Feb. 10, 1959 R. PEEL 2,872,796

JACK SELECTION MECHANISM FOR CIRCULAR KNITTING MACHINES

Filed Sept. 19, 1957 7 Sheets-Sheet 1

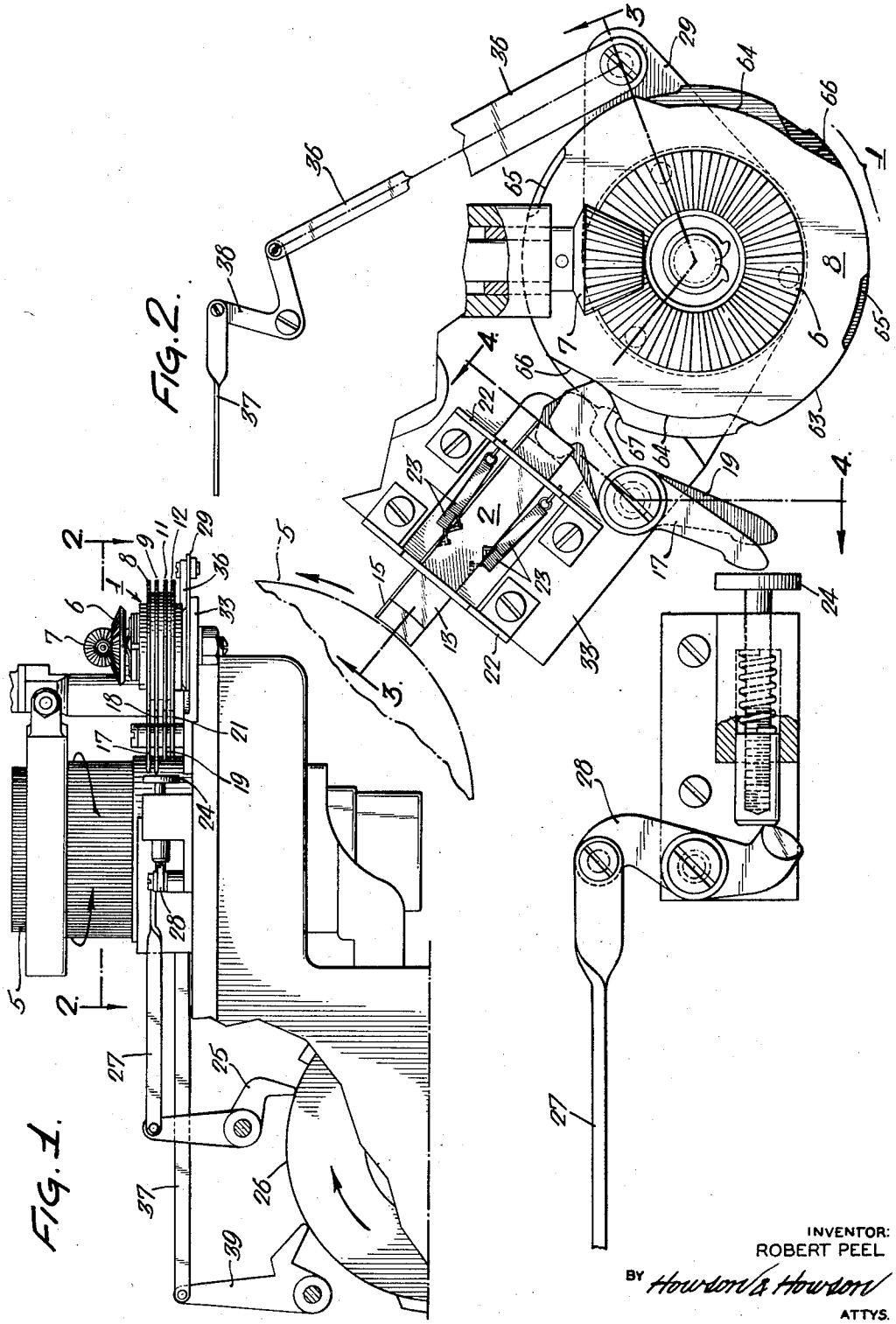

FIG. 2.

FIG. 1.

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FIG. 7.

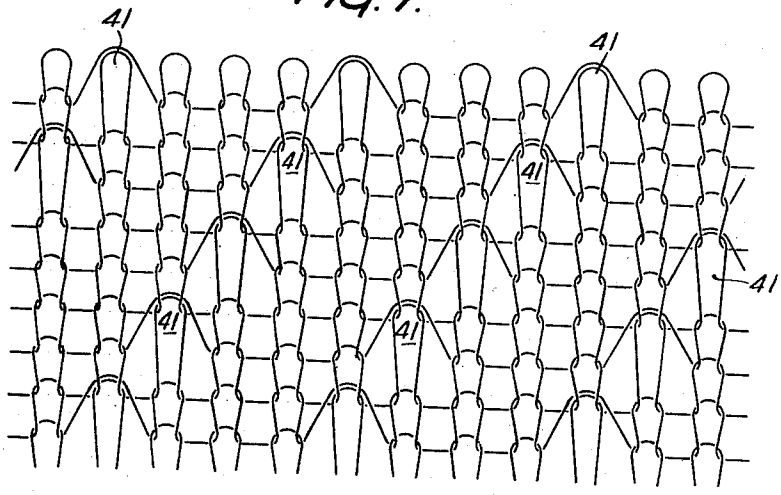


FIG. 4.

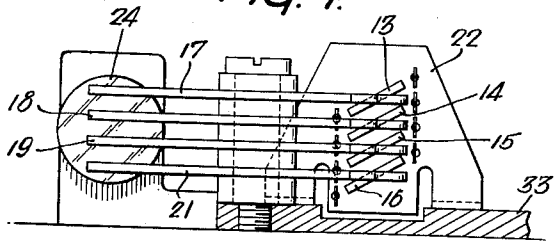
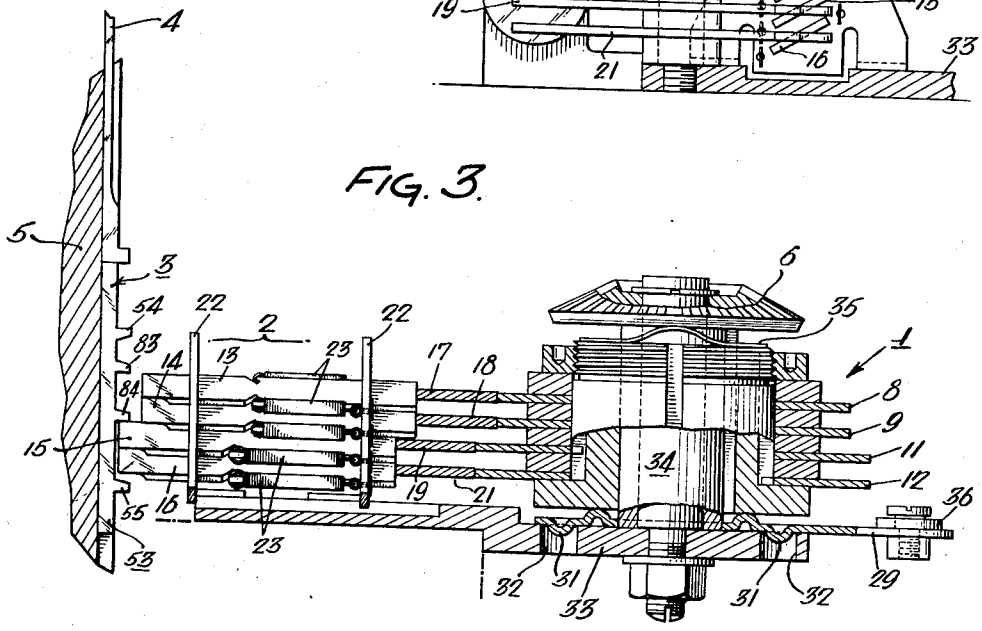


FIG. 3.



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JACK SELECTION MECHANISM FOR CIRCULAR KNITTING MACHINES

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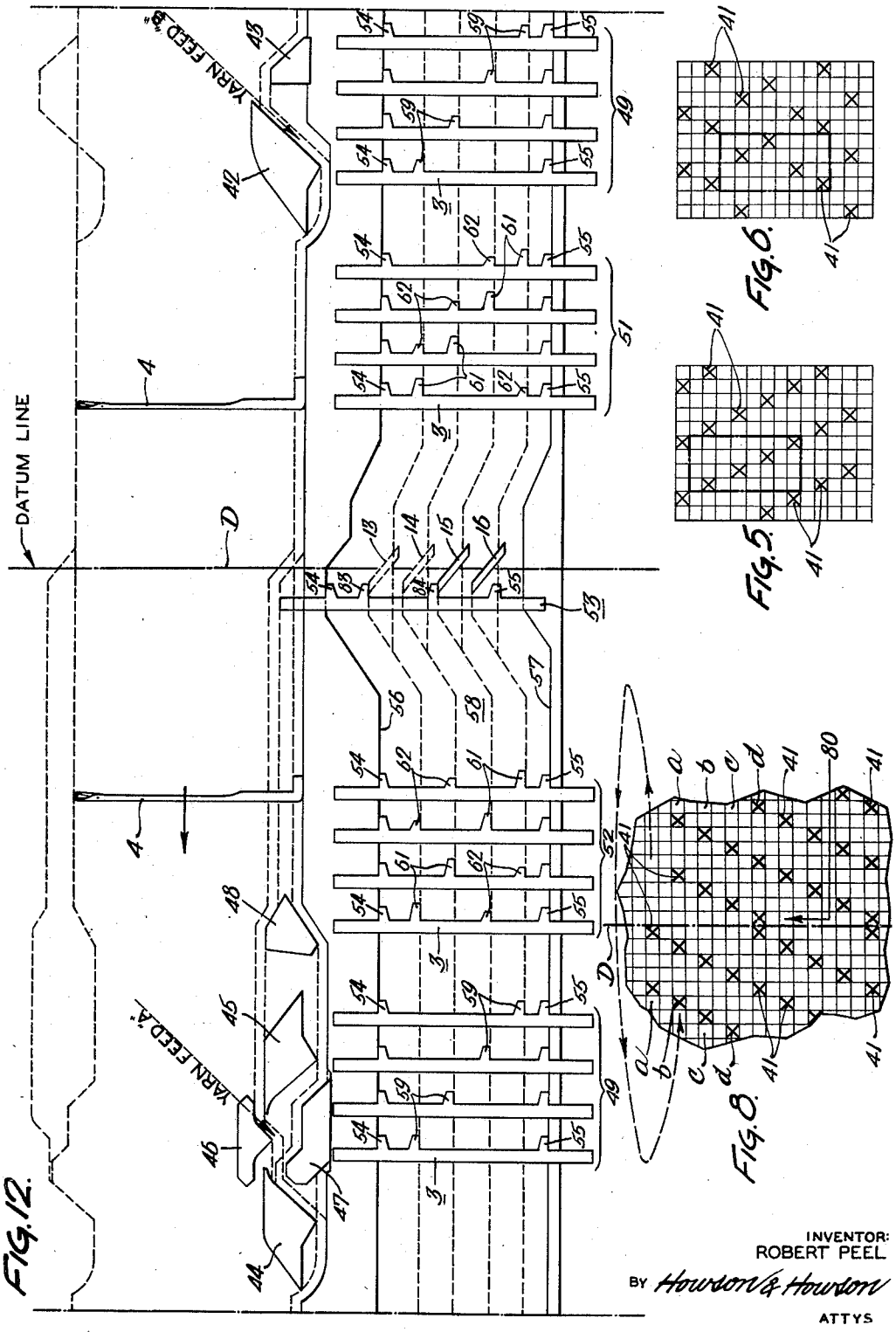

FIG. 12.

FIG. 6.

FIG. 5.

FIG. 8.

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FIG. 9.

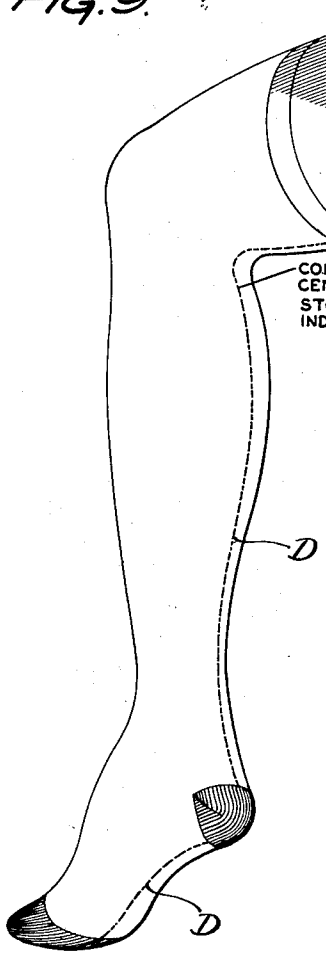


FIG. 10.

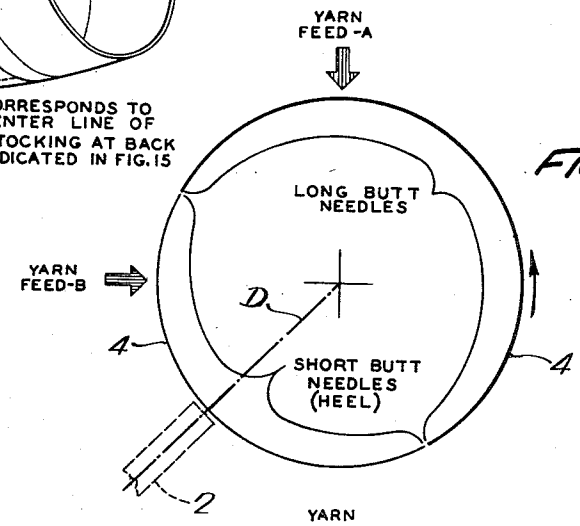
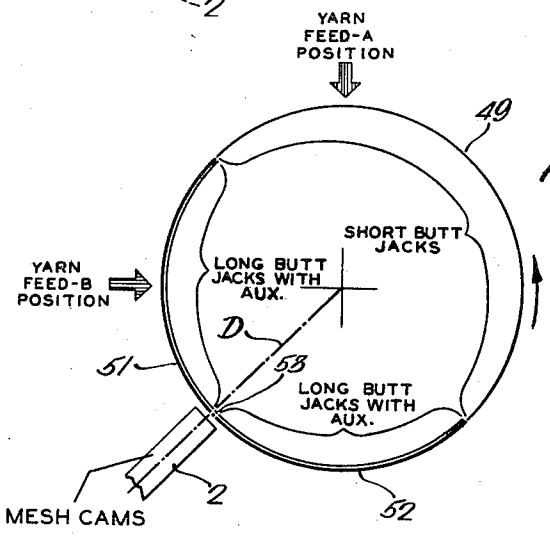


FIG. 11.



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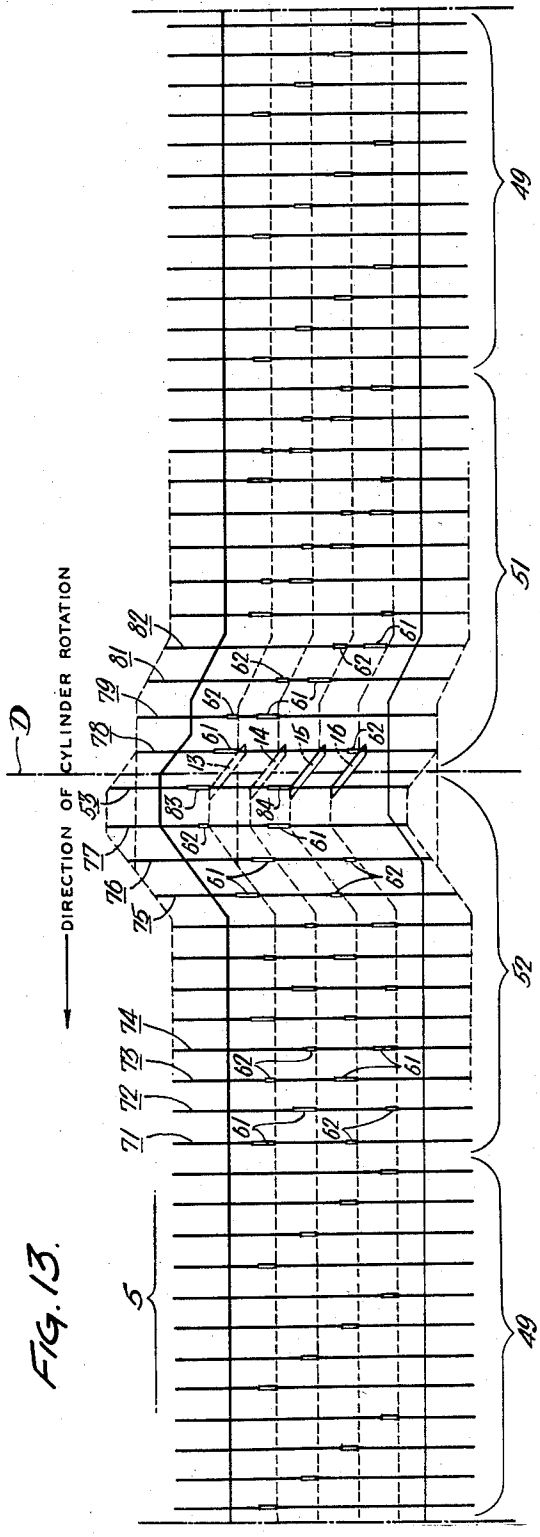
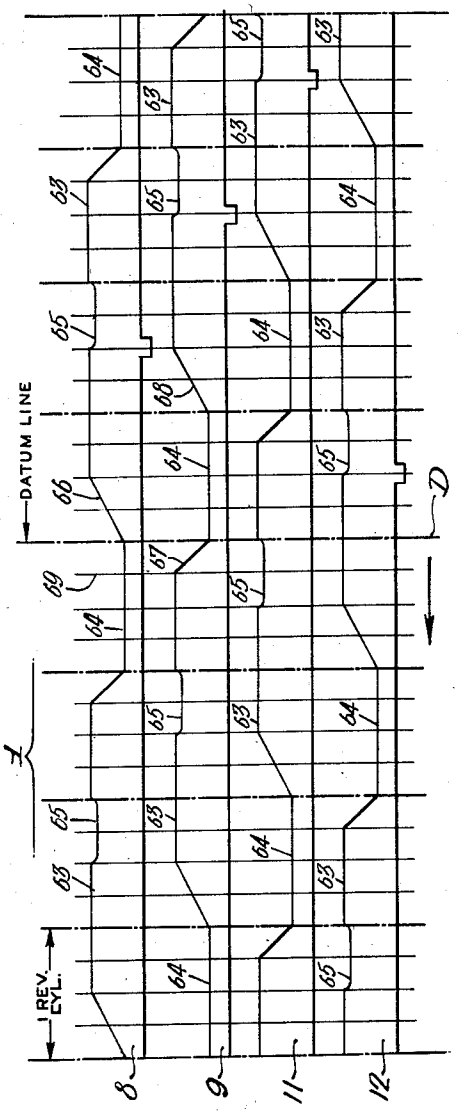


FIG. 13.

FIG. 14.



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JACK SELECTION MECHANISM FOR CIRCULAR KNITTING MACHINES

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FIG. 15.

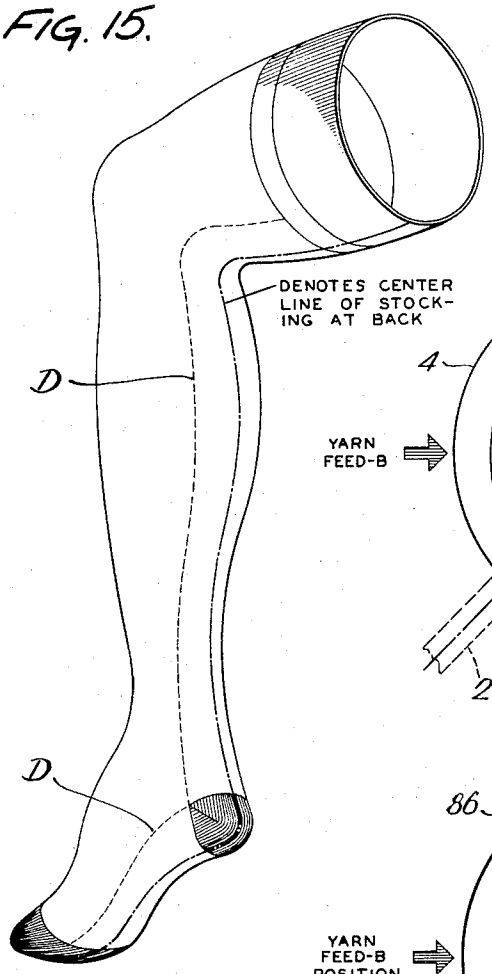


FIG. 16.

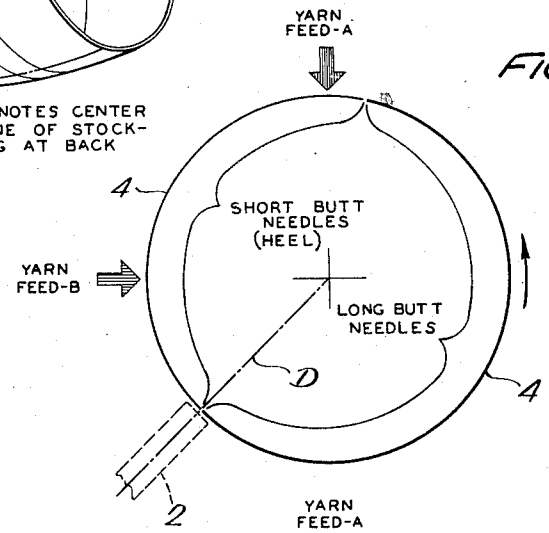
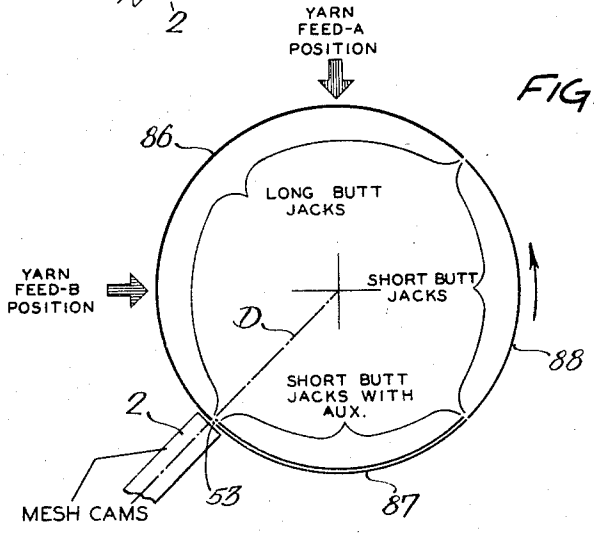


FIG. 17.



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JACK SELECTION MECHANISM FOR CIRCULAR KNITTING MACHINES

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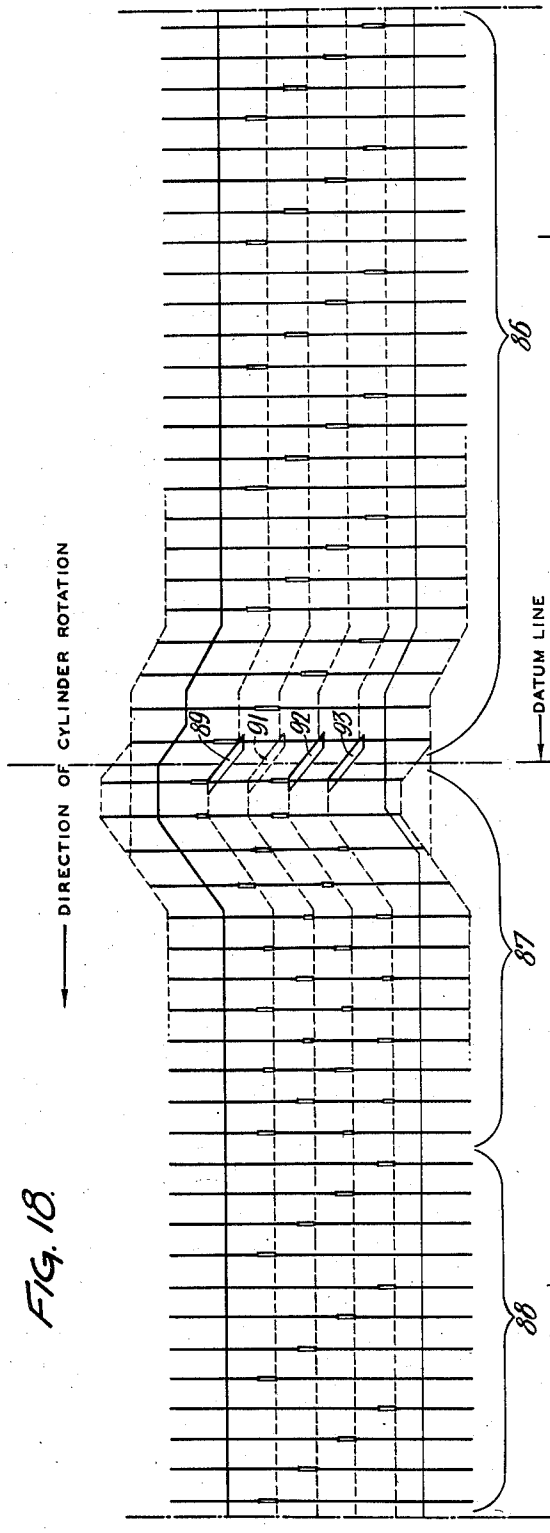
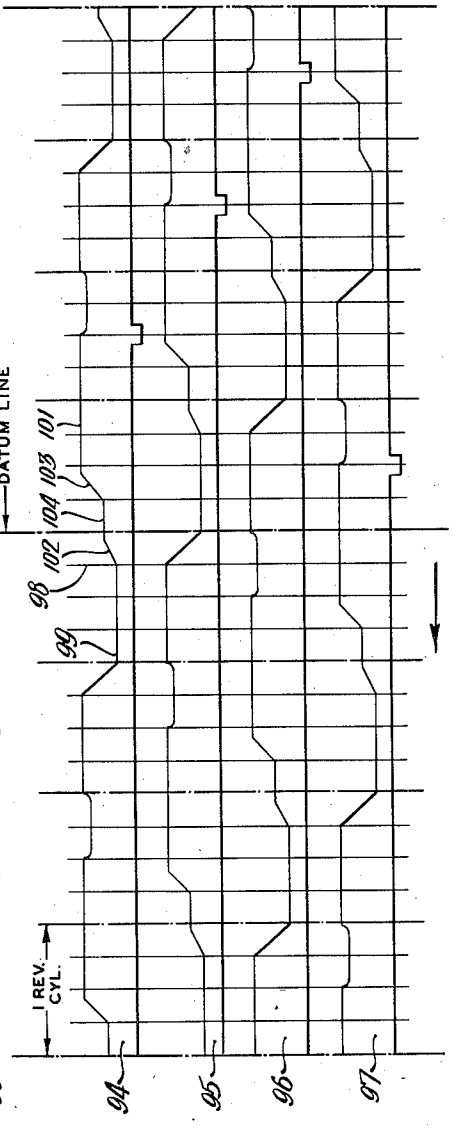


FIG. 18.

FIG. 19.



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JACK SELECTION MECHANISM FOR CIRCULAR KNITTING MACHINES

Robert Peel, Philadelphia, Pa., assignor to Fidelity Machine Company, Inc., Philadelphia, Pa., a corporation of Pennsylvania

Application September 19, 1957, Serial No. 684,950

9 Claims. (Cl. 66—50)

This invention relates primarily to circular hosiery knitting machines of multiple yarn feed type and more particularly to a method and mechanism for producing mesh fabrics on machines of that class.

The invention has a particular application to the finer gauge machines employed for production of sheer nylon hosiery, such for example as the 400 needle circular machine, wherein by reason of the added complication of the multiple yarn feed and of limitations in available space, the control of the needles to form tuck stitch mesh in desirable pattern presents a major problem.

The present invention presents a new principle of needle control whereby prior conventional mechanism for producing mesh fabrics on single feed circular machines may be adapted with slight modification for production of like fabrics on machines of multiple feed type.

The invention will be more readily understood by reference to the attached drawings, wherein:

Fig. 1 is a fragmentary side elevational view of a circular knitting machine of the type to which the invention relates;

Fig. 2 is a sectional view on enlarged scale taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view on the line 3—3, Fig. 2;

Fig. 4 is a sectional view on the line 4—4, Fig. 2;

Fig. 5 is a diagrammatic view representing a section of tuck stitch or mesh fabric as produced by the machine showing a prefered tuck stitch arrangement;

Fig. 6 is a similar view showing another possible distribution of the tuck stitches;

Fig. 7 is a diagrammatic view of the fabric itself with a tuck stitch arrangement corresponding to that shown in Fig. 5;

Fig. 8 is a diagrammatic view of the fabric illustrating a characteristic detail of the fabric structure;

Fig. 9 is a view in perspective of a stocking illustrating one mode of procedure in accordance with the invention;

Fig. 10 is a schematic view of the cylinder needle arrangement with reference to the tucking cam and yarn feed positions in producing the stocking illustrated in Fig. 9;

Fig. 11 is a schematic view of the needle jack arrangement corresponding to the needle arrangement in Fig. 10;

Fig. 12 is development or layout view of a part of the cylinder as viewed from the inside of the latter with reference more particularly to the jacks and the tucking cams;

Fig. 13 is a diagrammatic cylinder layout view showing the arrangement of the jack butts and their relation to the tucking cams;

Fig. 14 is a development of the rotary bank of mesh control cams as designed in conjunction with the jacks shown in Fig. 13 to produce the stocking of Fig. 9;

Fig. 15 is a view in perspective of a stocking illustrating an alternative mode of procedure;

Fig. 16 is a schematic view corresponding to Fig. 10 but with reference to the stocking of Fig. 15;

Fig. 17 is a schematic view corresponding to Fig. 10 but with reference to the stocking of Fig. 15;

Fig. 18 is a diagrammatic layout view similar to Fig. 12 but with reference to the stocking of Fig. 15, and

Fig. 19 is a development of the mesh cam bank corresponding to Fig. 14 but again with reference to the stocking of Fig. 15.

With reference first to Figs. 1 to 4 of the drawings, the invention contemplates the use of a rotary cam bank 1 to control the insertion and withdrawal of a set 2 of inclined tucking cams with respect to jacks 3 associated with the cylinder needles 4 of the machine. The cam bank 1 is continuously rotated in timed relation with the rotary movement of the needle cylinder 5 through medium of bevel gear 6 at the top of the bank and pinion 7 connected to the cylinder drive mechanism. In the present instance the bank 1 consists of four individual cams numbered 8, 9, 11 and 12 respectively in the drawings, and the tucking cams of the set 2 correspond in number and are identified by the numerals 13, 14, 15 and 16. The cams 8, 9, 11 and 12 act respectively upon the cams 13, 14, 15 and 16 to insert the latter cams through medium of a series of pivoted levers 17, 18, 19 and 21. The cams 13, 14, 15 and 16 are retracted in their guides 22, 22, when permitted to do so by cams 8, 9, 11 and 12, by springs 23 which are connected in pairs to the individual cams. The cams 13, 14, 15 and 16 may be inserted collectively, independently of the cams 8, 9, 11 and 12, by projection from its normal spring retracted position, shown in Figs. 1 and 2, of a plunger 24, such projection being effected by elevation of a pivoted dog 25 by a cam (not shown) on pattern drum 26 and by resultant actuation through rod 27 of a pivoted lever 28 engaged with the plunger. The cams of bank 1 may be elevated collectively out of engagement with the levers 17, 18, 19 and 21 by angular displacement about the axis of the bank of a plate 29, said displacement withdrawing bosses 31 from apertures 32 in support 33 and causing the bosses to ride on the upper surface of the support with consequent elevation of the plate and bank. The bank assembly is slidable on fixed pintle 34 and is held normally in the depressed position shown in the drawings by a spring 35. The plate 29 is connected by rods 36 and 37 and bell crank 38 to a dog 39 which is operatively associated with pattern drum 26 and is elevated by a suitable cam on the latter to displace the plate 29 as required. The drum 26 is rotated in conventional manner in timed relation with the cylinder 5 and the other moving parts of the machine.

Inclined tucking cams of this character associated with needle jacks and actuated by rotary cams of the character described have been previously used for needle control in production of mesh fabrics of the nature referred to above, and their use in a single feed machine is disclosed in United States patent application Serial Number 537,137 of Giorgio Billi. In that case, in which the jack-associated tucking cams and their rotary cam actuators were supplemented by an inclined cam similarly associated directly with the needles and by an additional cam element on the rotary cam bank for actuation of the needle cam, the device was well adapted to the production of tuck stitch or mesh fabrics of the character illustrated in Fig. 7 and, schematically, in Fig. 5 wherein the locations of the tuck stitches in the otherwise plain stitch fabric are indicated by the cross lines 41. In that fabric, wherein each course of stitches containing tuck stitches is separated from the adjoining like courses by an intervening full course of plain knitting, it was possible to insert and withdraw the tucking cams and also the supplemental needle cam

in conventional manner, utilizing the short butts to afford an initial partial insertion of the cams into the paths of the long butts with subsequent full insertion while in engagement with the latter, and withdrawing the cams while contacting the long butts by a first-step partial retraction to an extent maintaining long butt engagement while clearing the short butts and subsequent full withdrawal while in the short butt area. Each alternate course of plain and mesh knitting could thus be initiated and terminated sharply at a given line, and the rearrangement of the mesh cams required by the particular tuck stitch pattern could be made during the knitting of the plain courses and in a manner to afford complete courses of plain and mesh knitting without interruption or risk of damage to the machine elements.

In a two feed machine of the character to which this invention primarily relates, however, it is necessary for mechanical and economic reasons that the courses of plain stitches be produced exclusively from yarn fed from one feed station and that the courses containing tuck stitches be produced exclusively from yarn from the other feed station. In effect therefor the tuck stitch formation continues in every revolution of the needle cylinder and the prior mechanism is inadequate for control of the needles in the tucking operation under these circumstances.

The problem of control will be better understood by a consideration of the mode of operation of the cam system in the production of the fabric illustrated in Fig. 7. Each of the cams **8**, **9**, **11** and **12** is adapted to control the tucking operations in a single full row or course of knitting, and the cams act in succession and on successive courses. In a single feed machine this would mean that the cams in their tuck stitch function would act successively on alternate courses since in the fabric under consideration the courses containing tuck stitches alternate with courses of plain stitching. In a dual feed machine, however, the cams act in effect on successive courses since, as explained above the courses of plain stitches are produced from a separate yarn source and by an independent set of cams.

In the fabric shown in Fig. 7, a tuck stitch appears in every fourth wale and the tuck stitches in the adjoining courses are offset from each other course wise so that they form diagonal rows intersecting the wale lines. In the adjoining courses the extent of the offset is one wale. The pattern, therefor, requires the selection of every fourth needle for tuck formation and, in the 400 needle machine using four cams as described, a sequential repeat after every four complete revolutions of the cylinder during which the four cams have functioned in succession each in a single revolution. In a repeated sequence of this character, however, it is essential that all of the sequences start with the same needle and finish with the same needle, and this fact establishes an imaginary datum line extending precisely wale wise of the fabric and defining the start and finish of each sequence. In the very nature of the pattern it is inevitable that at one point in each sequence two tuck stitches will occupy adjoining wales in the same row of stitches, one at each side of the datum line. This is illustrated in Fig. 8. In this figure it is assumed that the sequence starts with a needle arbitrarily indicated as No. 1 of the full complement of 400 needles and immediately adjoining the datum line D, and that needle No. 1 is selected to make a tuck stitch. In the row of course of stitches *a* which begins at the datum line with this tuck stitch, the final tuck stitch must necessarily be made by needle No. 397, since in accordance with the pattern every fourth needle in the row has been selected for tuck stitch formation. In the next succeeding course *b*, with reference again to the datum line, the initial tuck stitch is formed by needle No. 2, and the final tuck stitch by needle No. 398. In the final row *d* of the four course sequence, therefor, the final tuck stitch would if formed by needle No. 400, immediately adjoin the datum line as illustrated. The succeeding sequence is then indicated by needle No. 1 which produces a tuck stitch immediately adjoining the datum line and therefor also immediately adjoining the final tuck stitch of the preceding sequence. These two tuck stitches occupying immediately adjoining wales, recurrent along the datum line at the beginning and ending of each four row mesh sequence (actually at the start and finish of every eight rows of knitting by reason of the intervening rows of plain stitches), would if unmodified constitute a visible departure in an otherwise uniform fabric and an apparent flaw. A single feed machine as previously indicated, has an inherent relative simplicity which facilitates the needle control required for production of tuck stitch patterns of this character, and also for avoiding the aforedescribed undesirable abnormality. The achievement of the same results with a similar cam system in a dual feed machine without undue complication of mechanism is the purpose of this invention.

Figure 9 of the drawings shows a stocking wherein the leg and foot, exclusive of the heel and toe reinforce areas and the welt, may be considered to consist of mesh fabric of the character shown in Fig. 7, and which has been produced on a dual feed machine having the cam system shown in Figs. 1 to 5. The welt consists of plain stitch fabric formed from yarn drawn from both feed sources, hereinafter referred to respectively as sources A and B. The heel and toe areas also consist of plain stitch fabric and are formed by oscillating the needle cylinder in conventional manner and from yarn drawn solely from source A. The alternate plain stitch courses of the mesh fabric of the leg and foot are formed from yarn drawn from source B; and the courses of the fabric which contain the tuck stitches are produced from yarn drawn from source A. As shown in Fig. 12, yarn source B has associated therewith the usual stitch cam **42** and lifting cam **43**, which may be considered to act continuously on all the needles during knitting of the entire stocking with exception of the aforesaid heel and toe areas. Associated with source A are the stitch cams **44** and **45**, the upper and lower intermediate cams **46** and **47**, and dividing cam **48** which function in conjunction with the aforedescribed jack cams in the tucking operations as hereinafter described.

For the purpose of describing the present invention, it may be considered that the cylinder contains 400 needles in two series of long and short butts respectively distributed as indicated in Fig. 10. This figure shows also the relative positions of the yarn feed stations and the tucking cams **2**. Since the datum line for the mesh fabric is made, arbitrarily, to coincide with the back center line of the stocking, the insertion and retraction of the cams **2** occurs at a point on the cylinder corresponding with the center of the short butt series, as indicated graphically in the drawing. The circle of 400 jacks underlying the needles and associated respectively with the latter, and with which the cams **2** are operatively associated, all as shown in Fig. 3, is illustrated in Fig. 11. The jacks are in three series indicated respectively by the numerals **49**, **51** and **52**. These three series comprehend all of the jacks of the circle with exception of one, numbered **53**, which differs from all the others and which lies between and separates the series **51** and **52**. Figs. 10 and 11 show the relative arrangement of the jacks with respect to the long and short butt needles. As indicated, insertion and withdrawal of the cams **2** occur at the junctures of the jack series **51** and **52**, the jack **53** being borrowed from one or other of these two series as hereinafter more fully described.

As shown in Fig. 12, all of the jacks have in common upper and lower butts, **54** and **55** respectively, for guiding engagement with the upper and lower edges **56** and **57** of a cam track **58**. In addition each of the jacks has a third butt for engagement with one or other of the cams **2**, these butts on the jacks of the series **51** and **52** being long butts and being indicated by reference

numeral 61 and the corresponding butts on the jacks of series 49 being short butts and being identified by the reference numeral 59. Also, throughout the jack circle, and excluding only jack 53, the jacks are arranged in successive groups of four, and in each such group the butts 59 or 61 as the case may be, are positioned each at a different level corresponding respectively to the positions of the cams 13, 14, 15 and 16 for engagement individually with the latter. In advance of the position of the cams 2 with reference to the direction of cylinder rotation, the cam track 56 through medium of the butts 54 and 55 will elevate the jacks to an extent bringing them to the bottoms of the needles 4 at tuck level, as shown in Fig. 12. If any one of the cams 2 is retracted the corresponding jack of each group of four will pass the cam position without further elevation, and the needles overlying those jacks will move into yarn feed station A at the tuck level. The other three jacks of each group, assuming that the corresponding cams of set 2 are fully inserted, will be elevated by the cams and will move into feed station A at a higher level.

This jack action and the effect thereof on the knitting process will be more readily understood by reference to Fig. 12. It will be apparent that as the jacks 3 approach the cams from the right, they will be elevated to a position wherein the cams, if inserted, will intersect the paths of the butts 61, and wherein also the upper ends of the jacks will lie in immediate proximity to the lower ends of the needles 4 at tuck level as the latter having passed yarn feed station B are moving toward feed station A any jack whose butt meets one of the cams will be elevated further and will thereby elevate its corresponding needle to an extent such that the dividing cam 48 will deflect the needle upwardly to the latch clearing level, preparing the needle to cast the loop carried from feed station B in normal manner by action of the cams 46 and 44. The jack whose butt fails to meet one of the cams will leave its corresponding needle at tuck level in which the needle butt will be acted upon by cam 48 to depress the needle for subsequent re-elevation by cam 47 to a point at which the needle will receive yarn at station A while still retaining the loop carried from station B above latch clearing position. This needle will not cast the loop at station A and will produce a tuck stitch. All of the jacks after passing the cams 2 will be returned by their butts 54 and 55 and cam groove 56 to their lower levels in which they are inoperative with respect to the needles 4.

With reference again to Figs. 9, 10 and 11, it will now be evident that with the datum line located at the back center of the stocking the tucking cams 2 will have to be inserted in, and withdrawn from, the jack circle in the segment occupied by the long butt jack series 51 and 52 which coincide with the short butt needles. In accordance with the invention, and in order that the cams may be withdrawn from the circle of the jack butts and reinserted without interruption in the formation of the mesh pattern, and without interference with the jack butts, I provide each of the jacks of the two long butt series 51 and 52 with auxiliary butts which are substantially shorter than the butts 54, 55, 59 and 61. These ultra short butts are identified in the drawings by the reference numeral 62. It will be noted that in some of the jacks the auxiliary butts are above the main butts 61 and that in others the auxiliary butts are below the main butts. In each instance the auxiliary butt is arranged relative to the main butt of the same jack, and to the cams 2 so that when the cam located in the path of the main butt is in course of withdrawal and incapable of completely elevating the jack, another of the cams then fully inserted will be engaged by the auxiliary butt which will assume the jack elevating function and move the jack to the fully elevated position. The auxiliary butt will function in like manner to elevate any jack moving into the tucking cam station whose main butt would otherwise interfere with the reinsertion of its tucking cam.

These functions of the auxiliary butts can best be visualized by reference to Figures 13 and 14 which, respectively, show developments of the cylinder jack circle and of the rotary cam bank 1. In Figure 13, the cams 13, 14, 15 and 16 are shown for convenience on the datum line. The cylinder and the cam bank 1 are timed relatively for eight revolutions of the cylinder to one of the cam bank. One full revolution of the cylinder corresponds, therefor to one main division of the cam bank as indicated; and each subdivision of the cam bank corresponds to a 90° turn of the cylinder. The cams 8, 9, 11 and 12 each comprises high parts or lobes 63, which coincide with a fully inserted position of the associated tucking cam; low parts 64 which coincide with a fully withdrawn position of the associated tucking cam; and a depression 65 in each of the lobes 63 which coincides with a partially retracted position of the tucking cam wherein the cam intercepts the long and short butts 61 and 59 but fails to intercept the auxiliary butts 62.

As the cams are shown in Figure 14, at the datum line the cam 13 associated with rotary cam 8 is fully withdrawn but is about to be reinserted, the reinsertion movement extending over 180° of cylinder rotation as indicated by incline 66. After 90° of this movement the cam 13 will have been inserted sufficiently to intercept the short jack butts 59. The cam 14 will also be fully withdrawn after a retractive movement covering 90° of cylinder rotation as indicated by incline 67. The cam 14 will remain retracted over one full revolution of the cylinder before the reinsertion movement on incline 68 begins The cam 15 will be fully inserted, having just completed a period of partial retraction extending over 180° of cylinder movement. The cam 16 will be fully inserted and will remain so for a dwell of 180° of cylinder movement followed by a period of partial retraction, by action of the recess 65, and a subsequent full reinsertion period.

Let is now be assumed that the cylinder is turned back 90° from the position shown so that the leading end of long butt series 52 coincides with the datum line. The cam bank 1 will be turned back correspondingly through one sub-division so that the line 69 coincides with the datum line. The jacks 71, 72, 73 and 74, considered as one of the operational groups of four adjoining jacks previously described will now lie together on or immediately adjoining the datum line. Cam 13 will be fully withdrawn and will remain so for 90° of cylinder rotation; cam 14 will be fully inserted but about to be retracted over the next 90° movement of the cylinder; cam 15 will be slightly retracted so as to avoid the auxiliary butts 62 and will remain so for the next 90° cylinder movement; and cam 16 will be fully inserted and will also remain there for the next 90° of cylinder movement.

Under these conditions the cam 13 will be withdrawn from the path of butt 61 of jack 71, and the cam 15 will be retracted sufficiently to avoid the auxiliary butt 62, so the jack 71 will pass through the cams 2 at tuck level. The needle overlying this jack will then produce a tuck stitch. According to the mesh pattern previously described the other three jacks 72, 73 and 74 of this group of four will be elevated by their respective cams 14, 15 and 16. As noted, cam 14 is in process of withdrawal but it is unimportant whether or not it acts to fully elevate jack 72 through butt 61 of that jack since the auxiliary butt 62 and cam 16 take over the elevating function, the latter cam being fully inserted at this juncture. Cam 15, while partly retracted is still in position to engage the main butt 61 of jack 73 to elevate the latter to knitting level; and jack 74 is similarly elevated through its main butt by cam 16.

As the cylinder approaches the end of this 90° of rotary movement, the leading jack 75 of the terminal group of series 52 (considering this group as constituted by jacks 75, 76, 77 and 53) will pass the cams 2 at tuck level in

the same manner as jack **71** of the leading group and will thereby form the final tuck stitch of the particular course, the initial tuck stitch of that course having been produced at the beginning of this 360° of cylinder rotation by action of leading jack **78** of the initial group of jack series **51** which includes also the jacks **79, 81** and **82**. The jacks **76** and **77** will be elevated to knitting levels, the former independently of cam **14** (now almost completely withdrawn) by action of the auxiliary butt **62** on fully inserted cam **16**, and the latter by action of its long butt on cam **15** which is only slightly retracted as described.

Jack **53** will also be elevated to knitting level, and this elevation occurs on every cylinder revolution by reason of the provision on this jack of two long butts **83** and **84** respectively which are located respectively for interception by the cams **13** and **15**. By reference to Figure 14 it will be noted that these cams always occupy reverse positions, i. e. when one is withdrawn from the jack circle, or is in process of insertion or withdrawal, the other is inserted to an extent intercepting the long butts. The cams thus act jointly to elevate jack **53** to knitting level on every revolution, the result being a wale composed solely of plain knit stitches immediately adjoining the datum line as indicated at **80** in Fig. 8. This breaks the continuity of the mesh pattern but only to the extent of preventing the condition wherein, as described above, two tuck stitches occupy adjoining wales in the same course.

When the cylinder and the rotary cam bank occupy the positions in respect to the datum line shown in Figures 13 and 14, the cam **13** is beginning its insertion movement. This movement continues over a cylinder rotation of 180° and a 22½° movement of the cam **8** of the rotary bank. It is evident that without means to the contrary the cam **13** during insertion would foul the main butts of the series **51** jacks. The avoidance of such interference is another function of the auxiliary butts **62**. Since, for development of the desired mesh pattern, the course initiated at this point must have its first tuck stitch formed by action of jack **79**, the preceding jack **78** and also the jacks **81** and **82** must be elevated to knitting positions. The jack **78** is so elevated by action of its auxiliary butt **62** on fully inserted cam **16**, and this elevation has the effect of clearing the main butt **61** from the path of the cam **13** as it moves inwardly toward the jack circle. Cam **13** will not be advanced sufficiently to engage the auxiliary butt of jack **79**, and since cam **14** is fully withdrawn the jack **79** will pass the cams **2** at tuck level to produce a tuck level to produce a tuck stitch as required. Cams **15** and **16** will engage the main butts **61** of jacks **81** and **82** respectively to fully elevate the jacks and to raise the associated needles to knitting level.

At the end of the 90° movement of the cylinder from the position shown in Figure 13, or of the corresponding 22½° movement of the rotary cam bank, the cam **13** will be halfway in and will at that point be sufficiently advanced to engage the short butts of the jacks of the series **49**. During this entire inward movement the jacks of series **51** which carry long butts in line with cam **13** are elevated independently of that cam by action of the auxiliary butts on cam **16** which during this period is fully inserted. In this way the long butts are diverted from in-moving cam **13** leaving the cam free for insertion. At the same time the jacks are actuated in accordance with the desired mesh pattern.

It will be apparent, therefor, that the auxiliary butts perform plural functions. First, by taking over the function of the main butts they permit withdrawal of the tucking cams in the middle of the two long butt jack series **51** and **52** without leaving any of the jacks, which pattern wise require elevation, in an intermediate or only partly elevated position with consequent disruption of the mesh pattern. Secondly, they provide for insertion of the cams in the same area by diverting the main butts which would otherwise interfere from the path of the cam as it moves inwardly, again assuming the function of the main butts to actuate the jacks as required by the pattern.

It will be apparent that selection of the datum line position is an arbitrary one and by way of illustration I have shown it placed in Figure 15 to one side of the rear centerline of the stocking extending from the forward corner of the heel pocket. Since the heel is formed on the short butt needles this corresponds to one end of the short butt needles series, as illustrated in Figure 16. On the jack circuit it corresponds to the juncture of the long butt jack series **86** and the short butt series **87**, the jacks of this latter series being provided with auxiliary butts in accordance with the principle of this invention. In this case, however, the auxiliary butts are confined to the short butt series **87** embracing only 90° of the jack circle and containing only one half of the short butt jacks, the remaining jacks having short butts being contained in the series shown at **88**.

The arrangement of the auxiliary butts on the jacks of series **87** and their relation to the tucking cams **89, 91, 92** and **93** and to the cams **94, 95, 96** and **97** of the rotary cam bank is illustrated in Figures 18 and 19. If it be assumed that the cylinder is turned back 90° so that the leading jack of series **87** lies at the datum line, and if the rotary cam bank be set back correspondingly i. e. so that the subdivision line **98** lies on the datum line, then the cam **89** is just beginning an insertion movement; the cam **91** is just beginning a withdrawal movement; the cam **92** will be retracted to an extent avoiding the auxiliary butts while still engaging the long and short butts; and cam **93** is fully inserted. In this case, however, the insertion of cam **89** takes place in effect in two steps, due to a modification in the form of cam **94**. From the low part **99** the cam rises to the high part **101** in two inclined sections **102** and **103** with an intervening dwell at **104**. The section **102** extends over slightly less than one of the subdivisions shown in Figure 19 and therefor corresponds to a cylinder movement of less than 90°. This section will insert the cam **89** to an extent such that the cam will intercept the long butts of the jacks while avoiding the short and auxiliary butts. When therefor the cylinder and the rotary cams have reached the datum line position shown in the drawings the cam **89** will be in position to intercept the leading long butt jack of series **86**, and the rest of the insertion movement can take place during the next 180° of cylinder movement in the long butt series. Actually, as indicated at **103** in Figure 19, full insertion is effected before completion of the full 180° of cylinder movement so that the cam will be in position to intercept the short butts of the series **88** jacks before the latter move into the tucking cam station. By thus advancing the cam **89** in the sector of the short butt jacks **87** to an extent intercepting the long butts of the following jacks **86**, it is possible to confine the auxiliary jacks to the short butt jacks of series **87**. Similar provision is made in each of the cams **95, 96** and **97** for the two step insertion of the cams **91, 92** and **93**.

In the 90° of cylinder movement in which the cams **89, 91, 92** and **93** are acting on the jacks of series **87**, the auxiliary butts operate in essentially the same manner previously described to assume the function of elevating the jacks requiring elevation and whose main butts are traversing a tucking cam in process of withdrawal, so that all of such butts may be completely elevated independently of their main butts. The insertion of the cams **89, 91, 92** and **93** is effected without assistance of auxiliary butts in the manner described above.

As previously stated, the position of the datum line is arbitrary, and does not necessarily coincide with the tucking cams as herein shown for purposes of illustration and description of the invention. It will be noted also that the mesh pattern may be modified as desired

by relative adjustments or redesign of the cams of the rotary bank and corresponding rearrangement of the jacks and their butts. One such mesh pattern now in wide use is shown in Figure 6 wherein a single repeat of four tuck stitches is shown within the area embraced by broken lines. The mechanism shown in the drawings is also susceptible of considerable modification without departure from the principle of the invention as defined in the following claims.

I claim:

1. In a circular knitting machine for producing a patterned mesh fabric composed of tuck stitches interspersed with plain stitches, the combination with the cylinder and cylinder needles of said machine and with stitch cams operative on said needles to form the knitted stitches, of means including needle jacks in the cylinder for directing the needles to the stitch cams at knitting and tucking levels selectively, a main butt on each jack, said butts being systematically arranged in a plurality of different levels, a jack cam for each butt level individually insertable and retractable into and from engagement with the butts in its particular level, said cams being arranged in vertical series in a common camming station, means for so inserting and retracting the cams in predetermined sequence with at least one said cam in its inserted position when another of the cams is in transition between positions of insertion and retraction, and an auxiliary butt on each of a consecutive number of said jacks adapted when its main butt cam is in the said transition stage to engage another of the cams which is then inserted to actuate the jack at the camming station independently of its main butt.

2. In a circular knitting machine, a circular series of needle jacks divided circumferentially into a plurality of equal groups, a main butt on each jack, said butts arranged in a plurality of different levels corresponding in number to the jacks in the individual group, with the butts in each said group occupying the different levels respectively and with a uniform arrangement of the butts in the several groups, a jack cam for each butt level individually insertable and retractable into and from its particular butt circle, said cams being arranged in vertical series in a common camming station, means for inserting and retracting the cams in predetermined sequence with at least one said cam in inserted position when another is in transition between positions of insertion and retraction, and an auxiliary butt on each of a consecutive series of said jacks adapted when its main butt cam is in the said transition stage to engage another of the cams which is then inserted to actuate the jack at the camming station independently of the main butt.

3. A circular knitting machine according to claim 2 wherein the means for inserting and retracting the jack cams comprises a bank of rotary cams comprising an individual cam for each of the jack cams, said individual cams being relatively fixed in respect to each other.

4. A circular knitting machine according to claim 3 including a cylinder containing said jacks and mechanism for rotating the cylinder and the cam bank in timed relation with each other.

5. In a circular knitting machine, a rotary cylinder, a circular series of needle jacks in said cylinder divided circumferentially into equal groups, a main butt on each jack, said butts being arranged in a plurality of levels corresponding in number with the jacks of the individual group with each butt in the individual group occupying a different one of said levels and with the butts uniformly arranged in the several groups, a jack cam for each butt level individually insertible and retractable into and from its particular butt circle, said cams occupying a common camming station and being arranged in vertical series in said station, means for inserting and retracting the cams in predetermined sequence whereby in each revolution of the cylinder one of the cams occupies the inserted position while another of the cams is in process of insertion, and an auxiliary butt on each jack of a group arranged so that when the main butt cam of any of the jacks is in process of insertion the auxiliary butt is engaged with the cam then inserted so as to actuate the jack independently of the main butt with consequent avoidance of interference between the main butt and its inwardly moving cam.

6. In a circular knitting machine, a rotary cylinder, a circular series of needle jacks in said cylinder divided circumferentially into equal groups, a main butt on each jack, said butts being arranged in a plurality of levels corresponding in number with the jacks of the individual group with each butt in the individual group ocupying a different one of said levels and with the butts uniformly arranged in the several groups, a jack cam for each butt level individually insertible and retractable into and from its particular butt circle, said cams occupying a common camming station and being arranged in vertical series in said station, means for inserting and retracting the cams in predetermined sequence whereby in each revolution of the cylinder one of the cams occupies the inserted position while another of the cams is in process of retraction and an auxiliary butt on each jack of a group arranged so that when the main butt cam of anyone of the jacks is in process of retraction the auxiliary butt is engaged with the cam then inserted so as to actuate the jack independently of the main butt.

7. In a circular knitting machine, a rotary cylinder, a circular series of needle jacks in said cylinder divided circumferentially into equal groups, a main butt on each jack, said butts being arranged in a plurality of levels corresponding in number with the jacks of the individual group with each butt in the individual group occupying a different one of said levels and with the butts uniformly arranged in the several groups, a jack cam for each butt level operative on the said butts when inserted to move the jacks to a different level and avoiding the butts when retracted, said cams occupying a common camming station and being arranged in vertical series in said station, means for readjusting the cams in each revolution and opposite the same segmental area of the cylinder so that in each revolution of each repetitive cycle comprising a plurality of revolutions equal in number to the cams, a different set of jacks of the respective groups less than the total number is selected for movement to the said different level, and an auxiliary butt on each of the jacks within the said readjustment area arranged so that when its main butt cam is in process of transition between the inserted and retracted positions the auxiliary cam will engage another of the cams then inserted to move the jack to the said different level independently of the main butt.

8. A circular knitting machine according to claim 7 wherein the said cycles begin and end with the same and adjoining jacks respectively, and wherein one of said adjoining jacks has a plurality of butts arranged with respect to each other and to the cams so that one at least of the butts will intercept a cam on each revolution for displacement thereby to the said different level.

9. In a circular knitting machine, a cylinder, an annular series of needle jacks in said cylinder, a main butt on each jack, said butts being at a plurality of different levels, a jack-actuating cam coactive with the butts at each level and being mounted for insertion into the respective butt circles and for retraction from said circles, mechanism operating in timed relation with the cylinder for actuating the cams to effect said insertion and retraction within a given segmental area of the cylinder wherein the jacks contain butts of corresponding length, said mechanism comprising means for sequential operation of the cams affording actuation of the jacks in predetermined pattern and so that one at least of the cams is fully inserted while others are in transition between the inserted and retracted positions, and an auxiliary butt on each of the jacks in said segmental area arranged with

respect to its companion main butt and to the cams so that when its main butt cam is in process of transition the auxiliary butt will engage another of the cams then inserted to actuate the jack independently of the main butt.

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