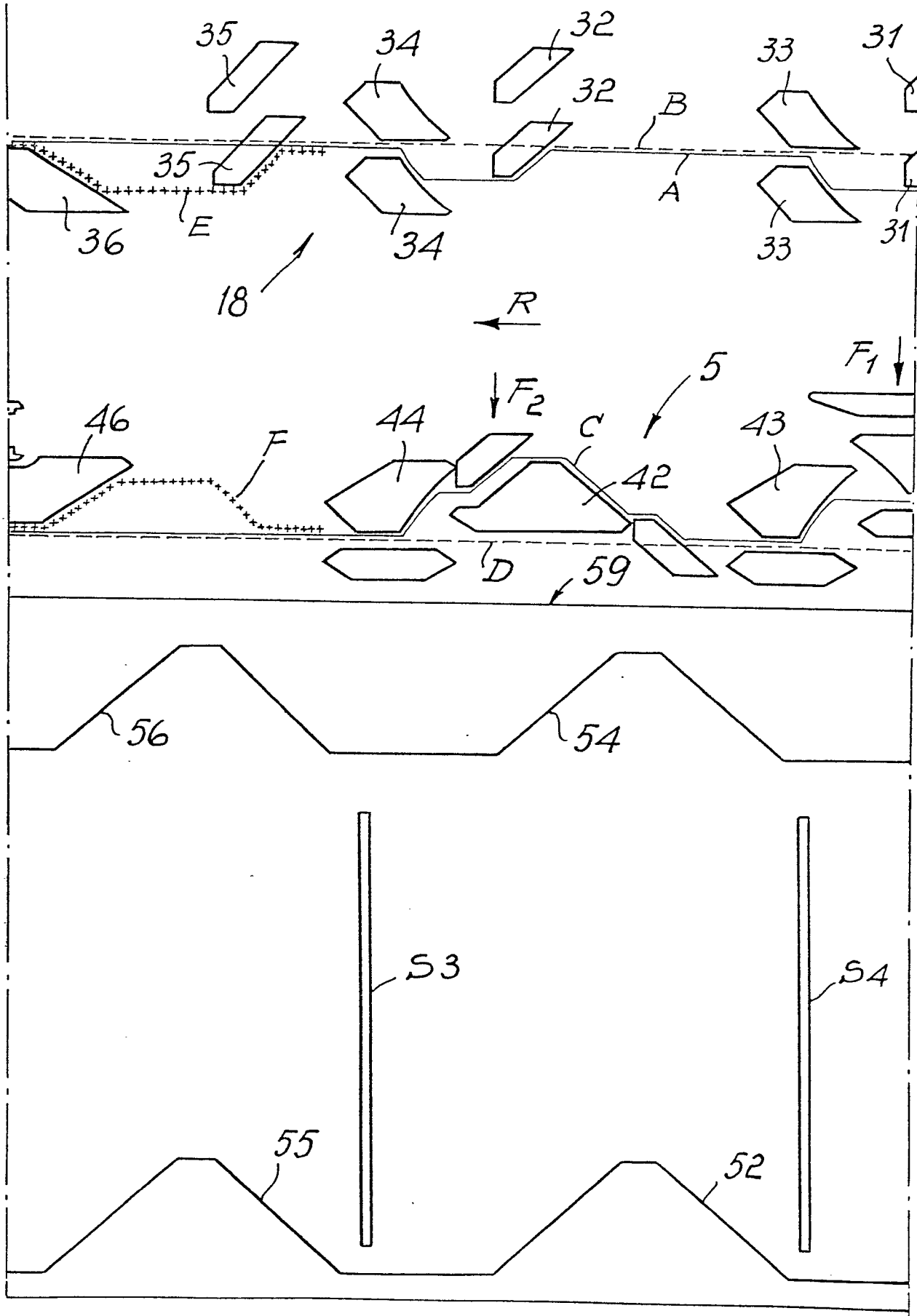


Fig. 3b

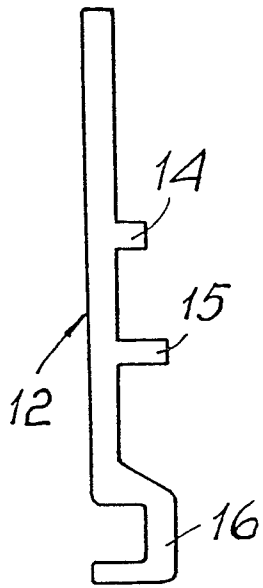


Fig. 4

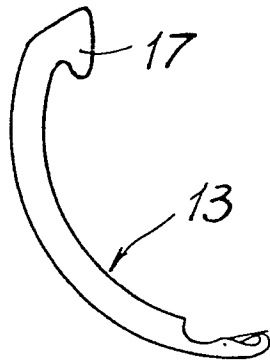


Fig. 5

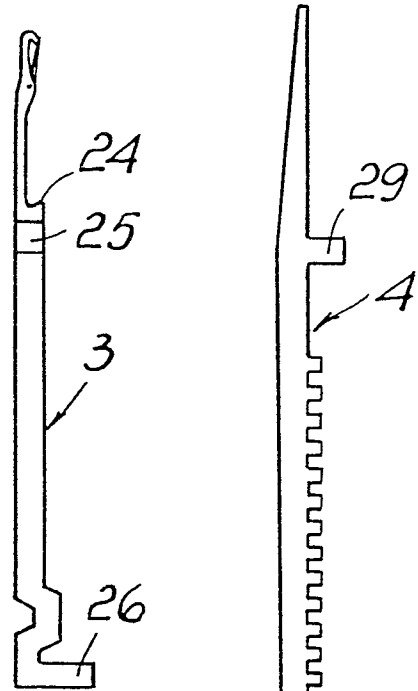


Fig. 6



Fig. 8a

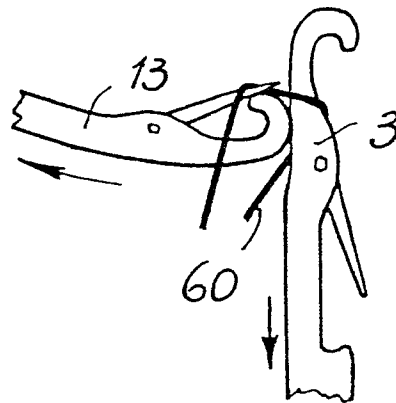


Fig. 8c

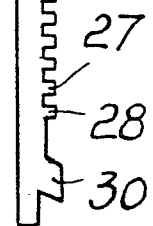


Fig. 7

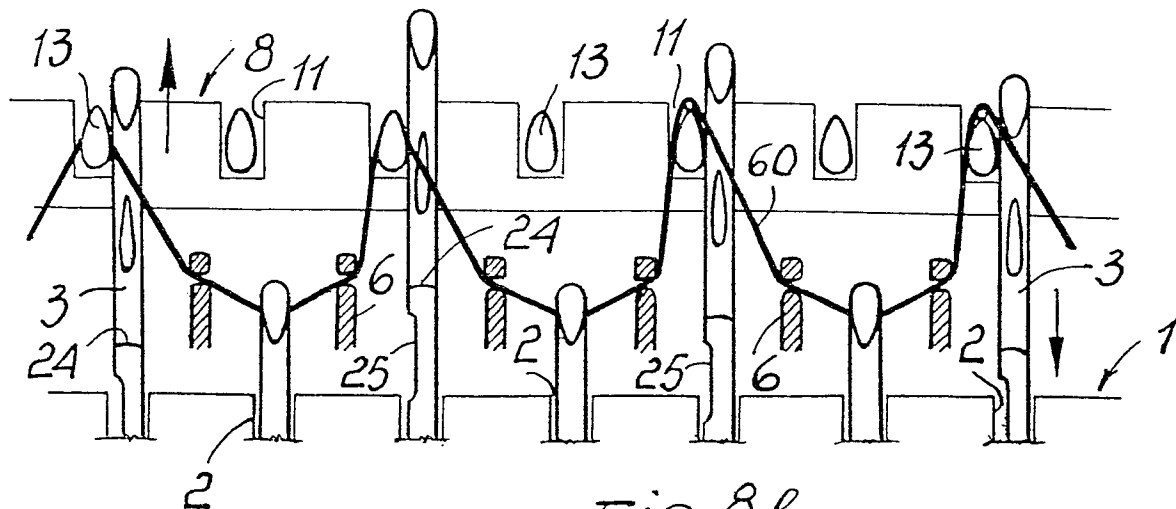


Fig. 8b

