March 28, 1967 P. A. MAHLER ETAL 3,310,962

CIRCULAR KNITTING MACHINE

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FIG. 1.

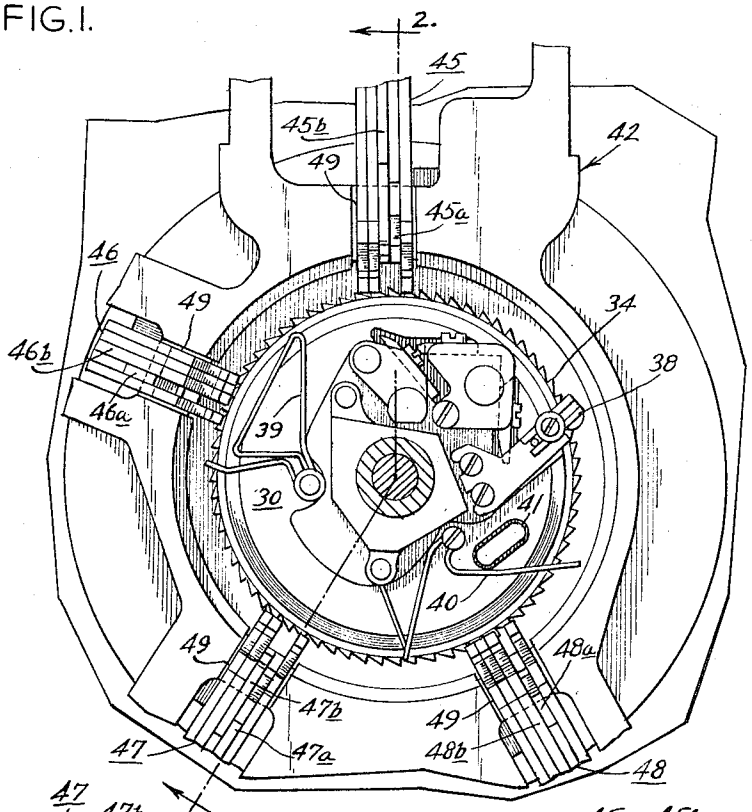


FIG. 2

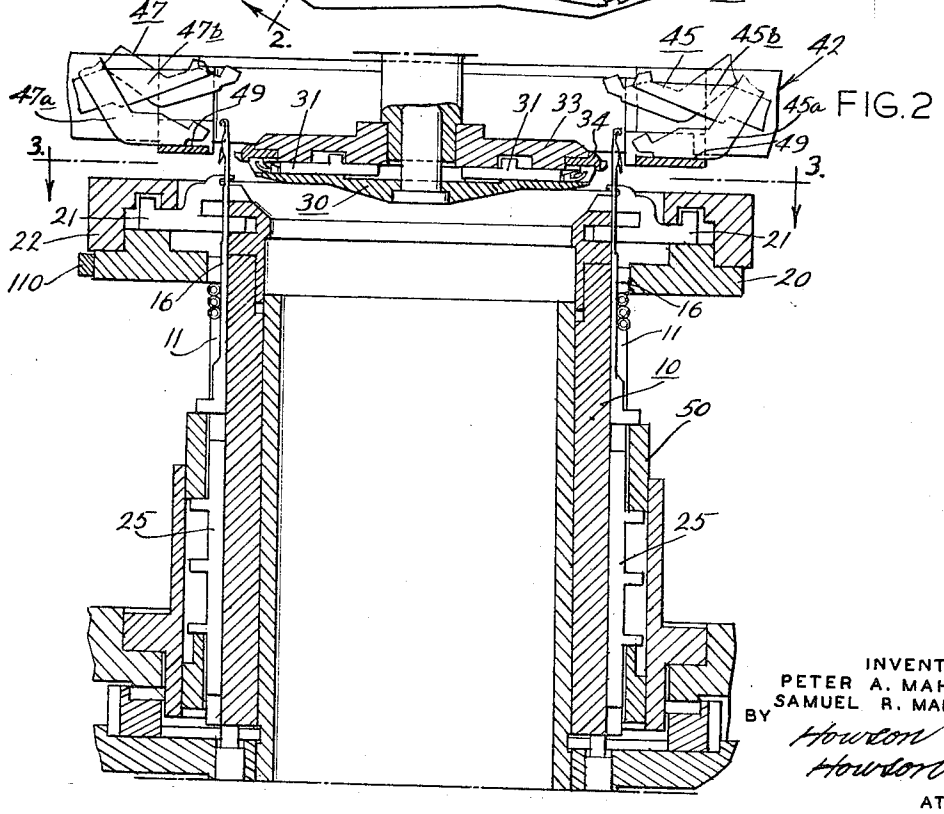


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FIG. 3.

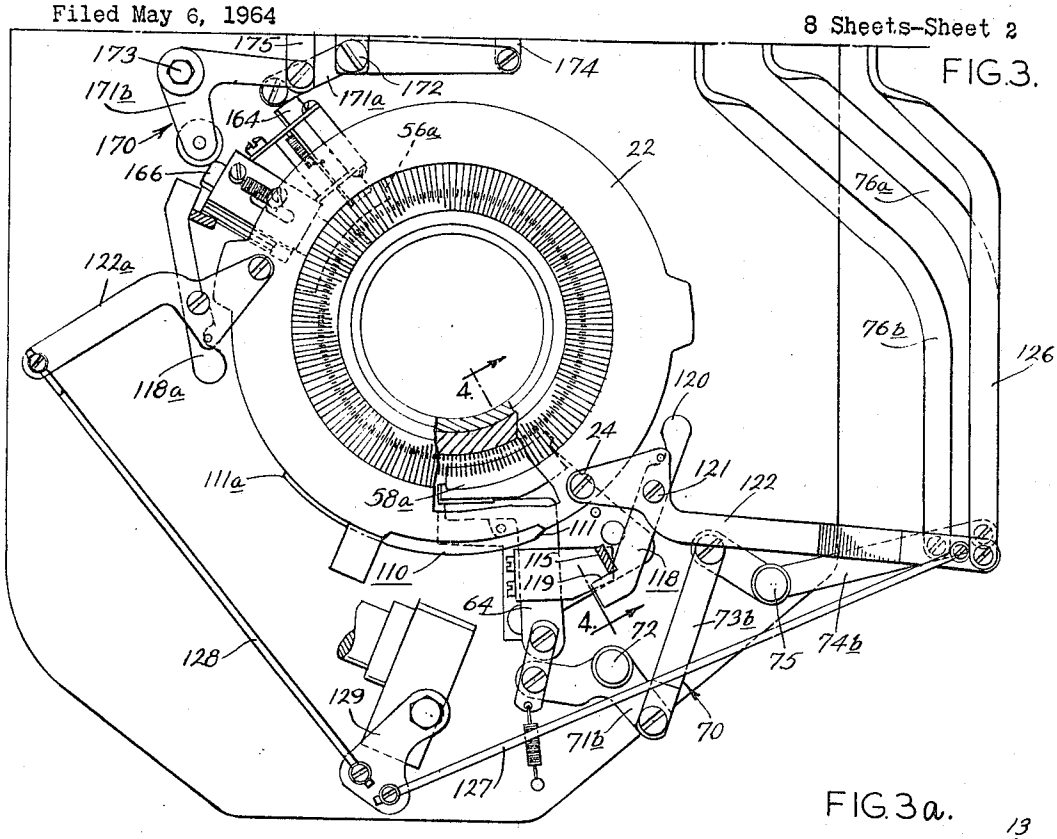


FIG. 3a.

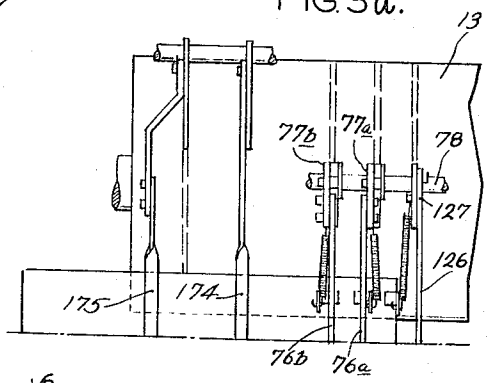


FIG. 4.

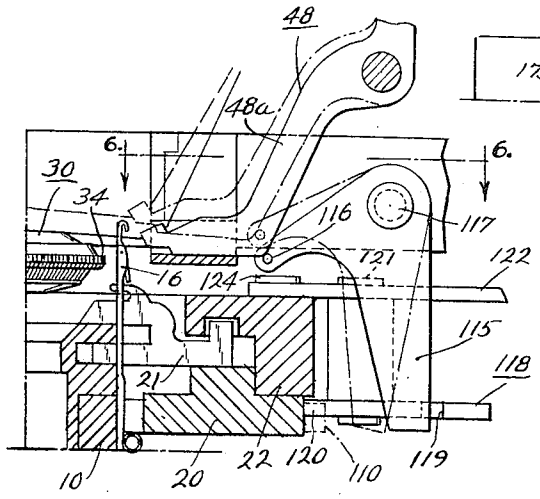


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FIG. 5.

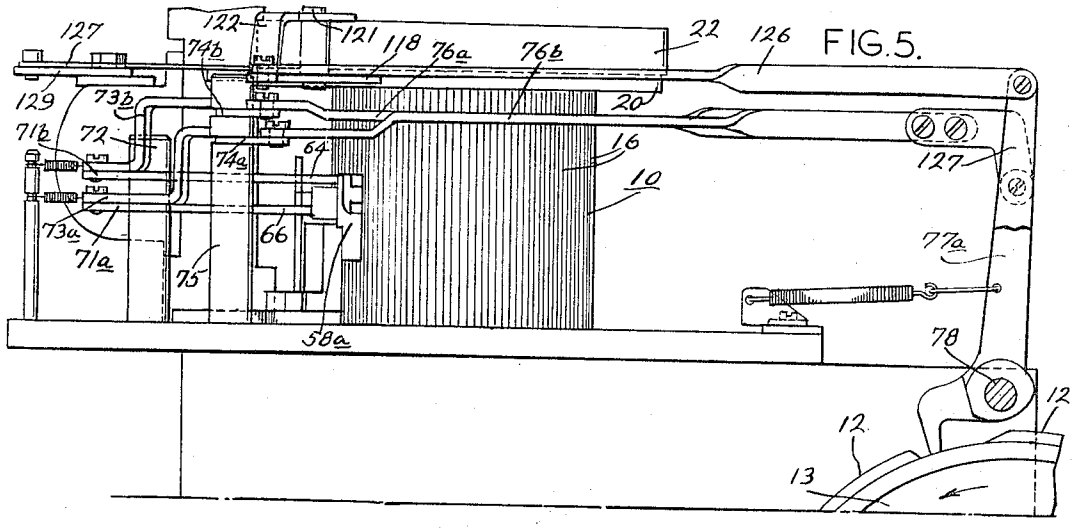


FIG. 6.

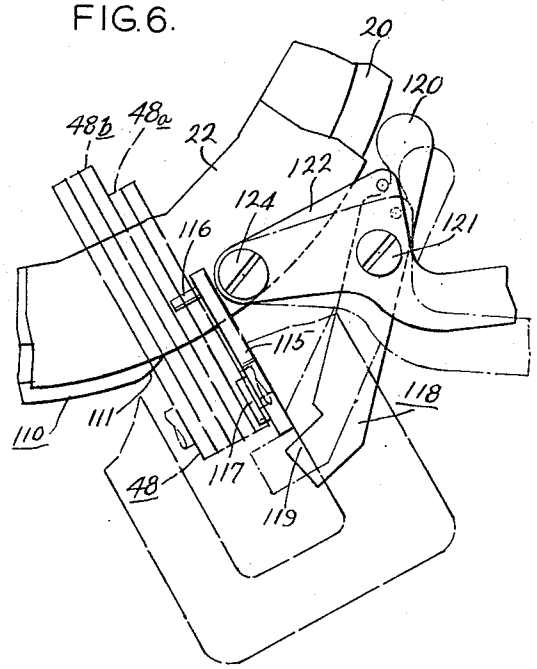


FIG. 7.

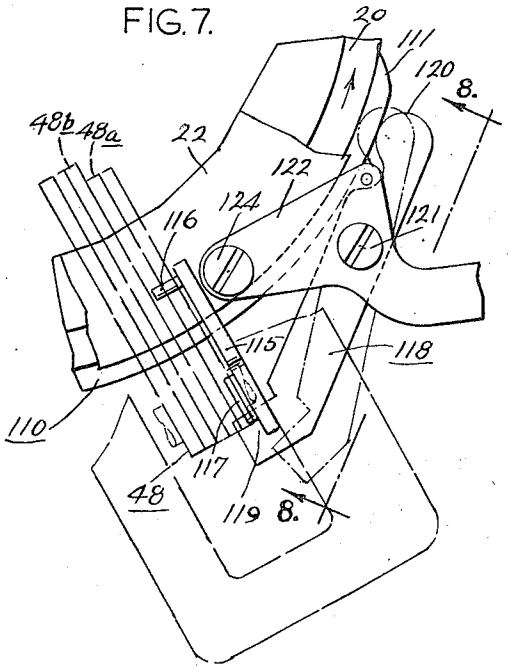


FIG. 8.

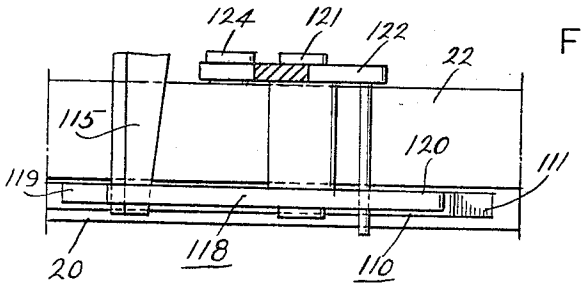


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FIG. 9.

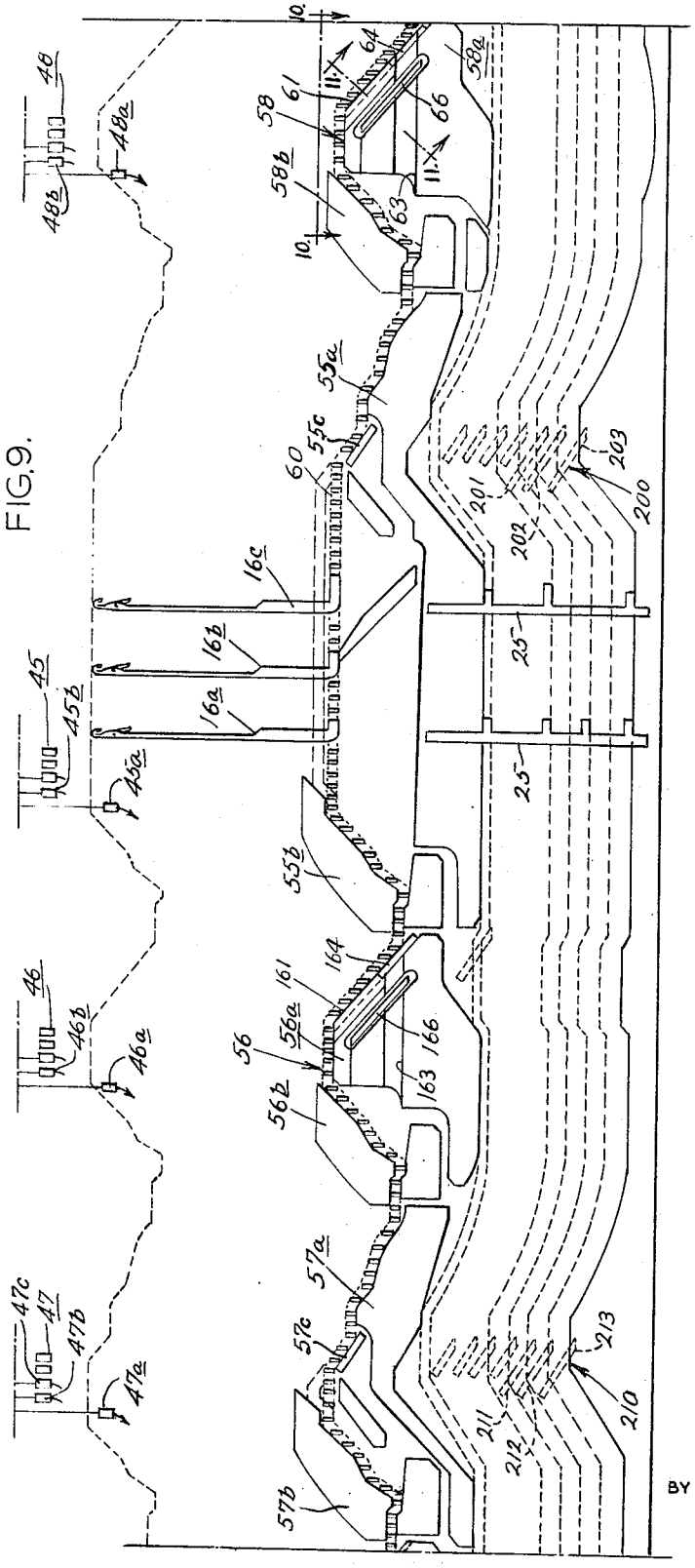


FIG. 11b.

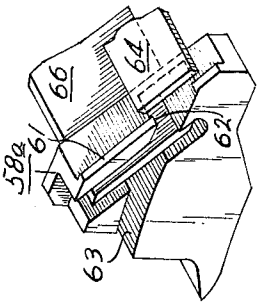


FIG. 11a.

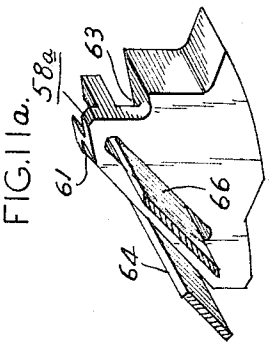


FIG. 11.

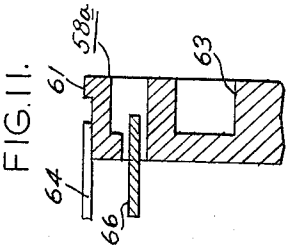
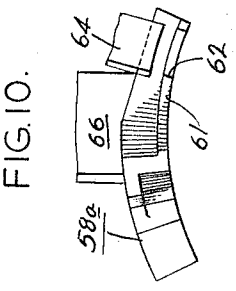


FIG. 10.



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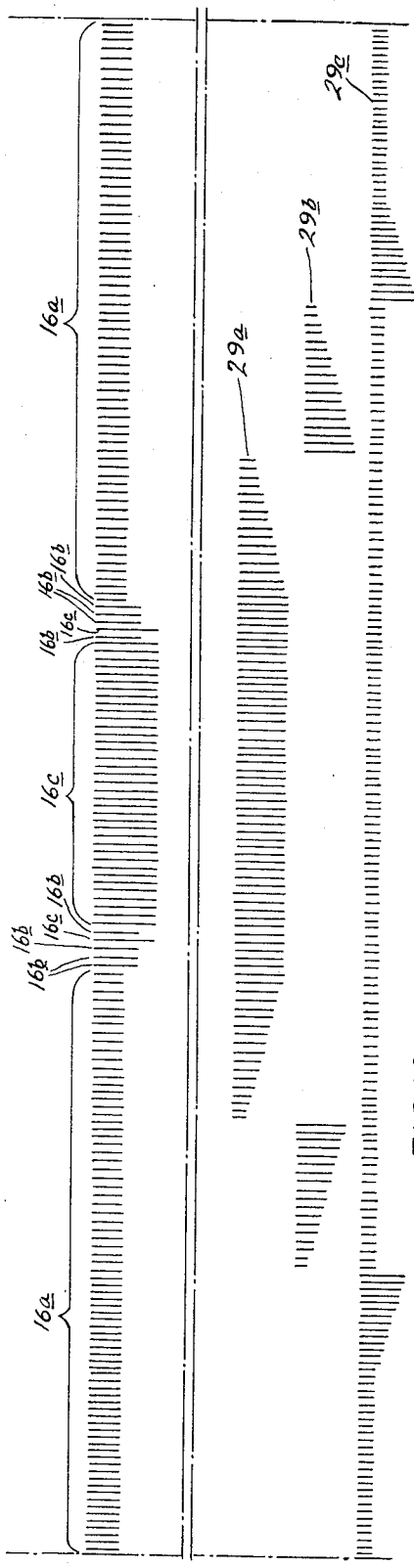


FIG. 12.

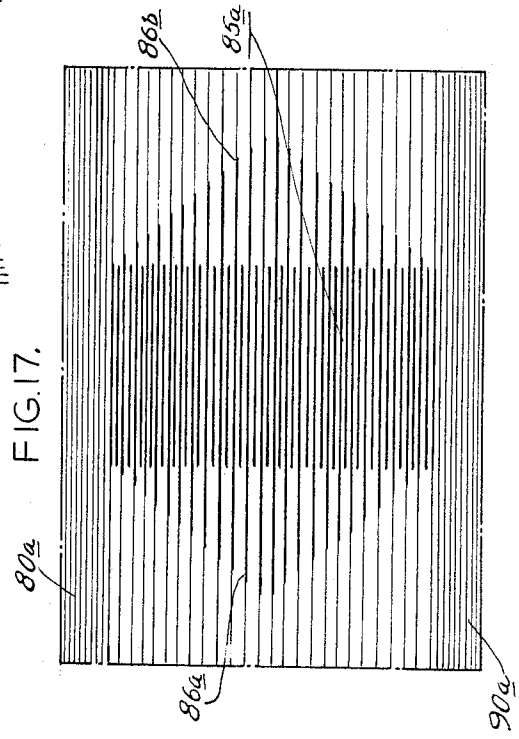


FIG. 17.

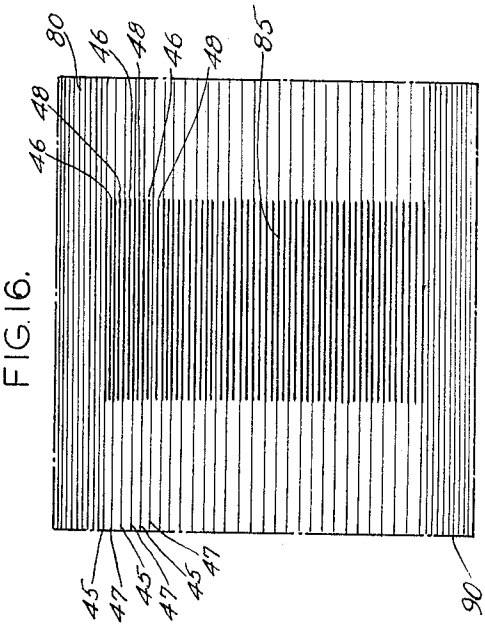


FIG. 16.

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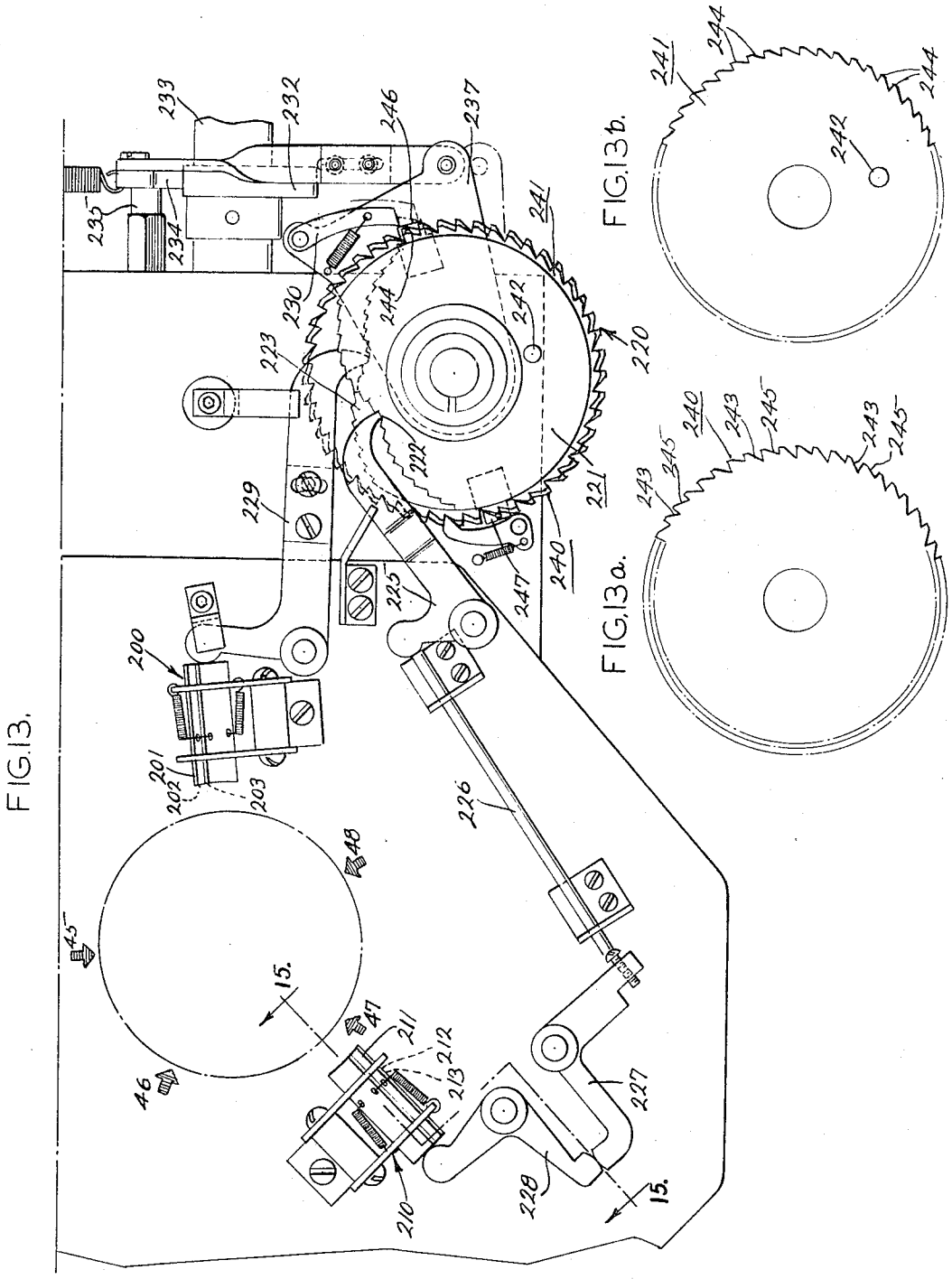


FIG. 13.




FIG. 13b.




FIG. 13a.

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FIG. 14.

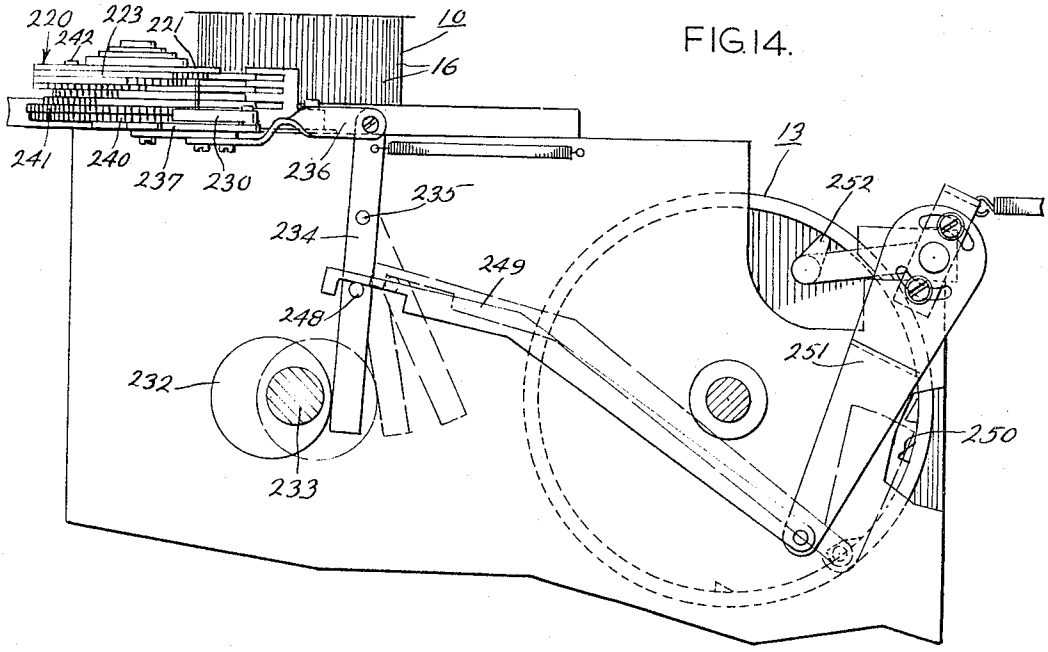


FIG. 15.

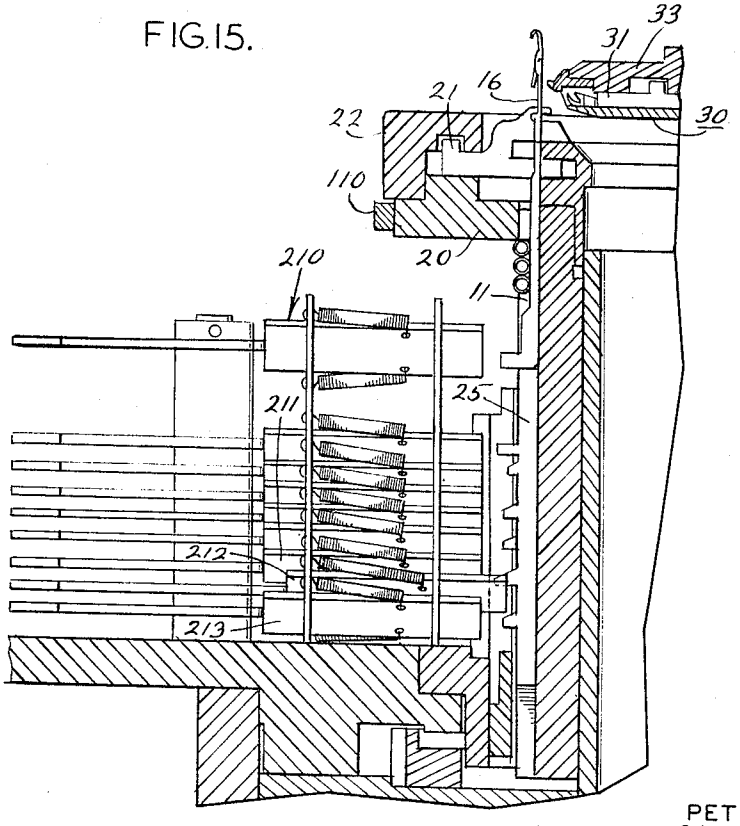


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FIG.18. FIG.19. FIG.20. FIG.21.

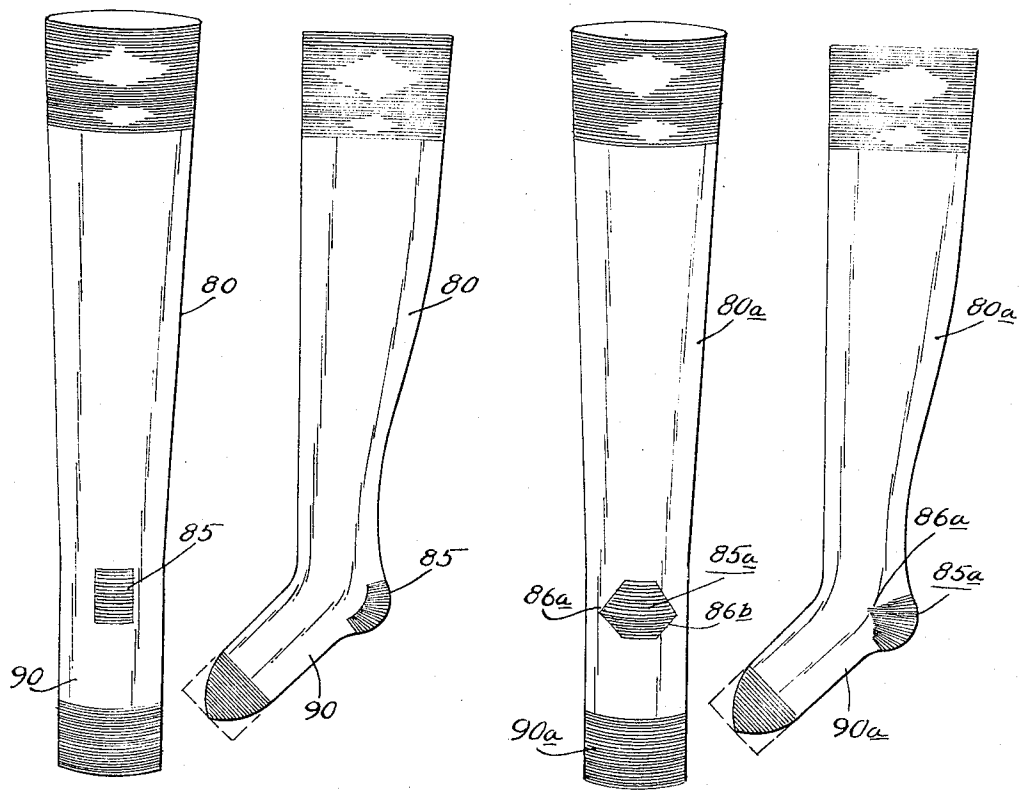
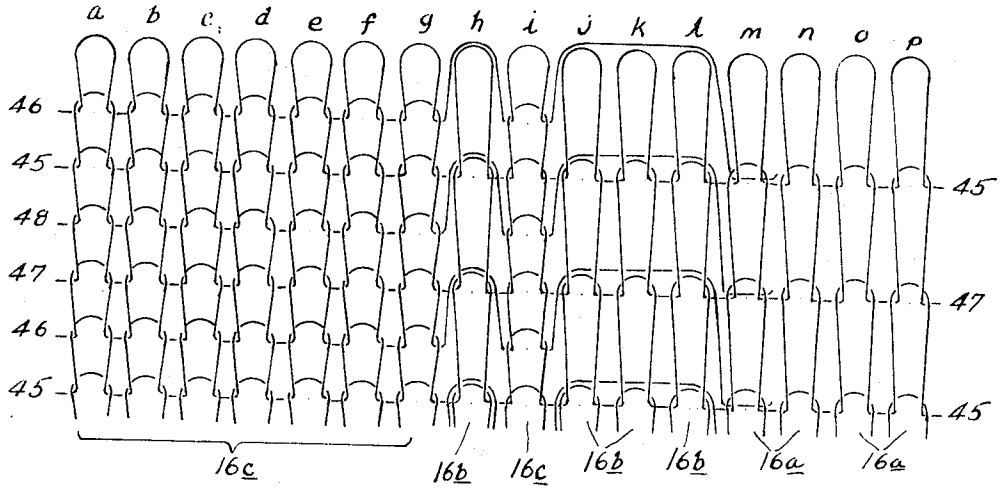



FIG.22.

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United States Patent Office 3,310,962 Patented Mar. 28, 1967



3,310,962

# CIRCULAR KNITTING MACHINE

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Filed May 6, 1964, Ser. No. 365,288
4 Claims. (Cl. 66—42)

The present invention relates to a method and apparatus for knitting ladies' stockings and more particularly to a method and apparatus for knitting the heel pouch of ladies' seamless stockings on a circular, multi-feed knitting machine wherein the needle cylinder rotates continuously in the same direction during the knitting of the entire stocking.

In the manufacture of women's hosiery, it is usual to form a pouch at the heel of the stocking by providing additional fabric at this location. In seamless stockings knit on a circular knitting machine it is customary to provide the heel pouch by knitting on approximately half of the needle circle and reciprocating the needle cylinder while knitting that portion of the stocking. Since the cylinder must reciprocate, there is a reduction in the production rate of the machine in producing the stocking.

In recent years to increase the production rate of women's hosiery on circular knitting machines, the machines have been designed to accommodate additional feed stations so that multiple courses could be knit in one cylinder revolution. In the case of four-feed machines, to simplify the mechanism and prevent crowding, and to increase the production rate of such machines, reciprocation of the cylinder was omitted and therefore the knitting was conducted in only one direction of cylinder rotation. The heel pouch in such stockings is formed in the finishing operation by stretching the stocking over a form and setting the yarn to the form's shape. To reinforce such a pouch, a yarn having a different weight is introduced in this portion of the cylinder revolution at the heel. Preferably the outline of the reinforcing simulates the appearance of the reciprocated heel, but such a heel does not have all of the desirable characteristics of a reciprocated heel, and there is a demand for a knit-in pouch.

Thus it is a principal object of the present invention to provide a method and apparatus for producing a knit-in heel pouch in a ladies' stocking on a multi-feed circular knitting machine in which the needle cylinder does not reciprocate but rotates continuously in one direction during the entire formation of the stocking.

Another object of the present invention is to provide a method and apparatus for knitting a seamless stocking with a heel pouch of improved appearance.

Another object of the present invention is to knit-in the desired heel pouch by use of the novel apparatus which in accordance with the method of the present invention operates to omit every other course from the instep during the knitting of the stocking heel.

Another object of the present invention is to provide apparatus which in conjunction with the knitting instrumentalities assures uniform lock-in of yarn ends between the edges of the heel pouch and the instep without causing eyelet formation.

Still another object of the present invention is to provide novel apparatus which facilitates proper insertion of yarn and withdrawal of the same between the instep and the heel portion of the stocking as it is knitted.

Another object of the present invention is to provide a method of forming a pouched heel on a circular knitting machine having a continuously rotating cylinder by, during the formation of the heel pocket, introducing yarns of a different character in alternate courses of the instep of the stocking.

Other objects and a fuller understanding of the invention may be had by referring to the following specification and claims taken in conjunction with the accompanying drawings in which:



FIG. 1 is a fragmentary plan view of a portion of a circular knitting machine embodying the present invention, with certain portions removed to more clearly show the pertinent parts of the machine;

FIG. 2 is an enlarged sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged sectional view taken along line 3—3 of FIG. 2;

FIG. 3*a* is a fragmentary reduced-scale plan view of pattern-drum-controlled linkages which cooperate with the apparatus illustrated in FIG. 3;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a side elevation of the portion of the knitting machine illustrated in FIGS. 3 and 4;

FIG. 6 is an enlarged sectional view in plan taken along line 6—6 of FIG. 4 showing a sinker-dial controlled feed finger actuator in full lines in operative position and in broken lines in an inoperative position;

FIG. 7 is an enlarged fragmentary sectional view in plan, showing the apparatus of FIG. 6 in the operative position, in full lines being activated and in broken lines being inactivated;

FIG. 8 is a sectional view taken along line 8—8 of FIG. 7;

FIG. 9 is a schematic layout of the needle and jack cams as viewed from the inside of the needle cylinder and illustrating the needle and jack paths as well as the relative location of the yarn feeding stations;

FIG. 10 is a fragmentary enlarged plan view of the portion of the needle cams as viewed from line 10—10 of FIG. 9;

FIG. 11 is an enlarged fragmentary sectional view taken along line 11—11 of FIG. 9;

FIG. 11*a* is an enlarged perspective view showing the entire cam illustrated in FIG. 11 as viewed from the outside of the needle cylinder;

FIG. 11*b* is an enlarged perspective view showing the opposite side of the cam shown in FIG. 11*a*;

FIG. 12 is a schematic layout of the needle and jack butts;

FIG. 13 is a plan view of the mechanism which operates on the jacks with portions of the machine removed to better show its operation;

FIGS. 13*a* and 13*b* show certain ratchet elements of the jack operating mechanism removed from the machine;

FIG. 14 is a side elevational view of the apparatus illustrated in FIG. 13;

FIG. 15 is an enlarged fragmentary sectional view taken along line 15—15 of FIG. 13;

FIG. 16 (sheet 5) is a schematic illustration of the knitted courses comprising a heel pouch made in accordance with the present invention;

FIG. 17 (sheet 5) is a schematic illustration of another heel pouch made in accordance with the present invention;

FIG. 18 is a rear elevation of a stocking blank having a heel pouch as illustrated in FIG. 16;

FIG. 19 illustrates a ladies' hose in side elevation after the finishing operations;

FIGS. 20 and 21 are views of a stocking blank and finished stocking respectively embodying a heel pouch knitted as illustrated in FIG. 17; and

FIG. 22 is a schematic loop diagram illustrating a portion of a heel pouch knitted in accordance with the present invention and illustrating the knitting transition between the heel and the instep of the stocking.

Referring now to the drawings, and especially FIGS.

1, 2, 3, and 5, the knitting machine illustrated therein comprises a rotary needle bed or cylinder **10** having axial slots **11** arranged about its outer periphery and mounting a plurality of axially slidable, latch needles **16** therein. Surrounding the upper portion of the needle cylinder **10** is affixed sinker cap **22** and a sinker dial **20** (see FIG. 2) which rotates with the needle cylinder **10** and mounts a ring of sinkers **21** which cooperate with the needles **16** in a conventional manner. Underlying the needles **16** in the slots **11** are jacks **25** having a plurality of radially projecting butts thereon. Within the circle of needles **16**, a rotary dial **30** is mounted for rotation in synchronism with the needle cylinder **10**. The dial **30** carries a series of conventional bitts **31** under a stationary dial cap **33** and an annular toothed ring **34** overlying the bitts. On the dial cap **33** is mounted a cutter **38** which cooperates with the toothed ring **34**, guide wires **39** and **40**, and suction tube **41** which operate respectively to sever, guide, and hold the yarn.

Surrounding the circle of needles **16** is a yarn carrier ring **42** which is interrupted at a plurality of locations by feed stations, in the present instance four which are designated **45**, **46**, **47**, and **48**. As in conventional practice, each of the feed stations comprises a throat plate **49** and a plurality of feed fingers which are designated by subletters after the feed station designation. In accordance with the usual practice, the needle cylinder and dial are rotated and the feed fingers are operated in timed relation to the needle cylinder to insert yarns into and withdraw yarns out of action by conventional pattern mechanism (not shown) such as a pattern drum and a pattern chain.

Extending about the needle cylinder **10**, and cooperating with the butts **16** of the needles **15** is a cam box **50** which, as illustrated in FIG. 9, has the same number of cam sets, designated **55** through **58** respectively, as there are yarn feed stations **45** through **48**. Each of the cam sets has a riser cam, designated by the subletter *a* associated with the cam set number (sets associated with the first and third feed stations including a clearing slide cam designated by the subletter *c*), and a stitch cam designated by the subletter *b* with its associated cam set designation, it being noted that the riser cam in every case is positioned immediately subsequent to the stitch cam of the preceding cam set.

In accordance with the invention, the production of the desired pouch shape for the heel of a woman's stocking is facilitated by the use of the novel apparatus which operates to omit, in the instance of a four-feed machine as above-described, every other course from the instep of the stocking during the knitting of the stocking heel. To this end and in accordance with the preferred embodiment of the invention, the needle layout of the cylinder comprises needles of at least three classes, i.e., three butt lengths. As illustrated in FIG. 12, the needles having short butts are designated **16***a*, those having intermediate length butts are designated **16***b* while the needles with the longest butts are designated **16***c*. During the knitting of the heel pouch, at the first and third feeds all of the needles take and knit at least one yarn, while the long butt needles may be elevated above the clearing level and take and knit a reinforcing yarn. However at the second and fourth feed stations a novel cam permits only the long and intermediate butt length needles to take yarn, notably a body and reinforcing yarn, and only the long butt needles to knit. In this manner two out of every four courses are knit on the short butt needles in the instep while four courses are being knit in the heel thus providing a heel pouch.

During normal knitting of the stocking, such as in the leg or foot portion, the needles **16** follow the path **60** as illustrated in FIG. 9, and with each of the feed fingers **45***a*–**48***a* respectively carrying a body yarn and in a yarn feeding position, four courses will be knit every revolution of the cylinder **10**. However, because of the novel



cam arrangement at the second and fourth feeding stations **46** and **48** respectively, at the heel portion of the stocking, only the first and third feeds knit continuously, while the second and fourth feeds knit solely at the heel pocket and miss entirely knitted courses in the instep thus producing a heel pouch of the desired form.

In order to increase the durability of the stocking at the heel pouch, and in order to setoff this portion of the knitted stocking, additional yarn of an increased weight such as 40 denier yarn is added to the needless as they knit this portion of the stocking, this is accomplished by placing feed fingers **46***b* and **48***b* and float fingers **45***b* and **47***b* into action during the knitting of the heel pouch and thereafter removing the fingers from action and cutting the heavier weight reinforcing yarn. While it is common practice to reinforce on alternate courses, it is frequently desired to reinforce at each course. The positioning of yarn float fingers **45***b* and **47***b* into and out of their active feeding positions is accomplished, as previously described, by conventional patterning mechanism which is not part of this invention. The apparatus, on the other hand, by which the feed fingers **46***a* and **46***b* and **48***a* and **48***b* are inserted into and removed from action at the beginning of the heel pocket in each course and the end of the heel pocket in each course will be described more fully hereinafter.

FIGS. 18 and 19 illustrate a stocking knitted in accordance with the present invention wherein the leg is designated as **80**, the heel pouch designated as **85** and the foot portion of the stocking is designated as **90**. A course diagram (FIG. 16) illustrates knitted courses schematically by lines and shows a portion of the leg **80**, the foot **90**, and the whole of the heel pouch **85**, while identifying by reference numbers the feeds wherein the heel and instep of the stocking are formed.

In accordance with the invention, novel riser cams, **56***a* and **58***a* of the cam sets **56** and **58** are provided with means whereby the long butt needles **16***c* raise to the stitch clearing level, the intermediate butt needles **16***b* raise to the tuck level, and the short butt needles **16***a* pass by the cam set and take no yarn at all. As the cam sets **56** and **58** are identical in all essential respects, reference will be made to FIGS. 11*a* and 11*b* with regard to the cam set **58**.

As is illustrated in FIG. 11*b*, the leading surface of the cam **58***a* is a needle rising surface **61** provided with an interruption or gap **62**. A needle butt groove **63** extends through the cam at one level from the interruption **62**. A slide **64** is mounted for radial movement in registry with the interruption **62** and is dimensioned and normally positioned with respect to the interruption so that, for example when knitting the leg and foot portion of the stocking, it bridges the gap and a smooth camming surface is provided for needless of all classes. Substantially parallel to the slide **64** and intersecting the needle butt groove **63** is a second slide cam **66** which is radially movable and dimensioned and positioned to intersect the needle butt groove **63** and of sufficient length along its cam surface to raise the needles whose butts engage the slide **66** to the tuck level.

As previously explained, when knitting the leg **80** or foot **90** of the stocking, the first needle slide **64** will be positioned in the interruption **62** thereby causing all needles to be elevated to the stitch clearing level. When knitting the heel portion of the stocking however, the first needle slide **64** and the second needle slide **66** are moved radially outwardly by slide actuating means **70** which will be more fully described hereinafter. The first needle slide **64** is moved a radial distance sufficient to permit only those needles designated **16***c*, i.e. the long butt needles, to engage the slide **64** and travel up the needle rising surface **61** to take yarn and draw down at the associated stitch cam. Simultaneously, the second needle rising slide cam **66** is radially positioned to permit those needles with intermediate length butts, i.e. the

needles 16*b*, to engage the slide and rise to an intermediate or tuck level. The short butt needles 16*a*, will miss both slides 64 and 66 and thus will pass along the needle butt groove 63 and not attain a level to take yarn. The purpose of raising a few needles 16*b* on either side of the long butt needles 16*c* to the intermediate or tuck level is to provide a lock-in along the edge of the heel pouch, which lock-in will be more fully described hereinafter.

The slide actuating means 70 for the cam 58*a* is best illustrated in FIGS. 3, 3*a*, and 5 and comprises a pair of spring biased arms 71*a* and 71*b* connected to the outer extensions of the slides 64 and 66 respectively. (See FIG. 5.) The arms 71*a* and 71*b* are pivoted at 72 and are connected to members 76*a* and 76*b* for operation from bell crank followers 77*a* and 77*b* through associated linkage including rods 73*a*, 73*b* and bell cranks 74*a*, 74*b* having a pivot at 75. The bell crank follower 77*a* is pivoted at 78 and moves the member 76*a* to the left, as viewed in FIG. 5, when the follower rides down the cam 12 on a pattern drum 13. The follower 77*b* is operated similarly from the drum. This causes the slides 64 and 66 to move radially to the positions heretofore described.

The first and second slides 164 and 166 of the second feed riser cam 56*a* are actuated in substantially the same manner, and in fact from the same pattern drum 13. As shown in FIGS. 3 and 3*a*, the first needle slide 164 and the second needle slide 166 are positioned by feed slide actuating means 170 which in the present instance comprises a pair of bell cranks 171*a* and 171*b* which pivot about points 172 and 173 and are connected through members 174 and 175 to cam followers which operate in a manner similar to that previously described with respect to slides 64 and 66 associated with riser cam 58*a*.

*Yarn insertion and withdrawal*

As previously explained with respect to FIG. 16, a reinforcing yarn usually of about 40 denier weight is added to the heel pouch during the knitting at least at the second and fourth feeds, and frequently at all four feeds. As explained, the insertion and withdrawal of the reinforcing yarn at the first and third feeds may be conventionally accomplished by raising the needles 16*c* to a reinforcing level to take yarn from the float fingers 45*b* and 47*b*. This is more fully described in the Mahler Patent No. 3,111,827. In any event, as is illustrated in FIG. 16, at the second and fourth feeds it is necessary to insert both a body yarn and a reinforcing yarn only during the knitting of the heel pouch 85, and at the end thereof to elevate the yarns to permit the same to be severed.

The primary purpose of elevating the yarn fingers carrying the yarns is to place the yarn removed from knitting in a position to be carried by the serrated ring 34 to the cutter 38. Further, as insertion and withdrawal of both the body and reinforcing yarn must be accomplished twice every revolution of the needle cylinder, yarn finger elevating means is directly coupled to the cylinder so as to be operative at the second and fourth feeds. Accordingly, as shown in FIGS. 3 and 6 a cam 110 having a slight radial protrusion is connected to the sinker dial 20, its leading edge 111 in the direction of cylinder rotation being angularly spaced from the trailing edge of the needles associated with the heel pouch 85. Thus the cam 110 is positioned so that it is effective to elevate the yarn feed fingers containing the body and reinforcing yarns at both the second and fourth feeds after the trailing intermediate butt length needles 16*b* have passed the feed stations 46 and 48.

Referring now to FIGS. 3, 3*a*, 4, 6, 7, and 8 the yarn finger elevating means illustrated therein is rendered operative from the pattern drum 13 (FIG. 3*a*). The elevating means comprises a bell crank 115 having a pin 116 (FIG. 4) which underlies the yarn feeding fingers 48*b* and 48*a*, so that upon clockwise movement of the bell crank 115 about its pivot 117, these feed fingers are elevated from their active to an elevated position. A cam follower 118, one end of which abuts the bell crank 115 at 119, the other end of which has a camming surface 120, is pivoted at 121 on a link 122. One end of the link is pivoted at 124 on the sinker cap 22, and the other end is connected through a member 126 to a conventional cam follower 127 which is in engagement with the pattern drum 13. When rendered operative, as best illustrated in FIG. 6, the link 122 is moved rearwardly or counterclockwise about its pivot 124 from the broken line position to the full line position, thus moving the cam follower 118 to a point adjacent the sinker dial 20. Thus when the camming surface 120 of the cam follower 118 engages the cam 110, as shown in FIG. 7 the cam follower moves clockwise about its pivot 121 to the full line position of FIG. 7 causing the abutting end 119 to move the bell crank 115 about its pivot 117, thus raising the feed fingers 48*a* and 48*b*. Thus the cam 110 causes the yarn fingers 48*a* and 48*b*, carrying their associated body and reinforcing yarns respectively, to be elevated once every revolution of the needle cylinder. It should be noted that the trailing edge of the cam 110, designated as 111*a*, releases the pressure on the cam follower 118 causing counterclockwise movement of the bell crank 115 and thus permitting the yarn fingers 48*a* and 48*b* to move into an active position for feeding yarns during the next revolution of the cylinder.

The principle of operation and yarn finger elevating means associated with feed station 46 are essentially the same as that previously described with regard to feed station 48; a cam follower 118*a* being positioned for actuation by the cam 110 when a link 122*a* is in active position. The link 122*a* is controlled simultaneously with the link 122 by rods 127 and 128 in conjunction with a pivoted plate 129.

*Method of operation*

The method of knitting the heel pouch will now be described in relation to FIGS. 9, 12, 16, and 22.

Referring first to FIGS. 9 and 16, the leg portion 80 of the woman's stocking is knit continuously with the feeds 45 through 48 having the feed fingers 45*a* through 48*a* respectively in an active position and feeding yarn. Because in the knitting of the leg portion the slides 64 and 164 associated with riser cams 58*a* and 56*a* respectively are fully inserted, all of the needles 16 take yarn and knit. At the outset of the heel pocket at feed station 45, if it is desired to reinforce at this feed, float finger 45*b*, carrying a reinforcing yarn, is made active and positioned at a reinforcing height, i.e. a level just above the level of yarn fed to needles at a clearing height. When reinforcing, the needles 16*c*, i.e. the needles corresponding to the selected portion of the needle circle wherein the heel pocket is formed, are raised to the reinforcing level by moving a slide into position to engage and elevate only the needles 16*c*. In this manner the needles 16*c* knit both a reinforcing and a body yarn at the first feed station 45. After the needles 16*c* pass through the feed station, the yarn is carried by the last needle and the serrated ring to the cutter 38. (See FIG. 1.) The remainder of the needles, i.e. those needles designated 16*a* and 16*b* in FIG. 12, receive in their hooks only the yarn being fed from the always active feed finger 45*a*, and thus are drawn down by the stitch cam 55*b* and form loops in a conventional manner. Simultaneously with the above occurrence, the slide actuating means 70 and 170 associated with the cam sets 58 and 56 position the first needle slides 64 and 164 to engage only the long butt needles 16*c* and the second needle slides 66 and 166 engage the intermediate butt needles 16*b*. These slides remain in this position during the remainder of the knitting of the heel pouch. Simultaneously with this occurrence, the yarn finger elevating means associated with feed stations 46 and 48 move the cam followers 118*a* and 118 respectively into active position adjacent the sinker dial, as previously described, so as to permit the cam 110 to move the yarn fed fingers 46*a* and 46*b*, associated with feed station 46, and yarn feed fingers 48*a*

and 48*b*, associated with feed station 48, between active and elevated positions. In a manner similar to that previously described, the yarn finger elevating means stays active throughout the remainder of the knitted heel pouch.

Upon reaching the second feed riser cam 56*a*, the needles 16*a* will pass along the needle butt groove 163 and therefore not receive any yarn at feed station 46. The four needles 16*b* at each side of the needles 16*c* as illustrated in FIG. 12, having butts of insufficient length to engage the first needle slide 164, pass into the needle butt groove 163 and engage the slide 166, causing these needles to raise to a tuck or a nonclearing height, thus retaining in their hooks the yarn fed to them at the first feed station 45 and receiving in their hooks the body and reinforcing yarn being fed at feed station 46. The remaining long butt needles 16*c*, will strike the first needle slide 164 and be cammed upwardly along the cam rising surface 161 to a stitch clearing level and there, receive the body and reinforcing yarn being fed by feed fingers 46*a* and 46*b*. After the last intermediate butt needle 16*b* leaves the stitch cam 56*b*, both of the feed fingers 46*a* and 46*b* are elevated by the cam 110 to insure carrying of the yarn by the serrated ring 34 to the cutter 38, and holding of the loose yarn ends, after cutting, by the air suction means 41.

At the third feed all needles again knit, if reinforcing is desired the float finger 47*b* being placed at the reinforcing level so as to feed a reinforcing yarn to the needles 16*c* as they are elevated to a reinforcing height in the same manner as at the first feed station 45. It is important to note at this time, and referring to FIGS. 9 and 12 especially, that the group of needles which comprise three intermediate length butt needles 16*b*, one long butt needle 16*c*, another intermediate length butt needle 16*b* and located at either side of the needles 16*c*, provide the lock-in of the yarn which have been inserted and removed at the previous feed station, i.e. station 46. The reason for this is that the needles 16*b* at station 46, did not raise, when taking yarns being fed by the feed fingers 46*a* and 46*b* to a clearing level and thus the yarns from the first feed station 45 were retained in the hooks at this feed station. However, since all of the needles are raised to the stitch clearing level by the action of the rise cam 57*a* and slide 57*c* at the third feed station 47, the needles 16*b* also rise to a stitch clearing level causing the yarns in the hook to clear the latch of the needle and move onto the shank of the needle. Thus as the needles move down the stitch cam 57*b* the yarns are cast over the hook and form a lock-in.

With regard to the fourth feed station, 48, the action is the same as that previously described with respect to feed station 46, the short butt needles 16*c* passing through the needle butt groove 63, the intermediate butt length needles 16*b* moving up the slide 66 to a tuck height, and the needles 16*c* moving up the slide 64 to a stitch clearing level. Throughout the remainder of the heel pouch, knitting continues as described above.

A portion of the heel pocket including the lock-in area is illustrated in FIG. 22. Wherein the wales have been designated *a* through *p* and the yarns fed by the feed stations designated the appropriate feed station number. It should be noted that the loops in wales *m n o* and *p* are formed at the feed stations 45 and 47 only and comprise a single loop of body yarn fed by feed fingers 45*a* and 47*a* respectively. For sake of clarity, single yarns are shown in wales *a–l* to avoid confusion and better illustrate the lock-in at the heel portion, however it should be understood that the loops, for example in the wale *a* may be composed of body and reinforcing yarns. Also, relating FIG. 22 to FIGS. 9 and 12, the heel portion which is knitted by the needles 16*c* have been so designated as well as the needles forming the lock-ins and the instep of the stocking.

Thus in the knitting of the heel portion of the stocking, the first and third feeds knit body yarns on all of the needles and may introduce into the needles 16*c* a reinforcing yarn, while at the second and fourth feeds novel cams allow only the needles 16*b* and 16*c* to take body and reinforcing yarns.

It is also possible with the method of the present invention to provide an extension of the reinforcements in the heel to thereby provide a panelled area at both sides of the heel pouch. Such a panelled area 86*a* and 86*b* is illustrated in FIG. 17 which shows the heel pouch and a portion of the instep of the stocking illustrated in FIGS. 20 and 21. In FIGS. 17, 20, and 21, the leg of the stocking is designated 80*a*, the foot 90*a*, while the heel pouch is designated 85*a*.

The means for providing a panelled reinforcement 86*a* and 86*b* on either side of the heel pouch 85*a* is fully set forth in the Mahler Patent No. 3,111,827, however the apparatus by which this is accomplished will be briefly described hereinafter. In order to provide the panelled areas 86*a* and 86*b*, which are formed only at feeds 1 and 3, the number of needles selected at either side of the heel pouch at yarn feeding stations 45 and 47 is gradually increased and then decreased with the rotation of the needle cylinder. That is, at these stations, the number of needles moved to a reinforcing level to take a reinforcing and a body yarn is gradually increased until the desired width of the panel is reached and then gradually decreased to the point coinciding with the last knitted course of the heel pouch.

This is accomplished by providing on the jacks 25, underlying the needles 16*b* and 16*c*, and at least some of the needles 16*a*, selectively differing butt lengths at, in the present instance, three successive levels. As illustrated in FIG. 12 the jacks have butts at a level 29*a*, a level 28*b*, and a level 29*c*. From an examination of FIGS. 9 and 15 it is apparent that these selectively differing butts cooperate with jack slides 201, 202, and 203 at the first jack selection station 200, and with the jack slides 211, 212, and 213 at the second jack selection station 210, the butts at the level 29*a* cooperating with slides 201 and 211, the butts at the level 29*b* cooperating with the slides 202 and 212, and the butts at the level 29*c* cooperating with the slides 203 and 213.

The jack slides 201–203 and the jack slides 211–213 are selected in progression by a plurality of superimposed, radially-stepped, rotatably driven cams 220, in the present instance a separate cam for each slide, i.e. three cams per jack selection station. (See FIG. 13.) For example, the cam 221 associated with the jack selection station 210, has a plurality of steps which radiate from a low position 222 and increase progressively to the outer periphery of the cam. Another cam 223 associated with jack selection station 200, is constructed the same as cam 221 but underlies and is angularly offset therefrom. The cam 221 operates through slide actuating means comprising a cam follower 225, a push rod 226, and a pair of bell cranks 227 and 228 to cause movement of the slide 211 of the jack selecting station 210 as the cam 221 is rotated. Identical slide actuating mechanism underlies the above-described slide actuating means and causes in a like manner movement of the slides 212 and 213 in response to stepped cams similar to those shown in the afore-mentioned Mahler patent. In a like manner, a cam follower 229, upon rotation of the cam 223, causes progressive movement of the slide 201 of the first jack slide selection station 200. As the cams 220 are stepped radially both inwardly and outwardly, as noted in FIG. 13, and rotate in a clockwise direction, the slides will first be moved radially inwardly and then radially outwardly thus providing, by means of the selectively differing butt lengths, a gradual increase of the needles selected at both sides of the heel pouch and thereafter a gradual decrease in the number of needles selected thus creating a panel of knitting reinforcement at either side of the heel pouch. The shape of the panel may be modified by altering the contour of the cams or by providing dwells in the advance thereof.

The driving means for causing rotation of the cams so as to provide progressive selection of the jacks and therefore the needles, is illustrated in FIGS. 13–14 and includes a pawl 230 which is continuously oscillated over the circumferential length of one tooth 244 of a ratch 241 as indicated by the broken lines in FIG. 13. This is accomplished by an eccentric 232, mounted on a main drive shaft 233 of the machine, continually causing oscillation of a cam follower 234 about its pivot 235, causing movement of an arm 236 to which a pivoted plate 237 is mounted supporting the pawl 230.

As the ratio of the drive shaft 233 is 1:1 with the needle cylinder, and as it is desirable to knit two courses at each feed for every two-needle increase at each panel, pawl over-riding means is provided so that the cams 220 are indexed so as to displace the slides radially once every two revolutions of the needle cylinder. To this end, the pawl over-riding means comprises a freely rotatable ratchet 240 which rides loosely on the ratchet 241. The ratchet 241, however, is connected to the cams 220 by a pin 242. As illustrated in FIG. 13*a*, the teeth of the ratchet 240 have a pitch equal to the teeth of the ratchet 241, but the adjacent teeth of the ratchet 240 have differing base heights. Thus the teeth 243, on the rachet 240, have a base height equal to the teeth 244 on the ratchet 241 while the alternate teeth 245 on the ratchet 240 have a base height insufficient to permit the pawl 230 to engage the teeth 244 of the ratchet 241. The outer diameter of the ratchet 241 is less than that of the ratchet 240, being equal to the root diameter of the teeth 245. Therefore every stroke of the pawl 230 causes one-tooth movement of the ratchet 240 but only every other stroke is operative to cause movement of the ratchet 241. Thus the movement of the slide actuating cams 220 has a ratio of 1:2 with respect to the cylinder rotation.

In order that when the cams 220 reach their low point, such as at 222 on cam 221, the pawl 230 does not continue to cause rotation of the cams, a pawl stop 246 is mounted on the ratchet to prevent the pawl from engaging and advancing the ratchets. Further, an additional pawl stop 247 is located 180 degrees from pawl stop 246 which pawl stop acts upon the pawl 230 to afford a dwell in the indexing of the cams 220 when all of the slides have been fully inserted and before they are retracted stepwise. In order to permit continued rotation of the cams 220 and allow disengagement of the pawl stops, stop over-riding means are provided in conjunction with the pattern drum 13 (see FIG. 14). To this end, a pin 248, located on the cam follower 234, is loosely engaged by a pivoted arm 249 which is connected to a biased lever assembly 251. The arm 249 normally permits the pin 248 to oscillate. However, when the lever assembly 251, and particularly a camming portion 252, engages a cam 250 located inside the pattern drum 13, the lever assembly is rocked counterclockwise causing engagement of the pin 248 by the arm 249 which causes the pawl 230 to over-ride the stop means.

In this manner progressive selection of the jack slides is caused which selects a first increasing and then decreasing number of needles adjacent the heel pouch thereby causing raising of these needles to a reinforcing level, thus creating a reinforced panel at either side of the heel pouch.

As is well known in the art of knitting ladies' stretch seamless hosiery, it is desirable to prevent twisting and an unseemly appearance of the stocking by knitting alternating courses with yarns of a different character thus preventing the unseemly appearance which occurs if all yarns knit at all stations are of the same character. Thus for example in a two-feed machine, it is common practice to introduce yarns having an S twist at the first feed station and yarns having a Z twist at the second feed station. In a four-feed machine as heretofore described, alternate feed stations are provided with yarns having the same character, i.e. the same twist. Thus for example feed stations 45 and 47 have yarns for kitting the leg and foot portion of the stocking, said yarns having an S twist while the yarns introduced for knitting the same portions of the stocking at feed stations 46 and 48 have a Z twist. As may readily be seen, since, in accordance with the invention, only alternate feeding stations provide yarn for knitting the instep of the stocking, in the present instance feed stations 45 and 47, and these feed stations both introduce yarns of the same character, it is desirable to change the yarn associated with the feed stations which introduce yarn for the first course of the instep in order that it may have a character or twist different from that of the other feed station which introduces the alternate yarn at the instep.

To this end and assuming that the first course of the instep is initiated at the third feed, a feed finger 47*c*, provided with a yarn having a character opposite to that contained by the feed finger 47*a*, at the third feed station 47, is placed in an active position and thereafter the feed finger 47*a* is elevated to an inactive position. This means that during the knitting of the heel portion of the stocking the associated instep will be knitted with adjacent courses having yarns of a different character or twist. In the same manner, after the knitting of the heel pouch has been completed, it is desirable to lower the feed finger 47*a* to its active position and then remove the feed finger 47*c* from its active position. The insertion of these yarns is effectively timed so that plating of the yarn ends is performed at station 47 when the needles 16*c* are taking yarn at this feed station, i.e. when the reinforced heel pouch is being knit.

It should be noted that each of the cam sets could be equipped with needle slides similar to those in the cam sets 56 and 58, thereby permitting certain of the slides of the individual cam sets to be inserted and withdrawn so as to permit any combination of courses in the instep versus courses in the heel. Of course, the maximum number of courses in the heel versus the minimum number of courses in the instep is 4:1 with a four feed machine. If this ratio were to be increased, it would be necessary to insert and withdraw the needle slides selectively at the feed stations during the knitting of the heel pouch.

In summary a method and apparatus is provided for knitting an entire stocking on a uni-directionally rotating cylinder, multi-feed knitting machine. This is accomplished by the novel apparatus and method of the present invention which permits knitting of four courses in the heel while knitting two courses in the instep of the stocking thereby giving shape to and forming a heel pouch on ladies' seamless hosiery.

Although the invention has been described with a certain degree of particularity it is understood that the present disclosure has been made only by way of example and numerous changes in the details of construction and the combination and arrangement of parts or the mode of operation may be made without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. For a circular knitting machine comprising an axially slotted needle cylinder mounting a plurality of radially butted needles therein, a cam box circumscribing said cylinder and positioned to engage the butts of the needles, and means to cause relative movement between said cam box and said cylinder thereby effecting axial movement of said needles to at least one of three levels: stitch clearing, tuck and stitch draw; a riser cam in said box having a body portion and a needle rising surface for engagement with the butts of said needles, said needle rising surface being of sufficient length to raise said needles to at least a clearing height, said rising surface having a gap below the tuck level, and a needle butt groove extending from said gap through said body portion, said gap and needle butt groove having an axial height at least equal to the axial height of the needle butts, a radially-movable first slide cam dimensioned and normally positioned to bridge said gap so as

to provide in conjunction with said rising surface a smooth, uninterrupted needle rising surface, a second radially-movable slide cam having a needle camming surface and positioned substantially parallel to said first slide and intersecting said needle butt groove, said second slide having a length along its cam surface sufficient to raise needles to a tuck level.

2. A riser cam for a circular knitting machine in accordance with claim 1 wherein said circular knitting machine has a needle layout comprising at least three classes of needle butts of differing radial lengths and wherein said riser cam, when said first slide is radially moved outwardly, permits needles of a class having at least the longest radial butts to move to a stitch clearing height, and the needles of at least the second of said classes to pass along said needle butt groove and engage said second slide cam for elevation to said tuck height.

3. In a multi-feed circular knitting machine comprising a circular needle cylinder having axial slots about its periphery and mounting a plurality of latched needles therein, each of said needles having radially projecting butts and a needle layout in said cylinder of needles having at least three classes of radial butt lengths, a cam box about said cylinder operable on said needle butts to cause vertical reciprocation of said needles upon relative rotation of said cam box with respect to said cylinder, at least two yarn feed stations spaced about said cylinder each mounting a plurality of yarn feed fingers, stitch-forming cam-sets in said cam box corresponding in number to the number of yarn feed stations, each of said cam sets including a needle rising cam surface and a stitch draw cam; the improvement in at least one of said sets comprising an improved needle rising cam having a body portion and a needle camming surface of sufficient length to raise needles to a clearing height upon engagement of said surface with said needle butts, said rising cam surface having an interruption and means defining a needle butt groove extending from said interruption through said body portion, a radially movable first slide cam dimensioned and normally positioned so as to bridge said interruption in said cam surface whereby a smooth needle rising surface is provided, a radially-movable second slide cam having a needle camming surface and dimensioned and positioned to intersect said needle butt groove, said camming surface being of sufficient length to raise needles to a tuck level, slide actuating means connected to said first and second slides and operable to cause selective radial movement of said slides whereby outward radial movement of said first slide permits only the class of needles having long butts to follow said camming surface to the stitch clearing level, the remaining needles following said butt-groove, and the second class of needles having intermediate length butts engaging the camming surface of said second slide and thereby being raised to a tuck level, the third class of needles having short butts moving along said butt-groove and missing said second slide.

4. In a multi-feed circular knitting machine according to claim 3 wherein said slide actuating means comprises pattern mechanism for displacing said slides to their operative position upon initiation of said heel portion.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 811,577 | 2/1906 | Paxton et al. | 66—42 |
| 1,159,873 | 11/1915 | Scott | 66—49 X |
| 1,231,443 | 6/1917 | Smith | 66—185 |
| 1,488,682 | 4/1924 | Jones | 66—49 |
| 2,974,506 | 3/1961 | Lawson | 66—42 X |
| 2,980,981 | 4/1961 | Reymes-Cole et al. | 66—185 |
| 3,023,594 | 3/1962 | Mahler | 66—42 |
| 3,080,739 | 3/1963 | Eaker | 66—42 |
| 3,090,216 | 5/1963 | Mahler | 66—140 |
| 3,093,985 | 6/1963 | Brown | 66—42 |
| 3,111,827 | 11/1963 | Mahler et al. | 66—49 |
| 3,148,518 | 9/1964 | Peel et al. | 66—57 X |
| 3,181,314 | 5/1965 | Miller | 66—42 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 895,672 | 5/1962 | Great Britain. |
| 153,997 | 8/1963 | Russia. |

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