

Nov. 25, 1958

H. E. CRAWFORD

2,861,440

MULTI-FEED CIRCULAR KNITTING MACHINE

Filed May 22, 1956

7 Sheets-Sheet 1

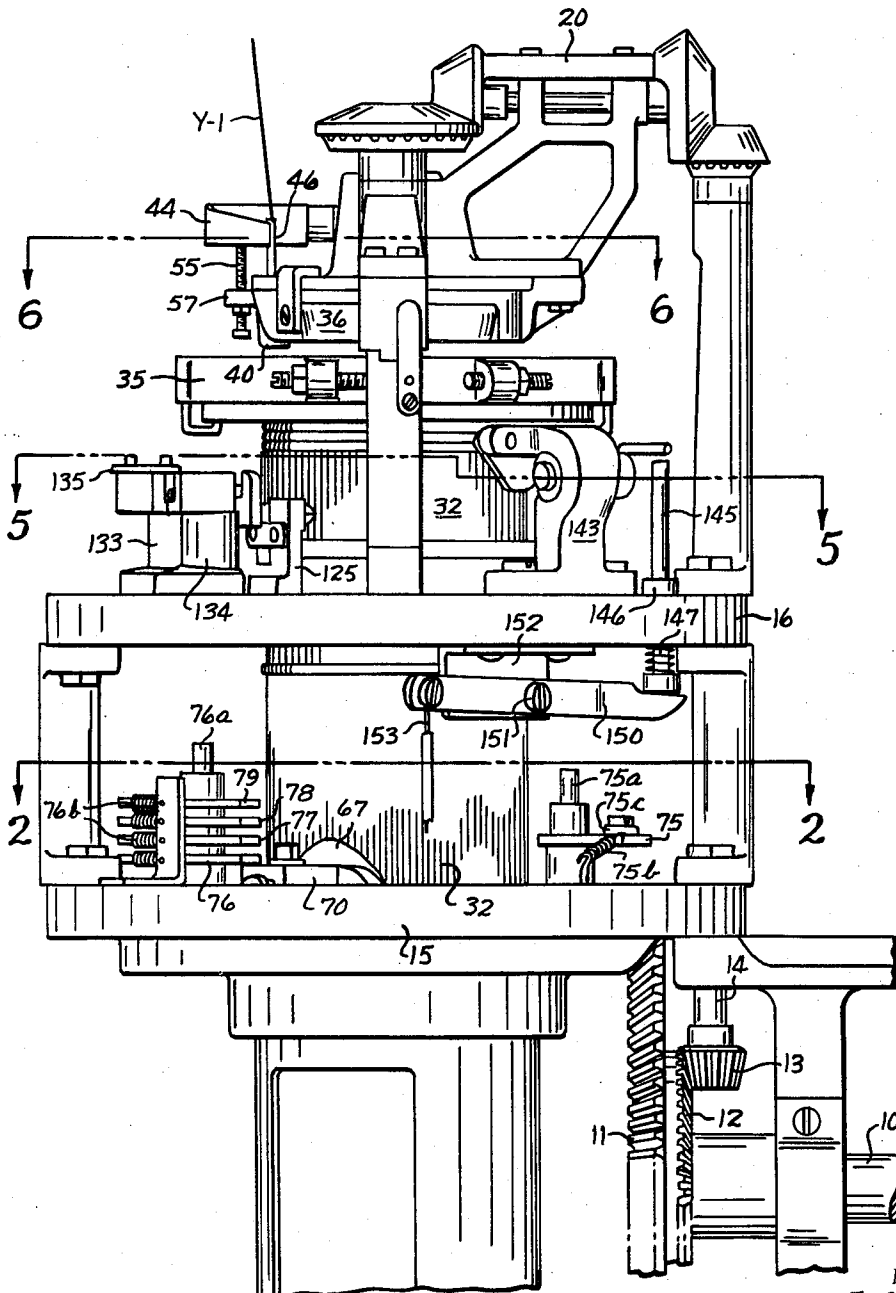


FIG-1

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Nov. 25, 1958

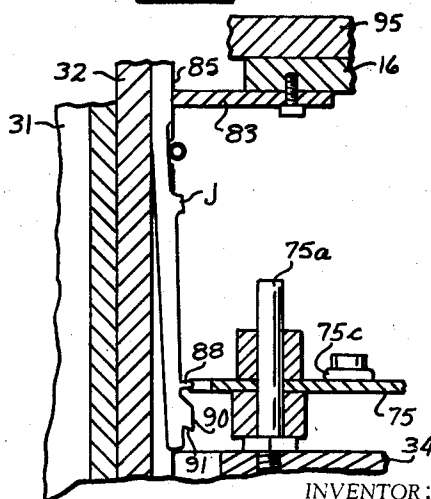
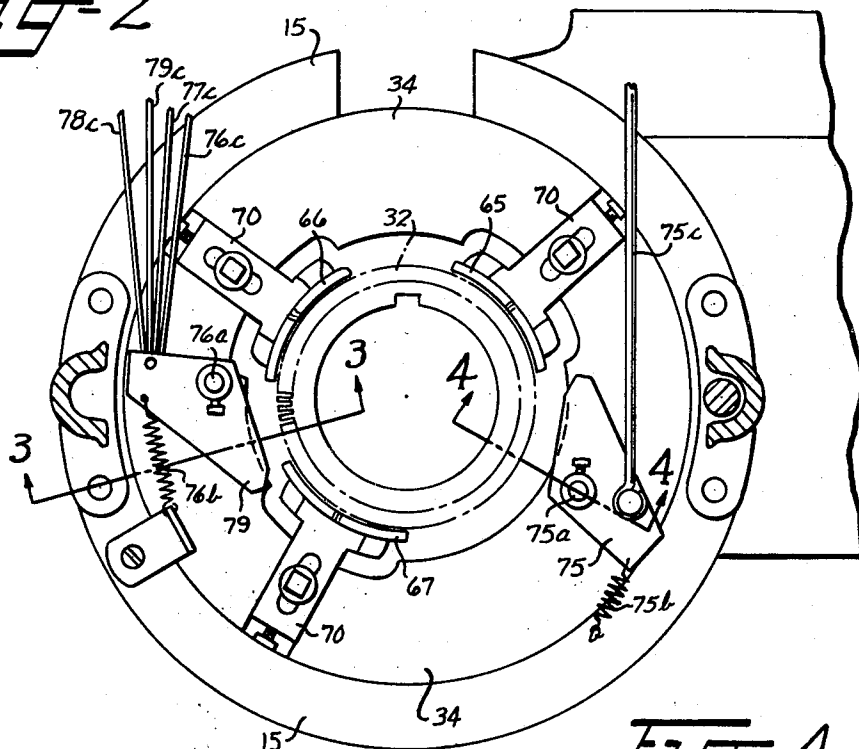
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MULTI-FEED CIRCULAR KNITTING MACHINE

Filed May 22, 1956

7 Sheets-Sheet 2



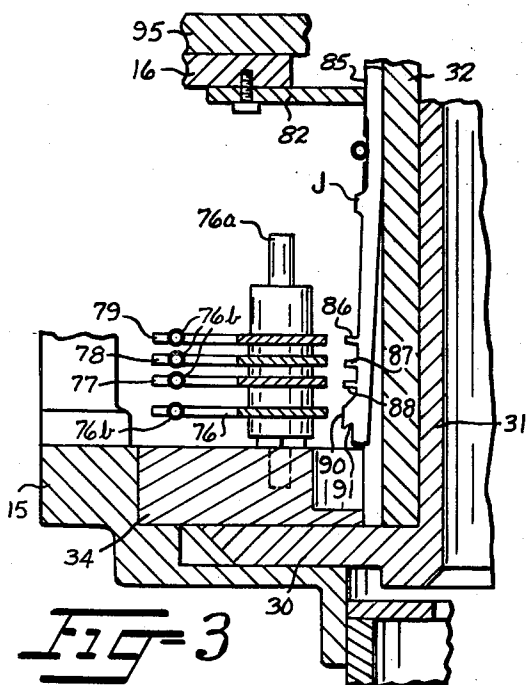
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MULTI-FEED CIRCULAR KNITTING MACHINE

Filed May 22, 1956

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FIG-5

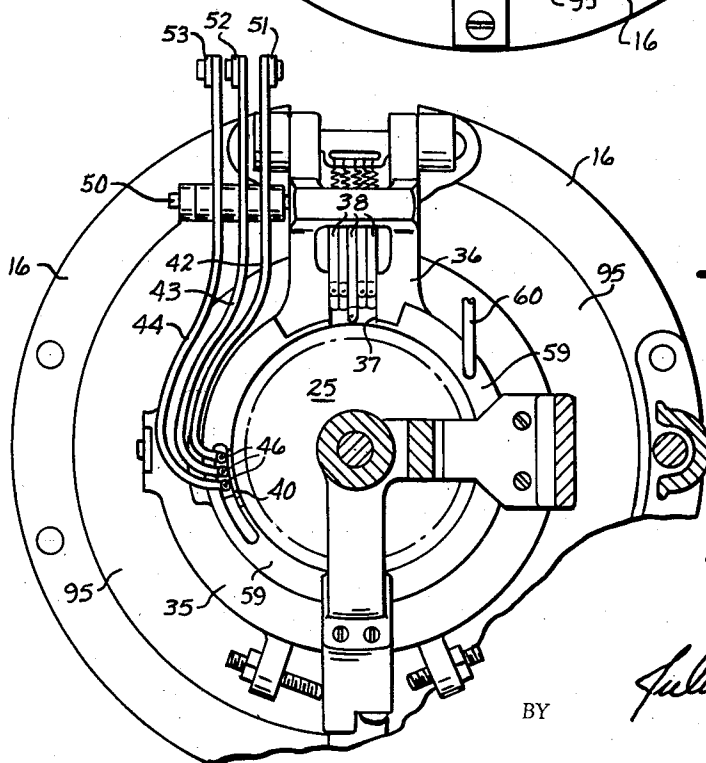
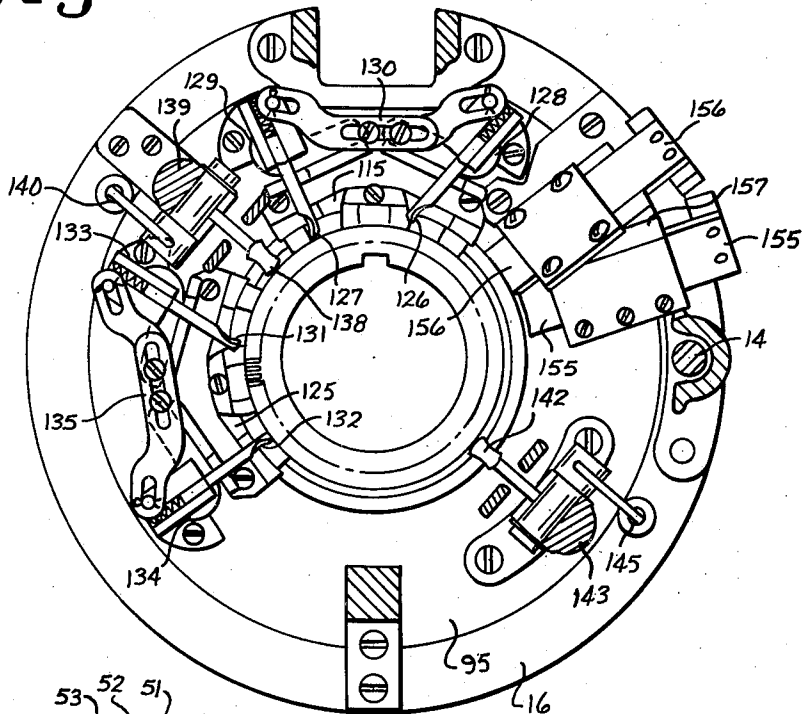


FIG-6

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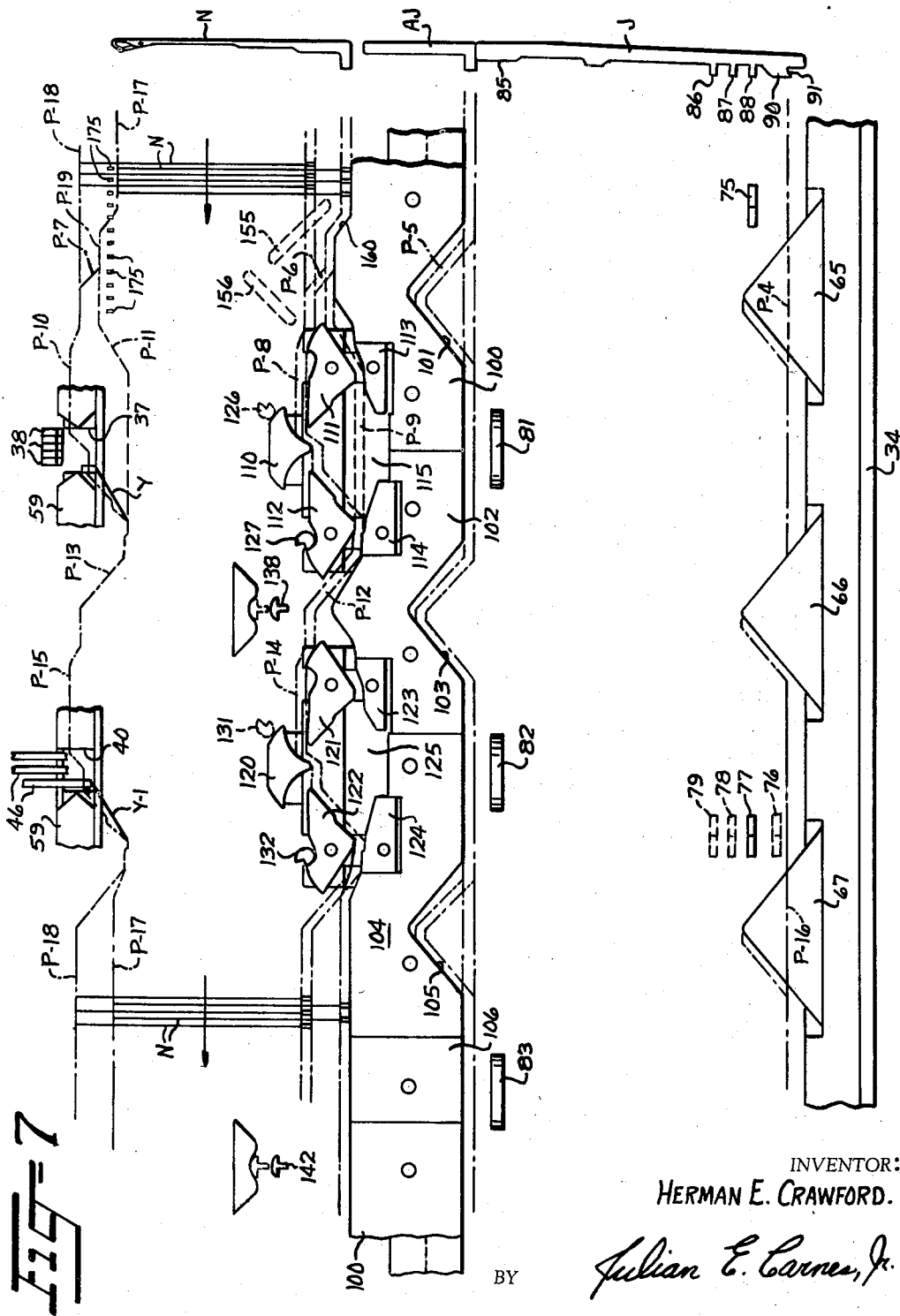
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2,861,440

MULTI-FEED CIRCULAR KNITTING MACHINE

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Nov. 25, 1958

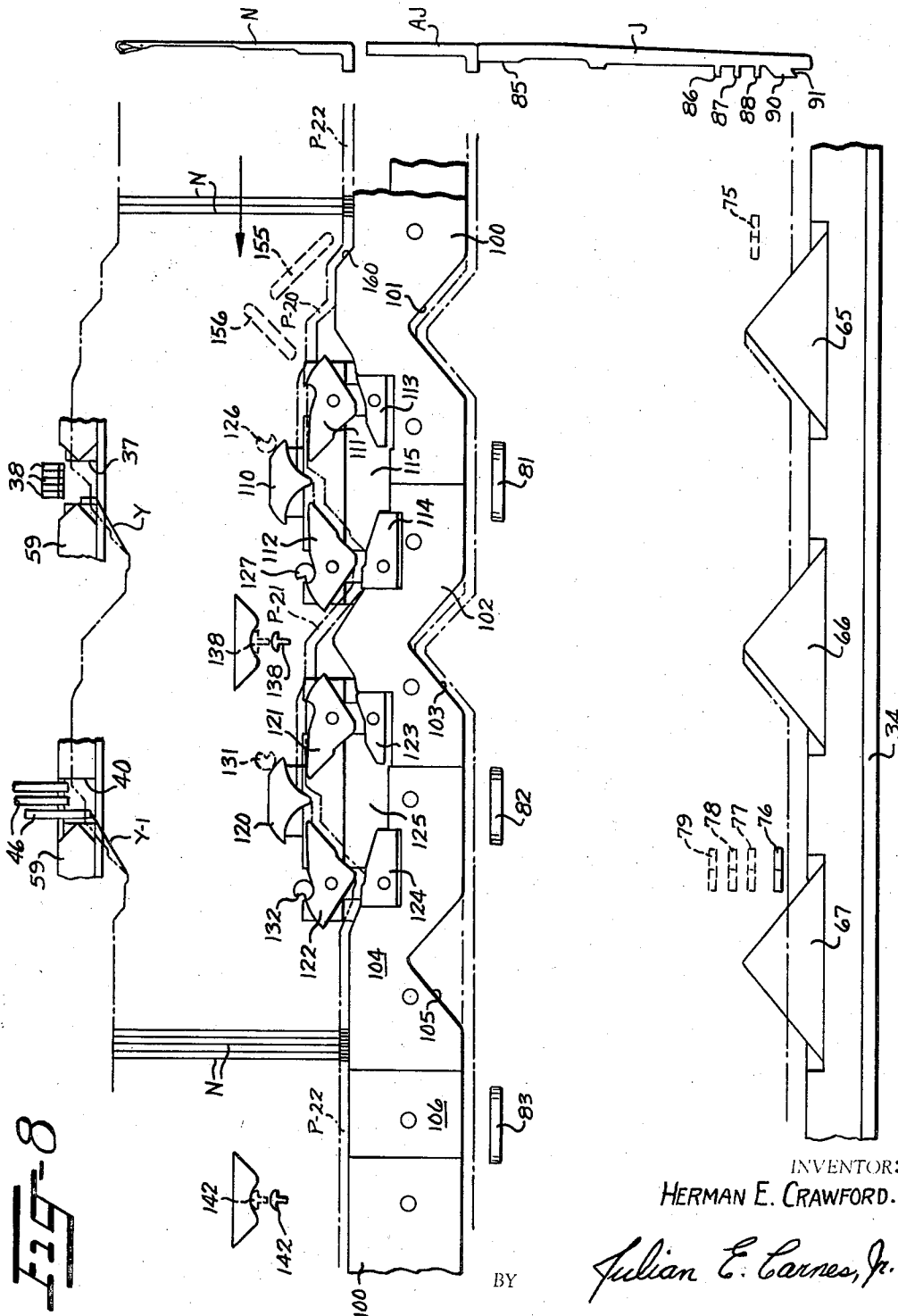
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MULTI-FEED CIRCULAR KNITTING MACHINE

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MULTI-FEED CIRCULAR KNITTING MACHINE

Filed May 22, 1956

7 Sheets-Sheet 6

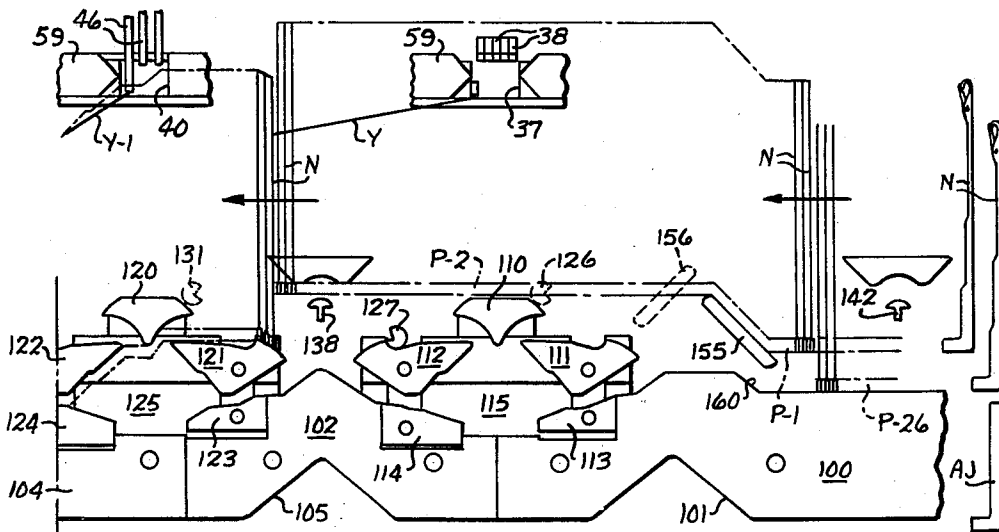


FIG-9

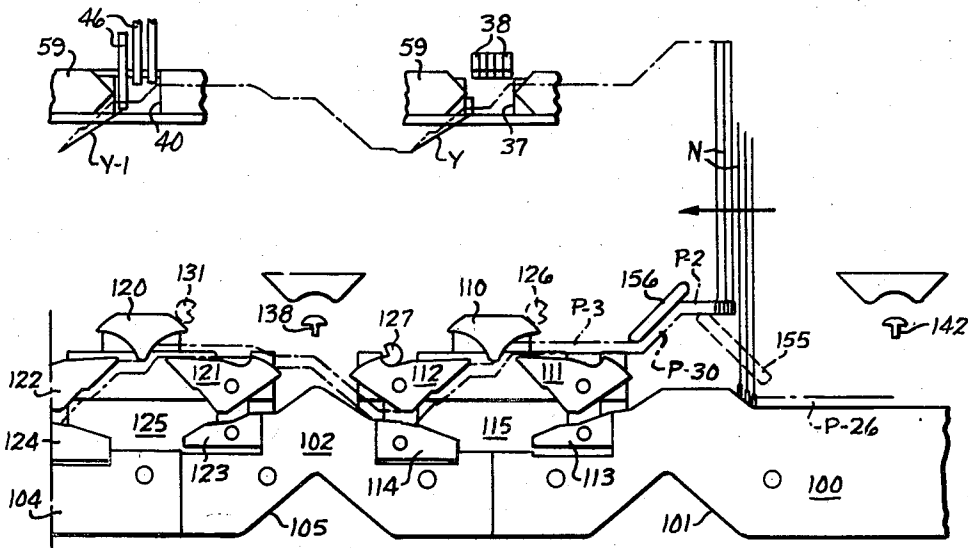


FIG-10

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MULTI-FEED CIRCULAR KNITTING MACHINE

Filed May 22, 1956

7 Sheets-Sheet 7

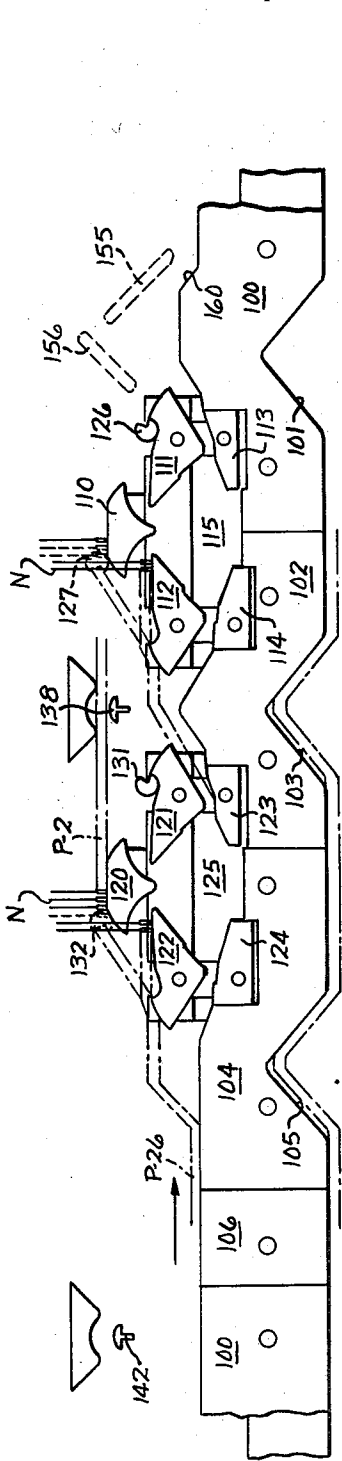


FIG-11

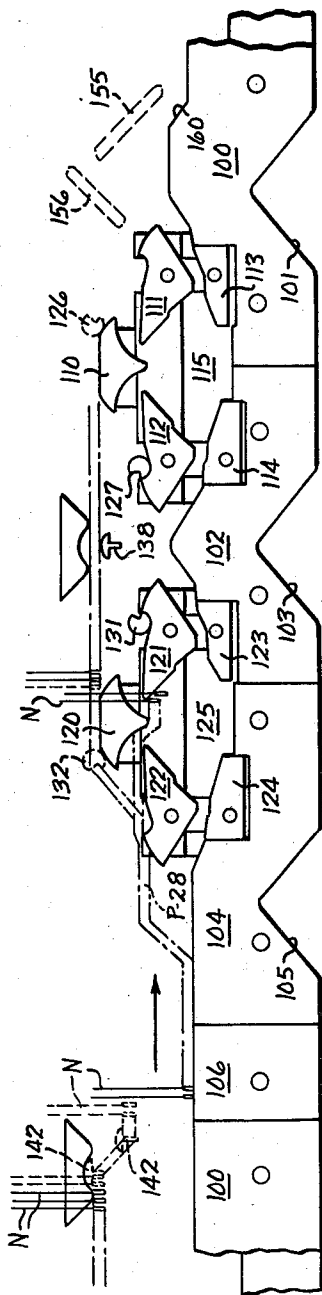


FIG-12

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MULTI-FEED CIRCULAR KNITTING MACHINE

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Application May 22, 1956, Serial No. 586,587

17 Claims. (Cl. 66—41)

This invention relates to improvements in circular knitting machines of the independent needle type and more especially to improvements in multi-feed circular knitting machines wherein the multi-feed knitting is employed throughout the article being knit.

It is well known to those familiar with the knitting art that multi-feed or two-feed knitting machines have heretofore been attempted and abandoned because of an inability to produce satisfactory heel and toe pockets and the complicated mechanism required to carry out this multi-feed in the leg and foot, as well as in the heel and toe portions of hosiery, especially in the finer gauge hosiery of the 400 needle class.

It is therefore a primary object of this invention to provide a simple feeding and knitting means for knitting a plurality of courses with each rotary motion of the needle cylinder during rotary knitting in the leg and foot portions, as well as knitting a plurality of partial courses with each reciprocatory motion of the needle cylinder in knitting the heel and toe pockets.

It is another object of this invention to provide a machine of the type described employing selector jacks beneath each of the cylinder needles to activate selected cylinder needles in forming the first few or make-up courses of a stocking, in the transfer of a welt portion from the dial bits to the cylinder needles, and to select groups of cylinder needles in preparation for knitting the heel and toe pockets.

It is another object of this invention to provide a multi-feed knitting machine which is able to knit two courses with each reciprocation of the needle cylinder during knitting of the heel and toe pockets of hosiery and to form a satisfactory suture at the heel and toe pockets while knitting two courses with each reciprocation of the needle cylinder. Satisfactory sutures at the heel and toe pockets mean that the junctures of the narrowed and widened areas contain no open places or "cat eyes" and the heel and toe sutures, while being knit two courses with each reciprocation of the needle cylinder, are formed in the same manner as sutures knit in a conventional manner with a single course being knit with each reciprocation of the needle cylinder. It is possible to knit the conventional heel and toe pocket, while knitting two courses with each reciprocation of the cylinder, by using a set of narrowing picks with each of two sets of knitting cams and a pair of widening picks, so that the number of needles in action at each knitting station and in each reciprocation during both the narrowing and widening operation is varied.

It is still another object of this invention to provide a simple arrangement for selection of the selector jacks beneath each of the cylinder needles, so that individual selected needles may be directed to pass through, above or below selected ones of the plurality of knitting stations employed in this improved machine.

Some of the objects of the invention having been stated, other objects will appear as the description proceeds

when taken in connection with the accompanying drawings in which—

Figure 1 is a front elevation of a portion of the improved knitting machine, showing a conventional dial mechanism associated therewith and the driving connections therefore;

Figure 2 is a sectional plan view taken substantially along the line 2—2 in Figure 1;

Figure 3 is a transverse vertical sectional view, at an enlarged scale, being taken substantially along the line 3—3 in Figure 2;

Figure 4 is a transverse vertical sectional view, at an enlarged scale, being taken substantially along the line 4—4 in Figure 2;

Figure 5 is a sectional plan view taken substantially along the line 5—5 in Figure 1;

Figure 6 is a sectional plan view taken substantially along the line 6—6 in Figure 1;

Figure 7 is a development of the various needle and pattern jack-cams taken as if looking outwardly from inside the needle cylinder and showing the paths of the cylinder needles, auxiliary jacks, and selector jacks during the make-up and transfer operations;

Figure 8 is a view similar to Figure 7, but showing the paths of travel of the needles and jacks during circular multi-feed knitting;

Figure 9 is a development of the cylinder needle cams only, and showing the operation preparatory to knitting a heel or toe pocket wherein a selected group of the needles are switched up to out of action or non-knitting position;

Figure 10 is a view similar to Figure 9, except showing the operation of switching down needles into operative position which have previously been raised to non-knitting position;

Figure 11 is a development of the needle cams and showing the action of the narrowing picks in a narrowing operation; and

Figure 12 is a view similar to Figure 11 except showing the operation of the various widening picks during a widening operation.

The machine generally is of the same general class as the well-known Scott & Williams Model K circular hosiery machine, and many of the basic parts of my improved machine are unchanged from the above-mentioned Scott & Williams Model K machine. The machine generally is under the control of a pattern chain, not shown, which, in turn, operates a main pattern drum rotated in a step-by-step manner to make one complete revolution during the knitting of a single article.

The pattern chain also controls rotary and reciprocatory action to a main drive shaft 10 (Figure 1) having a cylinder driving bevel gear 11 fixedly secured thereto and a dial driving bevel gear 12 secured to one face of the gear 11. The dial driving bevel gear 12 meshes with a bevel gear 13 fixedly secured to the lower end of a vertical shaft 14 which extends upwardly in Figure 1 through suitable housings, a lower bed-plate 15, an upper bed-plate 16 and into a dial driving gear housing 20. The gear housing 20 is provided with the usual gearing arrangement to drive the usual dial 25 (Figure 6) which is provided with conventional transfer bits, not shown.

The bevel gear 11 meshes with a bevel gear 30 (Figure 3) mounted for rotation in the lower bed-plate 15 and having an upstanding tubular portion 31 integral therewith. The needle cylinder 32 surrounds and is keyed to the tubular portion 31 and is adapted to be moved vertically relative to the tubular portion 31 in a conventional manner. The bevel gear 30 is held in the lower bed-plate 15 by a lower cam plate 34 surrounding the needle cylinder 32. The machine is also provided with the usual sinkers, not shown, mounted for radial move-

ment in a sinker cap 35 (Figures 1 and 6) adjacent the upper end of the needle cylinder 32. A latch ring 36 has a throat opening 37 in which a plurality of conventional yarn feeding fingers 38 are mounted and operated by conventional thrust bars, not shown, to move the yarn feeding fingers 38 into and out of yarn feeding position. For purposes of clarity and ease of description, this throat opening 37 and the yarn feeding fingers 38 will hereinafter be referred to as the first yarn feeding station.

Part of the novelty of this invention lies in a second yarn feeding station which includes a throat 40 (Figure 6). The throat 40 at the second yarn feeding station is shown as being provided with three yarn feeding fingers or levers 42, 43, and 44, each of which is provided with a yarn guiding tube 46 (Figure 1) at their end adjacent the throat 40. Each of the yarn finger levers 42, 43, and 44 is pivotally mounted as at 50 intermediate their ends and the outer ends of each of which are operated by thrust rods 51, 52, and 53. The lower ends of the thrust rods 51, 52, 53 are adapted to at times engage and ride along the main pattern drum, not shown, and at other times to be raised by cams placed on the main pattern drum to thus raise and lower the yarn feed fingers 42, 43, and 44 into and out of the yarn feeding position in the throat 40 of the latch ring 36. Downward movement of the yarn guiding tubes 46 on each of the yarn feeding fingers 42, 43, and 44 is limited by adjustment screws 55 (Figure 1) engaging the lower surface of the respective yarn feeding fingers 42, 43, and 44 and which screws 55 threadably penetrate and outwardly extending portion 57 of the latch ring 36.

The latch ring 36 is also provided with a gap closing ring 59 (Figure 6) having openings therein which correspond with the throats 37 and 40 of the latch ring 36 and which ring 59 is provided to close the throats 37 and 40 during reciprocatory motion of the needle cylinder 32 to prevent the latches the cylinder needles N from being thrown out into the throats 37 and 40 and becoming broken during reciprocatory motion of the needle cylinder 32. The gap closing ring 59 is moved to close the throats 37 and 40 in the latch ring 36 by a connecting link 60 which extends rearwardly in Figure 6 and is connected by suitable connections, not shown, to the main pattern drum for operating the gap closing ring 59 at the proper time.

The needle cylinder 32 is provided with conventional vertical grooves or slots therein and each of these slots is provided with a vertically movable cylinder needle N (Figures 7 and 8), an auxiliary jack AJ and a needle selector jack J. The needle selector jack J is the conventional rocking type jack and occupies the space substantially between the lower bed-plate 15 and the upper bed-plate 16, while the auxiliary jack AJ occupies the space adjacent the upper bed-plate 16 and the cylinder needle N occupies the space between the upper bed-plate 16 and the sinker cap 35 shown in Figure 1.

A novel needle selecting mechanism is provided on the lower bed-plate 15 and includes three jack raising cams 65, 66, and 67 (Figures 2, 7 and 8), the inner surfaces of which are in close proximity to the outer diameter of the needle cylinder 32. Each of the jack raising cams 65, 66 and 67 is fixedly secured to a bracket 70 mounted in a radially cut groove in the lower cam plate 34. A plurality of jack selecting fingers or levers 75, 76, 77, 78 and 79 are provided on the lower cam plate 34 to rock the lower ends of certain jacks J back into the slots in the needle cylinder 32 to a non-selected position so that they will not ride up the jack raising cams 65 or 67.

The jack selecting finger 75, adjacent the jack raising cam 65, is oscillatably mounted on a stud 75a the lower end of which is threadably embedded in the lower cam plate 34 and a tension spring 75b urges the reading end of the jack selecting finger 75 away from the needle cylinder (Figures 2 and 4). The finger 75 is, at times,

moved into selecting position by a pattern controlled link 75c connected thereto at one end and the opposite end of which extends to any suitable pattern controlled part of the machine, such as the main pattern drum, not shown. The selector fingers 76, 77, 78 and 79 are mounted on a stud 76a (Figures 2 and 3) and the reading ends thereof are urged toward the needle cylinder 32 by tension springs 76b. The selector fingers 76, 77, 78 and 79, are, at times, moved into selecting position by respective control links 76c, 77c, 78c and 79c suitably connected to any pattern controlled mechanism such as the main pattern drum, not shown.

As the needle cylinder is rotated in either direction, the needle selecting jacks J are rocked outwardly at their lower ends to the positions shown in Figures 3 and 4 by respective jack push-out cams 81, 82, and 83 engaging an upper butt portion 85 of the needle selector jack J as they approach the needle selector jack raising cams 65, 66 and 67 (Figures 3, 4, 7 and 8). Each of the needle selector jacks J is also provided with removable butts at three different levels, indicated at 86, 87 and 88 (Figures 7 and 8), as well as being provided with a stationary lower butt 90 and a jack raising step 91. The lower butt 90 is on every one of the jacks J and is in horizontal alignment with the selector finger 76. The removable butt 88 is broken off on alternate jacks J in the needle cylinder 32 and the butts 88 left on intervening jacks J and the butts 88 are in horizontal alignment with the selector fingers 75 and 77. The removable butt 87 is broken off a few more than half the selectors in the needle cylinder and in the case of a 400 needle cylinder this would be 240 selector jacks J without the butts 87 and 160 selector jacks J with the butts 87 left thereon and these butts are in horizontal alignment with the selector finger 78. The removable butt 86 is broken off half the selector jacks J and the butts 86, left on the selector jacks J are in horizontal alignment with selector finger 79.

It is thus seen, that since each of the butt portions 85, of the needle selector jacks J is rocked inwardly into the slots in the needle cylinder 32 by the fixed pushout cams 81, 82 and 83 the steps 91 on the lower end of the selector jacks J will approach each of the jack raising cams 65, 66 and 67 in substantially the positions shown in Figure 3, that is, with the steps 91 out of the slots in the needle cylinder 32 and in position to engage the sloping sides of the jack raising cams 65, 66 and 67 to thereby raise the jacks J along these sloping surfaces. If, however, it is desired to have selected one of the selector jacks J pass the jack raising cams 65 or 67 without being raised, it is necessary to push or rock the lower ends of the selector jacks J back into the slots in the needle cylinder 32 by one of the selector fingers 75, 76, 77, 78 or 79, sometime before the step portion 91 of the selector jack J reaches the respective jack raising cams 65 or 67.

The fixed needle cams on an upper cam plate 95 (Figures 5, and 7 through 12) in the upper bed-plate 16 include; a first needle raising or end cam 100 having an inverted V-shaped opening 101 therein, for allowing space for the butt of the auxiliary jack AJ to be raised by the jack raising cam 65, a second or center needle raising cam 102 having an inverted V-shaped cut-out 103 therein, which is similar in shape and operation to the cut-out 101 in the first needle raising cam 100, a third needle raising or end cam 104, also having an inverted V-shaped cut-out 105, similar to the cut-outs 101 and 103 and a jack gate or fill-in cam 106. Each of these cams 100, 102, 104, and 106 is fixedly secured to an upstanding portion of the upper cam plate 95, and they surround the needle cylinder 32 in close proximity thereto.

Other cams surrounding the needle cylinder 32 and mounted on the cam plate 95 include; a first knitting station comprising a top center needle guiding cam 110, right hand stitch cam 111, left hand stitch cam 112, right hand end cam 113 and a left hand end cam 114. These

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cams 110 thru 114 comprise the first knitting station and are so arranged and adapted to draw stitches when the needle butts pass over the upper clearing cam surface of one stitch cam and along the inclined stitch drawing surface and beneath the other stitch cam in either direction, as the needle cylinder 32 is caused to rotate or reciprocate. The cams 110 thru 114 are fixedly secured to a first knitting station cam block 115 (Figures 8 thru 12 and Figure 5), the lower end of which is fixedly secured on the cam plate 95.

A second knitting station, which is identical to the first knitting station is spaced from the first knitting station and comprises; a top center needle guiding cam 120, a right hand stitch cam 121, a left hand stitch cam 122, a right hand end cam 123 and a left hand end cam 124, all of which are fixedly secured on a second knitting station cam block 125 (Figures 8 thru 12 and Figure 5). A pair of conventional narrowing picks 126 and 127 are associated with the first knitting station and are adapted to work in notches in respective right hand and left hand stitch cams 111 and 112. The picks 126 and 127 are mounted in conventional pick stands 128 and 129 (Figure 5) and are inner-connected by a link 130 which causes these narrowing picks to operate in a conventional manner, that is, when one narrowing pick is in the lower position or the solid line position shown in Figure 8, the other narrowing pick will be in the inoperative or dotted line position shown in Figure 8. A similar pair of narrowing picks 131 and 132 are adapted to work in notches in the respective right hand and left hand stitch cams 121 and 122, at the second knitting station. The picks 131 and 132 are mounted in conventional pick stands 133 and 134 (Figure 5) and are inner-connected by a connecting link 135. The narrowing picks 126, 127 and 131, 132 are in the present instance, constructed to pick up one needle each.

A widening picker 138, constructed to pick down two needles in either direction, is mounted between the first knitting station and the second knitting station in a conventional widening pick stand 139 (Figure 5). The widening picker 138 may be moved to inoperative position, or to the position shown solid lines in Figure 8, by a vertically extending plunger 140 (Figure 5) which is pattern controlled through suitable linkage by the main pattern drum. The widening pick 138 may be moved from the position shown in solid lines in Figure 8 to the dotted line position shown in Figure 8 when it is desired that the widening picker 138 become operative. Another widening picker 142, which is identical to the widening picker 138, is mounted in a widening pick stand 143 (Figures 1, 5 and 8) and the movement of the widening picker 142 from operative to inoperative position is controlled by a vertical post 145 (Figure 1) mounted for vertical sliding movement in the bed-plate 16 and carrying a fixed collar 146 which is urged downwardly against the bed plate 16 by a compression spring 147 surrounding the lower end of the post 145.

The post 145 is, at times, raised by one end of a lever 150 oscillatably mounted as at 151 on a bracket 152 fixedly secured on the bed-plate 16 and the outer or left hand end in Figure 1 is moved vertically by a control cable 153 the opposite end of which extends to any suitable connections adjacent the main pattern drum, not shown, for raising the vertical post 145 to thus move the widening pick 142 from the position shown in dotted line Figure 8 to the solid line position shown in Figure 8 or from the operative to the inoperative position.

The other cams on the cam plate 95 surrounding the needle cylinder 32 include a radially movable needle raising or switch cam 155 and a radially movable needle lowering or switch cam 156 both of which are slidably mounted in a cam block 157 (Figure 5) and the outer ends of the cams 155, 156 are adapted to be moved by conventional linkage, not shown, and controlled by the

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main pattern drum to cause the cams 155 or 156 to either raise to inoperative position or lower in to operative position a selected portion of the needles in the needle cylinder during the formation of the heel and toe pockets.

These cams 155 and 156 are the ordinary switch cams and are for the purpose of switching up out of action a certain selected group of needles before beginning knitting in the heel and toe pockets and to return the elevated or non-knitting needles to a lowered or knitting position as shown in Figure 10.

The operation of the switch cams 155, 156 in the present instance varies from their usual use in that the needle raising cam 155 is used in cooperation with the jack raising cam 67 to further raise the needles partially raised by the jacks riding up the cam 67. Thus, in dividing the needles to start the heel and toe pockets the jacks J, beneath the cylinder needles N to be switched up out of action, will engage and ride up the jack raising cam 67 to raise the butts of the cylinder needles N to the height indicated at P-1 in Figure 9 so that they will be raised higher by the switch cam 155 to follow a path P-2 above the center stitch cams 110 and 120. In order to lower the raised cylinder needles N following the paths P-2 in Figures 9 and 10, after completing the heel and toe pockets, the switch cam 156 is moved inwardly to engage the cylinder needle butts and lower them to a path P-3 in Figure 10 so that the needles will then take yarn and draw stitches.

It is thus seen that I have provided spaced identical knitting stations each of which includes the three conventional stitch cams, that is, the top center cam, right and left hand stitch cams and each of the right and left hand stitch cams has a narrowing pick operating therein. I have also provided a pair of widening pickers one of which is placed between the first knitting station and the second knitting station and the other of which is placed substantially opposite the first widening pick across the needle cylinder 32. It is the combination of these two conventional knitting stations and their narrowing picks plus the two widening picks that makes possible the knitting of heel and toe pockets with even suture junctures while knitting two courses with each reciprocation of the needle cylinder. The manner in which a complete article is knit including the formation of the heel and toe pockets will now be given.

Method of operation

Before any yarn is introduced to the throats 37 and 40, the needle cylinder 32 is caused to rotate in the forward direction shown by the arrow in Figure 7, in order to form a make-up or selvage starting from the bare needles, the butts 85 of all of the needle selector jacks J are engaged by the jack push-out cam 83 to position the lower end of the needle selector jacks J in substantially the position shown in Figure 3. The selector finger 75 is moved inwardly towards the needle cylinder 32 to its operative position to engage the butts 88 on alternate needle selector jacks J to cause these jacks to be pressed back into the slots in the needle cylinder 32 and pass behind the jack elevating cam 65 along the pathway P-4 in Figure 7 to thus remain in the lowered position. The jack raising step 91 of the intervening jacks J will engage and ride up the cam 65, the auxiliary jacks AJ will follow the path indicated at P-5 in Figure 7, the corresponding needle butts will follow a pathway indicated at P-6 and the upper end of the needles N will follow a pathway indicated at P-7.

Thus, as the needle butts approach the first knitting station, they are separated alternately at two levels so that the needle butts at the upper levels pass above the right hand stitch cam 111 along a path indicated at P-8 and the needle butts at the lower level will follow a path P-9 beneath the right hand stitch cam 111 so that the hook ends of the needles N will follow the respective

paths indicated at P-10 and P-11. The hooks on the needles following the path P-10 will pick up and knit the first yarn Y at the first throat opening 37 and as the jacks J approach the raising cam 66, the upper ends of all the jacks are rocked inwardly and the lower ends are rocked outwardly of the slots in the needle cylinder 32 so that all of the steps 91 will ride up the jack raising cam 66. The jacks J thus raise the auxiliary jacks AJ and the cylinder needles N so that the butts of all the cylinder needles N follow a pathway indicated at P-12 and the upper end of the needles N will follow a pathway indicated at P-13 in Figure 7. The needle butts of the cylinder needles N will be raised high enough by the needle selector jacks J and the auxiliary jacks AJ so that all of the butts will pass over the clearing cam surface of the right hand stitch cam 121, at the second knitting station, and follow a pathway P-14 and the hooks of all the cylinder needles will follow the pathway P-15 to draw stitches with the yarn Y-2 at the second throat 40. As the needle selector jacks J approach the jack raising cam 67, the selector finger 77 is moved to operative position and the lower end of each of the needle selector jacks J is rocked outwardly of the slots in the needle cylinder 32 by the jack push-out cam 82 engaging the butt portion 85 of the needle selector jacks J, alternate ones of the selector jacks J are again pushed in at their lower ends so that only intervening jacks J will ride up the jack elevating cam 67. Alternate selector jacks will follow a path P-16 to thus leave the hooks of alternate cylinder needles at a lower position to follow a pathway P-17 and the hooks of intervening needles will be raised to follow a pathway P-18.

Thus, in the make-up every other or alternate cylinder needles N pass through the stitch cam at the first knitting station and intervening cylinder needles pass beneath the stitch cams at the first knitting station to thus place the yarn Y in the hooks of alternate needles at the first knitting station and as the needles which pass beneath the first knitting station are raised along the pathway P-13 the yarn Y is placed behind these needles. All the cylinder needles N pass through the stitch cams at the second knitting station to draw stitches with the yarn Y-1 and complete the make-up or selvage with the first revolution of the needle cylinder 32 after the yarn is introduced to the needles.

As the second revolution of the needle cylinder is made, conventional cams in the dial 25 cause the transfer bits indicated at 175 in Figure 7 to move outwardly over the hooks of the lowered cylinder needles N following the pathway P-17 at approximately the position shown in Figure 7. As the transfer bits pass the first knitting station, the yarn Y is laid over the hooks of the transfer bits. The transfer bits 175 are moved inwardly again by conventional cams, not shown, in the dial 25 to move the bits inwardly between the first throat 37 and the second throat 40 so that the yarn Y-1 is not picked up by the hooks of the transfer bits 75 at the second knitting station. The hooks of the transfer bits 175 hold the yarn Y thereon during the knitting of the turned welt portion of the hose.

On the next course plain knitting will occur, that is, all the cylinder needles will pass through both of the knitting stations and draw stitches at both stations to knit two courses with each rotation of the needle cylinder 32. All of the cylinder needles are caused to pass through both the first and second knitting stations by moving the selector fingers 75 and 77 to inoperative position and moving the selector finger 76 to operative position (Figure 8). The steps 91 on the jacks J are then caused to ride up the jack raising cams 65 and 66 to thus raise the butts of the cylinder needles N along respective paths P-20 and P-21. The butts of all the cylinder needles will thus be raised high enough to engage and pass over the respective right hand stitch cams 111 and 121 and

draw stitches as they pass beneath the respective left hand stitch cams 112 and 122. The illustration of the knitting action shown in Figure 8 shows the selector finger 76 in operative position, causing all of the steps 91 of the selector jacks J to pass behind the jack raising cam 67 and remain in a lowered position. The butts of the cylinder needles N leaving the stitch cam 122 are raised slightly by the end cam 104 and travel around at a low elevation indicated at P-22, until being raised slightly by an inclined surface 160 of the end cam 100 and then raised additionally by the jack raising cam 65. It is to be understood that the selector finger 76 could be moved to inoperative position to allow the selector jacks J to be raised by the jack raising cam 67 and raise the cylinder needles N so that the needles would travel at an elevation high enough to pass over the stitch cam 111 without being raised by the selector jacks J riding up the jack raising cam 65. Any desired number of courses may then be knit before transferring the yarn Y held by the transfer bits back to the hooks of the cylinder needles N.

The transfer of the loops from the transfer bits 175 to the cylinder needles (Figure 7) is effected to provide a turned welt by moving the selector finger 77 into operative position to engage butts 88 on alternate selector jacks J so that the steps 91 of the alternate selector jacks J are rocked inwardly and pass behind the jack raising cam 67. Intervening jacks J have their butts 88 broken off and therefore will not be rocked back into the slots in the needle cylinder by the selector finger 77 so that the step 91 thereof will engage and ride up the jack raising cam 67. Thus the hooks of alternate cylinder needles N will travel the low pathway P-17 and the hooks of intervening cylinder needles N will travel a higher pathway P-18 (Figure 7) as the cylinder needles N approach the first knitting station. The transfer bits are again moved outwardly from the dial and over the needles following the pathway P-17 and these lowered needles will be raised, by the inclined surface 160 of the end cam 100, high enough that their hooks pass through the openings in the transfer bits to a level indicated at P-19. The transfer bits 175 are then moved back into the dial 25 leaving their loops in the hooks of these cylinder needles N. As the selector jacks J approach the jack raising cam 65, they will all be raised by the cam 65 since the selector finger 75 will then be in inoperative position. The butts of alternate auxiliary jacks AJ will follow the pathway P-5, the alternate cylinder needle butts will be raised along the pathway P-6 and the hooks of the alternate cylinder needles N will be raised along the pathway P-7. All of the hooks of the cylinder needles N then follow the pathway P-10 to take yarn and draw stitches at the first knitting station. Thus, the transfer is completed at the first knitting station and all of the steps 91 on all of the selector jacks J will be rocked outwardly by the cam 81 and ride up the jack raising cam 66 as the needle cylinder 32 is traveling in the forward direction to cause the hooks of all of the cylinder needles N to follow the pathway P-15 and take and draw stitches with the yarn Y-1 as the needles N pass beneath the left hand stitch cam 122. After the cylinder needles N have received the loops of yarn from the transfer bits 175 in the dial 25 the machine then continues to knit in rotary knitting while knitting two courses with each revolution of the needle cylinder 32 to knit the leg of the hose.

Preparatory to making a heel pocket a selected group of needles N is moved to inoperative position and in order to facilitate selection a group of jacks J have the butts 87 on the selector jacks J broken off so that as the selector finger 78 is moved to operative position the selector jacks J with the butts 87 left thereon will be moved inwardly to pass behind the jack raising cam 67 and the jacks J with the selector butts 87 broken off will

ride up the jack raising cam 67 to thus divide the cylinder needles into upper and lower needles traveling at the heights indicated by the pathways P-1 and P-26 (Figure 9) as they approach the switch-up cam 155. The cam 155 is moved into operative position while the group of needles traveling the pathway P-26 is moving therebeneath and as the group of needles traveling the pathway P-1 engages this switch cam 155 they will ride upwardly high enough to pass above the top center cams 110 and 120 to assume a non-knitting position and travel the pathway P-2. This dividing of the needles by the switch-up cam 155 in cooperation with the selector jacks J occurs on the last course in a forward direction before the needle cylinder starts to reciprocate in making the heel pocket.

Upon the first reverse stroke or reciprocation of the needle cylinder 32, in making the narrowed portion of a heel pocket the leading needle of the active group of needles following the pathway P-26 (Figure 11) is lifted by the left hand narrowing pick 132 at the second knitting station so that it joins the trailing end of the non-knitting group of needles traveling the pathway P-2 to thus decrease the number of needles passing through the second knitting station in this first course in a clockwise direction by one needle. After the cylinder needles N pass through the second knitting station, they are raised by the cam 66 to pass above the left hand stitch cam 112 and the first or leading needle of this active group will be raised from operative to inoperative position by the left hand narrowing pick 127 to thus decrease the number of active needles by one needle at the first knitting station. Thus two partial courses of different lengths are knit in the first clockwise or rearward reciprocation of the needle cylinder in making the heel pocket. Upon the next succeeding counterclockwise or forward stroke of the needle cylinder 32 the first or leading needle of the lowered or active group of needles will engage the right hand narrowing pick 126 and be raised upwardly thereby to an inactive or non-knitting position above the center stitch cam 110 to thus decrease the number of active needles which will pass through the stitch cams at the first knitting station by one needle. The group of needles knitting at the first knitting station are raised by the cam 66 to pass above the right hand stitch cam 121 at the second feeding station and the leading needle thereof will engage the right hand narrowing pick 131 and be raised upwardly thereby to pass above the top center cam 120 and be moved to an inactive or non-knitting position to thus decrease the number of needles which will pass beneath the left hand stitch cam 122 at the second knitting station by one needle. Upon the next clockwise or reverse stroke of the needle cylinder the group of lowered or active needles will be reduced by one needle at the second knitting station and an additional needle at the first knitting station. This action continues until the desired number of narrowed partial courses have been made and a widening operation is then started.

In the widening operation shown in Figure 12, the first stroke of widening takes place in a reverse or clockwise direction of the needle cylinder 32. Both of the widening picks 138 and 142 are brought into operative position with the widening pick 138 riding against the butts of the raised or non-knitting needles and the widening pick 142 will be moved into the notch in its guard cam as the lowered or active group of needles passes thereby to thus engage the first two of the raised or inactive needles and lower them to the active position shown in Figure 12. The group of lowered or active needles passes through the second knitting station in the selector jacks J and the auxiliary jacks AJ to follow a pathway P-28 (Figure 12). The leading needle of this lowered group will be raised to inoperative position above the center stitch cam 120 by the left hand narrowing pick 132. Thus, as the lowered group or active

needle passes through the second knitting station in the first reciprocation of the widening operation the leading needle of this lowered group will be raised to inoperative position by the left hand narrowing pick 132 and the group will be increased by two additional needles at its trailing end by the widening pick 142 lowering two needles from the inactive group to pass beneath the center cam 120 and to thus draw stitches at this second knitting station. As the lowered group of needles passes beneath the right hand stitch cam 121 and draws stitches with the yarn Y-1 it is raised by the jack raising cam 66 to pass over the left hand stitch cam 112 at the first knitting station. The leading needle of this group will be raised by the left hand narrowing pick 127 to join the inactive group of needles passing above the center stitch cam 110 and the widening pick 138 will move upwardly into its guard cam as this lowered group passes therebeneath and engage the leading two needles of the inactive group to lower them so that they will pass beneath the center stitch cam 110. Thus two additional needles are added to the trailing end of the active group and one needle is removed at the leading end of the active groups as they pass through this first knitting station in the first clockwise or reverse direction of the needle cylinder in the widening operation.

With the next forward reciprocation of the needle cylinder in the widening operation the widening pick 142 will engage and lower the leading two inactive needles to add them to the trailing end of the lowered or active group of needles and the leading needle of the active group will be engaged by and raised to inoperative position by the right hand narrowing pick 126 to thus decrease the group of needles knitting at the first knitting station by one at the leading end, and to add two needles to the trailing end of the lowered or active group of needles passing through the first knitting station and give a net gain of one needle. As the lowered or active group of needles passes through the second knitting station the leading needle of this group will be engaged by the narrowing pick 131 and moved upwardly to inoperative or non-knitting position above the center stitch cam 120 and the widening pick 138 will move two additional needles into action from non-knitting position to pass beneath the center stitch cam 120 at the second knitting station to thus add two additional needles at the trailing end of the active group and give a net gain of one needle knitting at this second knitting station. The widening operation continues in this manner with alternate reciprocations of the needle cylinder and an additional needle being added to the knitting group at each knitting station until the desired number of needles have been brought back into operation or knitting position from the inoperative or non-knitting position.

It is thus seen that, in a narrowing operation the number of lowered or active needles in a group is decreased by one leading needle at each knitting station with each reciprocation of the needle cylinder in both directions and the lowered or knitting needles in the active group are caused to draw stitches to form partial courses of different lengths at both the first and second knitting stations. In the widening operation one needle is raised from the active or knitting position to the inactive or non-knitting position at the leading end of each group of lowered needles at each knitting station and two additional needles are brought into action at the trailing end of the lowered or active group of needles at each knitting station to give a net result of increasing the number of needles knitting at each knitting station by one needle with each reciprocation of the needle cylinder while knitting the active group of needles at both the first and second knitting stations.

After the widening operation is completed the raised or inoperative needles are again lowered into operative position upon a forward stroke of the needle cylinder by the switch-down cam 156 moving inwardly radially to

the needle cylinder 32. As the butts of the raised group of needles following the pathway P-2 engage the switch-down cam 156 they will follow a pathway P-30 (Figure 10) and all of the needles lowered by the cam 156 will pass through the first knitting station and draw stitches with the yarn Y. The conventional clutch mechanism, not shown, then operates to switch from reciprocatory to rotary motion and the needle cylinder 32 rotates in a counterclockwise or forward direction to knit the foot of the hose, two courses with each rotation of the needle cylinder 32.

The conventional clutch mechanism is again operated to cause the needle cylinder to change from rotary motion to reciprocatory motion to knit the toe pocket. The toe pocket may be knit in an identical manner to the heel pocket already described and in the present instance the only difference is in the number of needles raised to inactive or non-knitting position and the selector finger used to select these needles to be raised. On the last rotary course of the foot the selector finger 79 is moved to operative position to cause the selector jacks J with the butts 86 left thereon to be rocked inwardly to pass behind the jack raising cam 67 and approach the switch-up cam 155 along the pathway P-26 (Figure 9). The selector jacks J with the butts 86 broken off will engage and ride up the jack raising cam 67 and raise the corresponding cylinder needles to follow the pathway P-1 as they approach the switch-up cam 155. The switch-up cam 155 is then moved to operative position and the needles whose butts are traveling the pathway P-1 (Figure 9) will be raised to inactive or non-knitting position to follow the pathway P-2. With the first reverse or clockwise stroke of the needle cylinder, a narrowing operation takes place which is identical to the narrowing in the heel pocket already described.

After the desired number of narrowed courses have been made, the widening picks 138 and 142 are moved to operative position to widen in a manner identical to the widening in the heel pocket. Upon completion of the widening courses, the clutch mechanism is again shifted to switch from reciprocatory to rotary knitting and the switch-down cam 156 is moved to operative position to lower all of the raised or non-knitting needles to pass through and draw stitches at both knitting stations. A few plain courses are then knit which are known as the usual loopers rounds. The loops on the needles are then shed by removing and cutting the yarns Y and Y-1 at both feeding stations and the completed hose will fall down the center of the needle cylinder. In the description of knitting the hose it was assumed, for simplicity, that there were no yarn changes at either of the yarn feeding stations while as a practical matter and in practice the various parts of fine gauge ladies' hose such as the welt, leg, heel and toe pockets are usually knit of different denier yarn. The yarn feeding fingers 38 at the throat 37 and the fingers 46 at the throat 40 may be supplied with different denier yarns and changed in a conventional manner to knit the various parts of the hose.

In the drawings and specification there has been set forth a preferred embodiment of the invention, and although specific terms are employed they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being defined in the claims.

I claim:

1. In a two-feed circular independent needle hosiery knitting machine having a rotatable needle cylinder, independent needles mounted for vertical movement in said needle cylinder, and means for effecting reciprocation of the needle cylinder, a pair of closely spaced sets of stitch cams adjacent said needle cylinder, each of said sets including a right hand stitch cam, a left hand stitch cam and a stationary top center needle guiding cam, all of said needles adapted to draw stitches at each set of stitch

cams with rotation of the needle cylinder and a group of said needles being adapted to draw stitches in both directions at each set of stitch cams as the needle cylinder is caused to reciprocate in the formation of a knit pocket.

2. In a circular independent needle hosiery knitting machine having a rotatable needle cylinder, independent needles mounted for vertical movement in said needle cylinder, and means for effecting reciprocation of the needle cylinder, a plurality of separate sets of closely spaced stitch cams adjacent said needle cylinder, all of said needles adapted to draw stitches at each set of stitch cams with rotation of the needle cylinder, a group of said needles being adapted to draw stitches in both directions at each separate set of stitch cams as the needle cylinder is caused to reciprocate in the formation of a knit pocket, and means for independently varying the number of needles drawing stitches at each set of stitch cams during reciprocation of the needle cylinder, said last-named means including means interposed between said sets of stitch cams.

3. In a circular independent needle hosiery knitting machine having a rotatable needle cylinder, independent needles mounted for vertical movement in said needle cylinder, and means for effecting reciprocation of the needle cylinder, first and second spaced sets of stitch cams adjacent said needle cylinder, all of said needles adapted to draw stitches at each set of stitch cams with rotation of the needle cylinder, a group of said needles being adapted to draw stitches in both directions at each set of stitch cams as the needle cylinder is caused to reciprocate in the formation of a knit pocket and needle selecting means positioned in advance of said first set of stitch cams.

4. In a circular independent needle hosiery knitting machine having a needle cylinder and means for rotating and reciprocating the needle cylinder the combination of; two sets of spaced stitch cams, each set of stitch cams including a right hand stitch cam, a left hand stitch cam and a top center cam, a pair of narrowing picks operative with each set of stitch cams, a widening pick between said sets of stitch cams and needle selecting means positioned in advance of the first set of stitch cams as the needle cylinder is rotated for selecting cylinder needles to pass through said first set of stitch cams or to pass beneath said first set of stitch cams.

5. In a circular independent needle hosiery knitting machine having a needle cylinder and means for rotating and reciprocating the needle cylinder the combination of; two sets of spaced stitch cams, each set of stitch cams including a right hand stitch cam, a left hand stitch cam and a top center cam, a pair of narrowing picks operative with each set of stitch cams, a widening pick between said sets of stitch cams and needle elevating means positioned in advance of each set of stitch cams for elevating cylinder needles to pass above the right hand stitch cam of each set of stitch cams with rotation of the needle cylinder.

6. In a circular independent needle hosiery knitting machine having a needle cylinder and means for rotating and reciprocating the needle cylinder the combination of; first and second sets of spaced stitch cams, each set of stitch cams including a right hand stitch cam, a left hand stitch cam and a top center cam between said right hand and said left hand cams, a pair of narrowing picks operative with each set of stitch cams, a widening pick between said sets of stitch cams and needle elevating means positioned in advance of each set of stitch cams for elevating cylinder needles to pass through said sets of stitch cams in both directions with reciprocation of the needle cylinder.

7. That method of knitting make-up courses on a multi-feed circular independent needle knitting machine having a plurality of spaced sets of stitch cams including a first set and a subsequent set, vertically movable needles, a selector jack beneath each needle and jack selecting

means in advance of the first of said sets of stitch cams, the steps of advancing the needles along a lower path to normally pass beneath the first set of stitch cams, selecting certain jacks to raise corresponding needles to pass through and knit at the first set of stitch cams while selecting certain other jacks to cause corresponding needles to remain in the lower path and pass beneath the first set of stitch cams and passing all of the cylinder needles through the subsequent set of stitch cams to knit.

8. That method of knitting make-up courses on a multi-feed circular independent needle knitting machine having a plurality of spaced sets of stitch cams including a first set and a subsequent set, vertically movable needles, a selector jack beneath each needle and jack selecting means in advance of the first of said sets of stitch cams, the steps of advancing the needles along a lower path to normally pass beneath the first set of stitch cams, selecting alternate jacks to raise corresponding needles to pass through and knit at the first set of stitch cams while selecting intervening jacks to cause corresponding needles to remain in the lower path and pass beneath the first set of stitch cams and passing all of the cylinder needles through the subsequent set of stitch cams to knit.

9. That method of knitting make-up courses on a multi-feed circular independent needle knitting machine having a first and second sets of spaced stitch cams, vertically movable needles, a selector jack beneath each needle, jack selecting means in advance of the first set of stitch cams and jack raising means in advance of the second set of stitch cams, the steps of advancing the needles along a lower path to normally pass beneath the first set of stitch cams, selecting alternate jacks to raise corresponding needles to pass through and knit at the first set of stitch cams while selecting intervening jacks to cause corresponding needles to remain in the lower path and pass beneath the first set of stitch cams and raising all of the jacks to raise corresponding needles to pass through and knit at the second set of stitch cams.

10. That method of knitting on a multi-feed circular independent needle knitting machine having a plurality of separate spaced sets of stitch cams, a plurality of yarn feeding stations and adapted to knit multi-feed on both rotary and reciprocatory movements, the steps of knitting a partial course at each set of stitch cams with the same given group of needles with each reciprocation and increasing the number of needles in the group knitting each successive partial course at each set of stitch cams.

11. In a method of knitting on a multi-feed circular independent needle knitting machine having first and second knitting stations, first and second yarn feeding stations and adapted to knit multi-feed on both rotary and reciprocatory movements, the steps of knitting a first plurality of partial courses at each set of stitch cams with a given group of needles with each reciprocation while decreasing the number of needles in the group knitting each partial course at each set of stitch cams and knitting a second plurality of partial courses at each set of stitch cams with the given group of needles with each reciprocation while increasing the number of needles in the group knitting each partial course at each set of stitch cams.

12. In a method of knitting on a multi-feed circular independent needle knitting machine having first and second spaced sets of stitch drawing cams each adapted to draw stitches on both rotary and reciprocatory movements, a pair of narrowing picks operative with each set of stitch drawing cams adapted to move needles from operative to inoperative position and a widening pick between said sets of stitch cams adapted to move needles from inoperative to operative position, the steps of knitting a first plurality of partial courses at each set of stitch cams with each reciprocation while decreasing by the use of said narrowing picks the number of needles knitting each partial course at each set of stitch cams, knitting a second

plurality of partial courses at each set of stitch cams with each reciprocation while increasing the number of needles knitting each partial course at each set of stitch cams by the use of both the narrowing picks and the widening picks and joining the second plurality of partial courses knit to the first plurality of partial courses as the second plurality of courses are knit.

13. In a circular multi-feed independent needle knitting machine having first and second spaced knitting stations each adapted to knit in both a rotary and reciprocatory manner, each of said knitting stations comprising two stitch drawing cams and a center needle guiding cam, a yarn feeding station above and in vertical alignment with each of said knitting stations, a narrowing pick operative with each of said stitch drawing cams, a widening pick between the first and second knitting stations and a widening pick between the second and first knitting stations.

14. In a circular multi-feed independent needle knitting machine having first and second spaced knitting stations each adapted to knit in both a rotary and reciprocatory manner, each of said knitting stations comprising two stitch drawing cams and a center needle guiding cam, a yarn feeding station above and in vertical alignment with each of said knitting stations, selector jacks beneath each cylinder needle, a narrowing pick operative with each of said stitch drawing cams during reciprocatory knitting, a widening pick between the first and second knitting stations, a widening pick between the second and first knitting stations, a selective jack elevating cam positioned in advance of the first knitting station, a jack elevating cam positioned between the first and second knitting stations and a selective jack elevating cam positioned after the second knitting station.

15. A circular knitting machine having a needle cylinder adapted to rotate and reciprocate, independent cylinder needles, selector jacks beneath each cylinder needle, first and second yarn feeding stations and first and second corresponding knitting stations, each of said knitting stations including a right hand and left hand stitch drawing cam spaced apart from each other, each of said stitch drawing cams having a clearing cam surface and an inclined stitch drawing surface and having their inclined stitch drawing surfaces facing each other, a center needle guiding cam above and between said right and left hand stitch drawing cams, a narrowing pick operative in the clearing cam surface of each of said stitch cams and adapted to engage and elevate cylinder needles above the center cam, a widening pick between said first and said second knitting stations, a second widening pick between said second and said first knitting stations, a first jack elevating cam in advance of the first knitting station, a second jack elevating cam between the first and second knitting stations, a third jack elevating cam following the second knitting station and jack selector means in advance of the first and third jack elevating cams.

16. A circular knitting machine having a needle cylinder, adapted to rotate and reciprocate, independent cylinder needles, selector jacks beneath each cylinder needle, a dial and transfer bits in said dial, there being half as many transfer bits as cylinder needles, first and second yarn feeding stations, first and second knitting stations, each of said knitting stations including right hand and left hand stitch drawing cams spaced apart from each other, each having a clearing cam surface and an inclined stitch drawing surface and having their inclined stitch drawing surfaces facing each other, a center needle guiding cam above and between said right and left hand stitch drawing cams, a narrowing pick operative in the clearing cam surface of each of said stitch cams, a widening pick between said knitting stations, a jack elevating cam in advance of the first knitting station, jack selector means in advance of said jack elevating cam for selecting alternate jacks to engage said jack elevating cam and raise alternate needles to pass through the stitch drawing cams

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at the first knitting station and for selecting intervening jacks to pass behind said jack elevating cam and allow the cylinder needles to pass beneath the stitch drawing cams at the first knitting station and a second jack raising cam between the first and second knitting stations for engaging and raising all of said selector jacks and the cylinder needles thereabove so that all of the cylinder needles pass through the stitch drawing cams at the second knitting station.

17. A method of knitting on a circular multi-feed 10 knitting machine having independent cylinder needles, selector jacks beneath each cylinder needle, a dial, radially movable transfer bits in said dial, there being half as many transfer bits as cylinder needles, first and second separate yarn feeding stations, first and second separate 15 knitting stations, a needle raising surface in advance of said first knitting station, a first jack raising cam following said second knitting station, jack selector fingers in advance of said first jack raising cam, a second jack raising cam in advance of the first knitting station and a 20 jack selector finger in advance of said second jack raising cam, the steps of selecting jacks at the first jack raising cam to raise alternate cylinder needles to an inter-

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mediate level and allowing intervening cylinder needles to remain at a low level, moving the transfer bits outwardly of the dial in advance of the first knitting station between alternate cylinder needles and over intervening cylinder needles, raising intervening needles through the transfer bits by the needle raising surface, moving the transfer bits inwardly to the dial to transfer the loops from the transfer bits to the cylinder needles and raising intervening cylinder needles by the second jack raising cam to pass through the first knitting station.

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