United States Patent

[11] 3,603,116

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Continuation of application Ser. No. 726,374, May 3, 1968, now abandoned, continuation-in-part of application Ser. No. 364,178, May 1, 1964, now abandoned,

[54] **SEAMLESS STOCKING AND METHOD OF KNITTING POCKETS THEREIN**
6 Claims, 23 Drawing Figs.

[52] **U.S. Cl.** **66/187,** 66/49, 66/178
[51] **Int. Cl.** **D04b 9/56**
[50] **Field of Search** 66/183–187, 170, 178, 169, 40, 49, 42

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Primary Examiner—Ronald Feldbaum
Attorney—Polachek & Saulsbury

ABSTRACT: A method of knitting tubular fabric with integral pockets is described. The pockets are formed by partial courses of different length. All complete circular and partial courses are knitted in the same direction. Parts of a circular knitting machine involved in performing the method are described. The method is described in connection with forming heel and/or toe portions of a stocking.

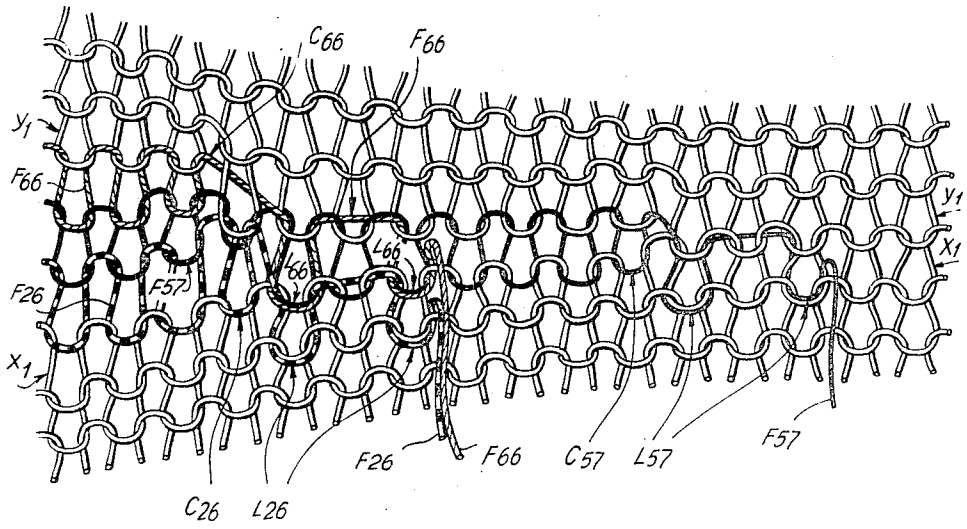

Fig.1

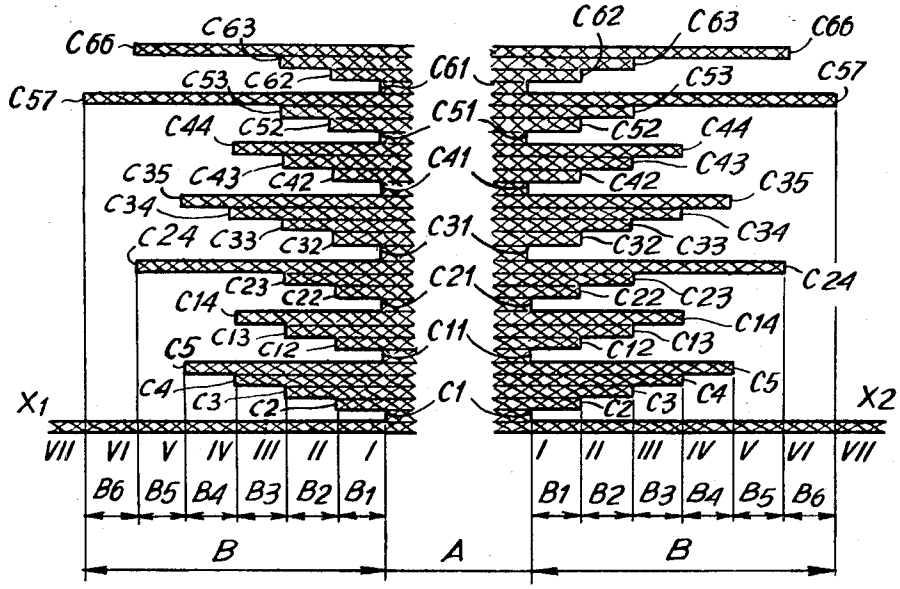

Fig.2

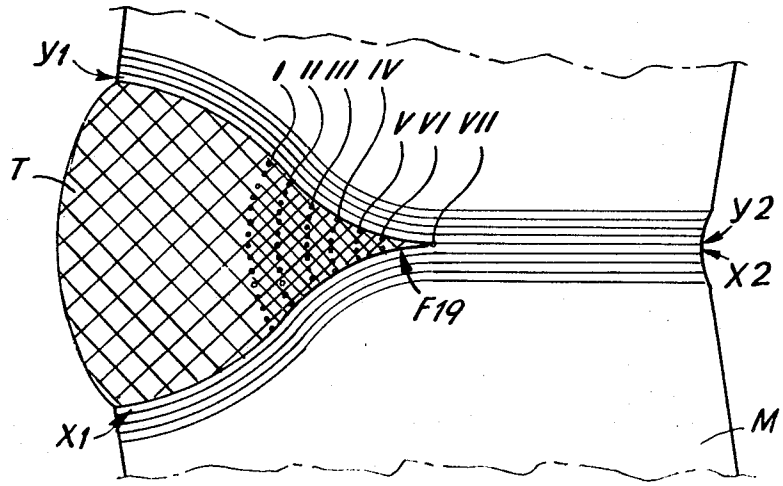

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Fig.3

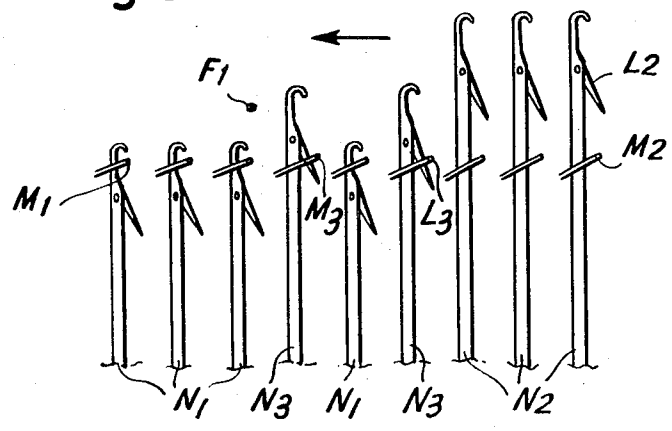


Fig.4

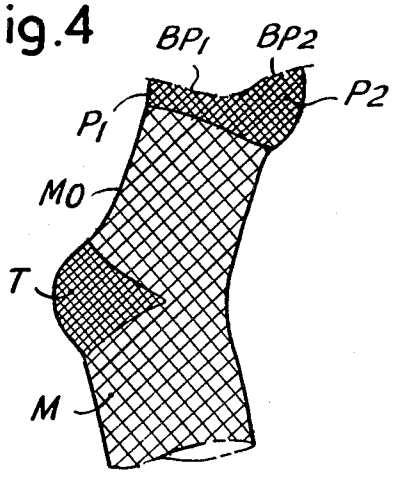


Fig.5

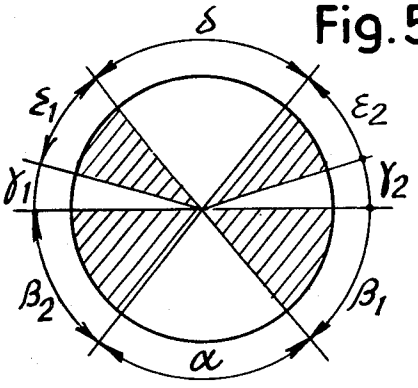
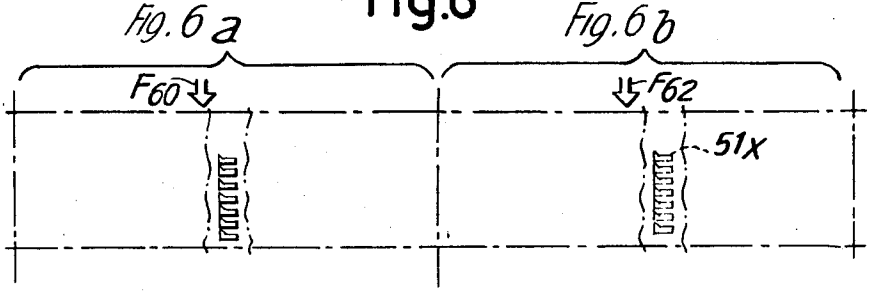


Fig.6



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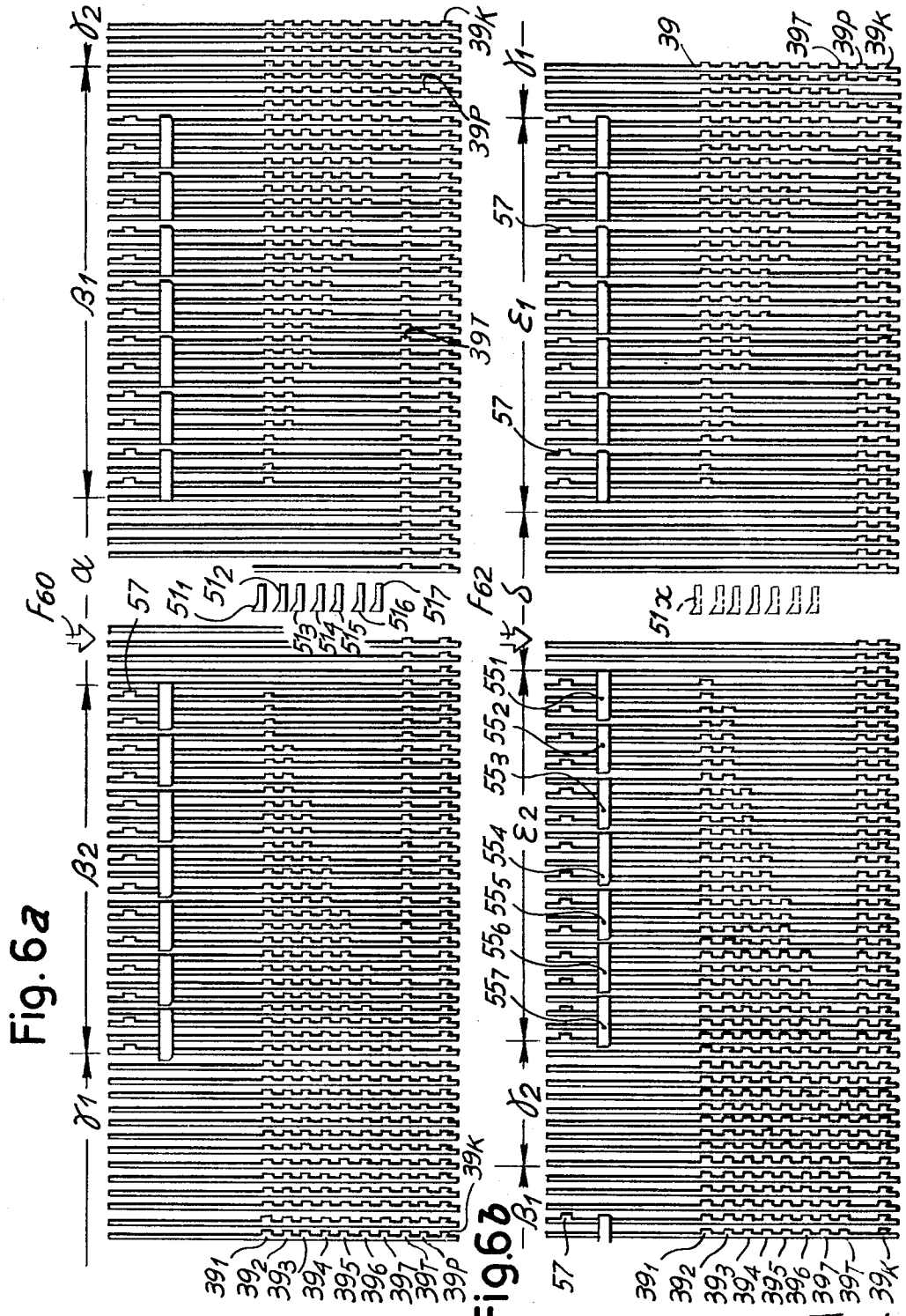

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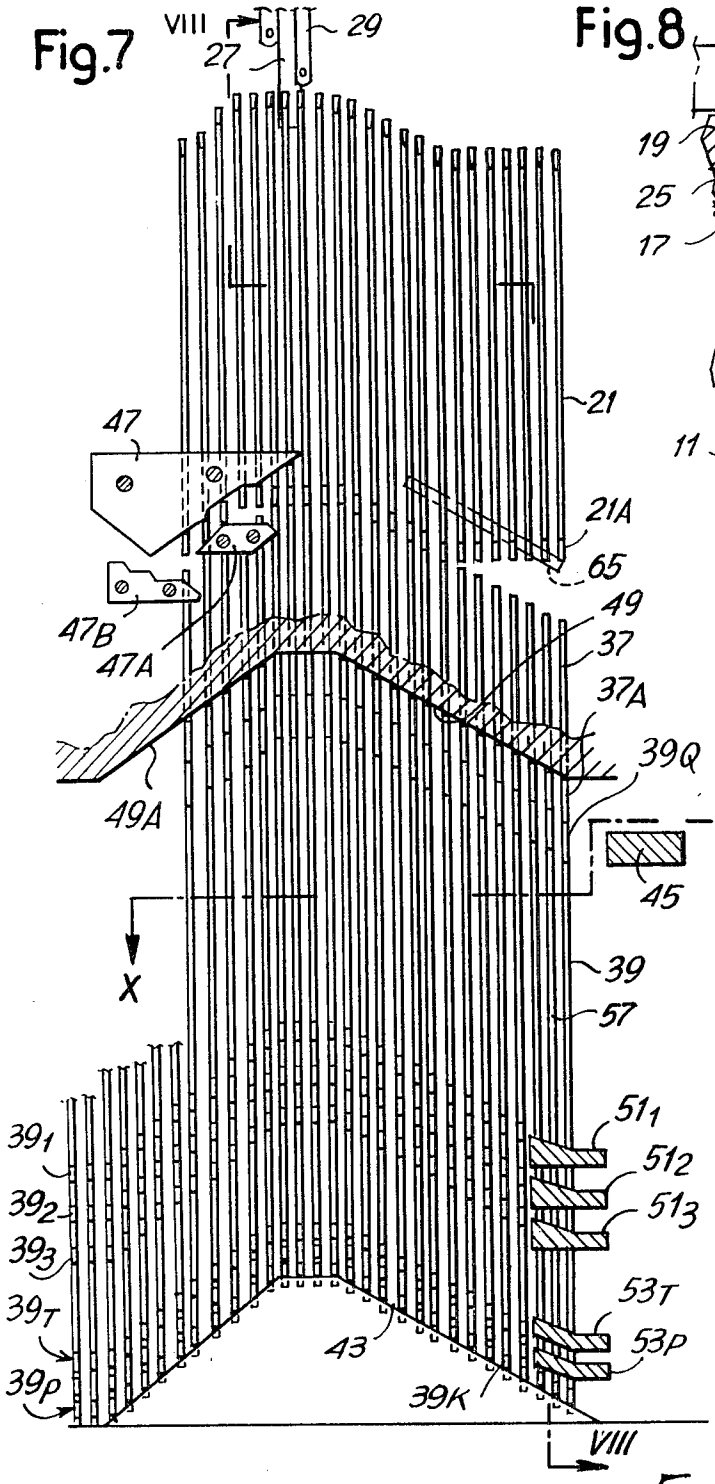
Fig.7



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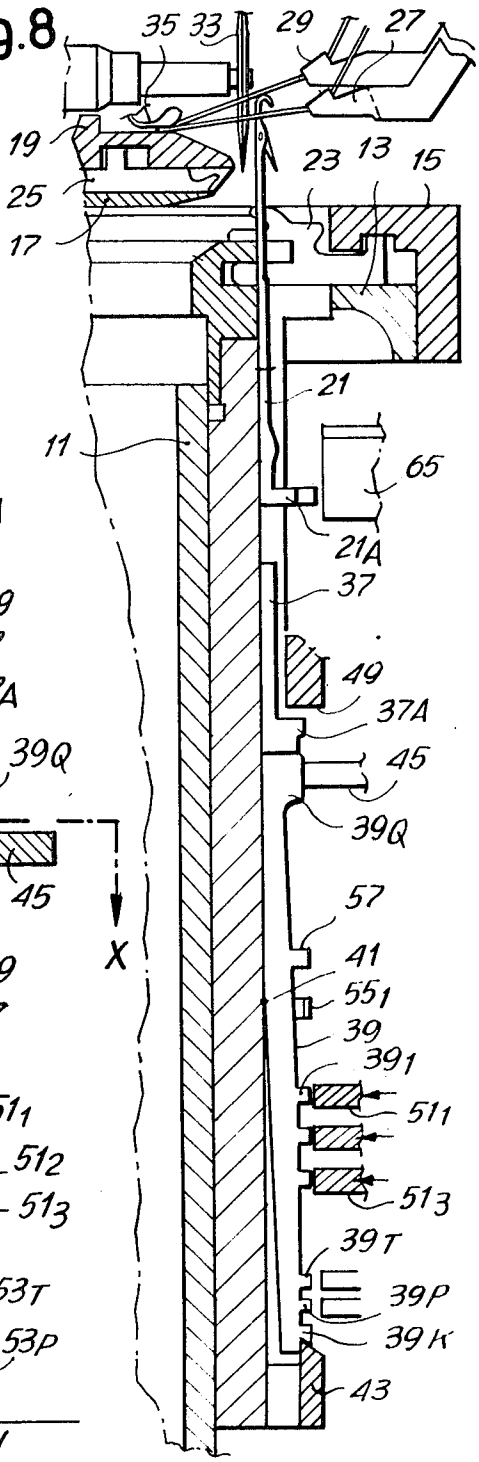

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Fig.9

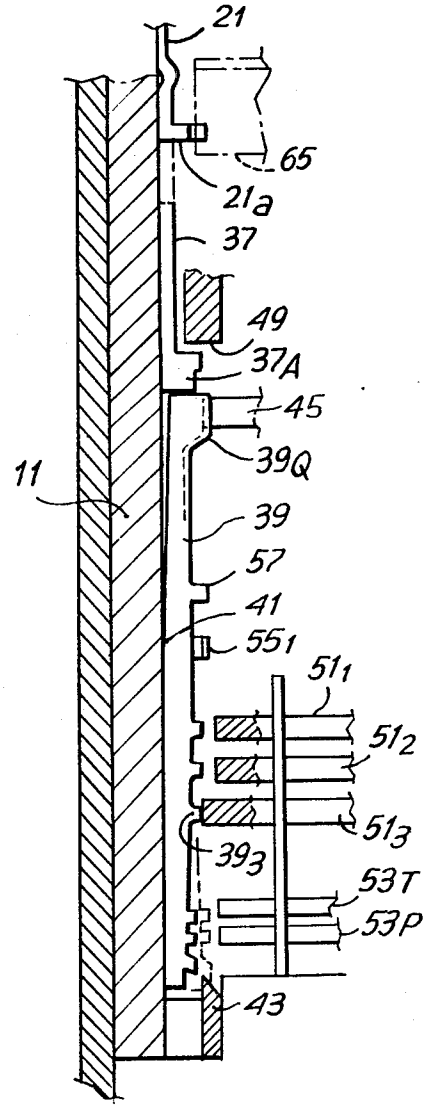

Fig.10

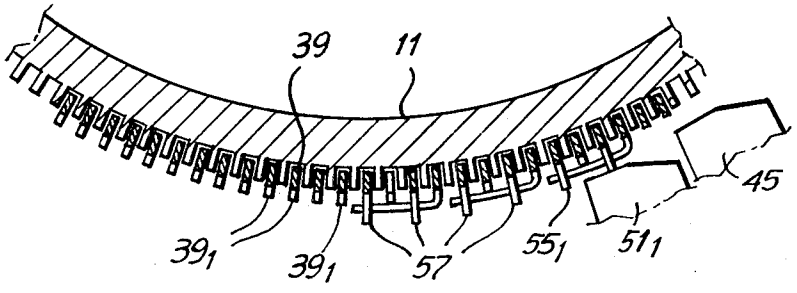

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Fig.11

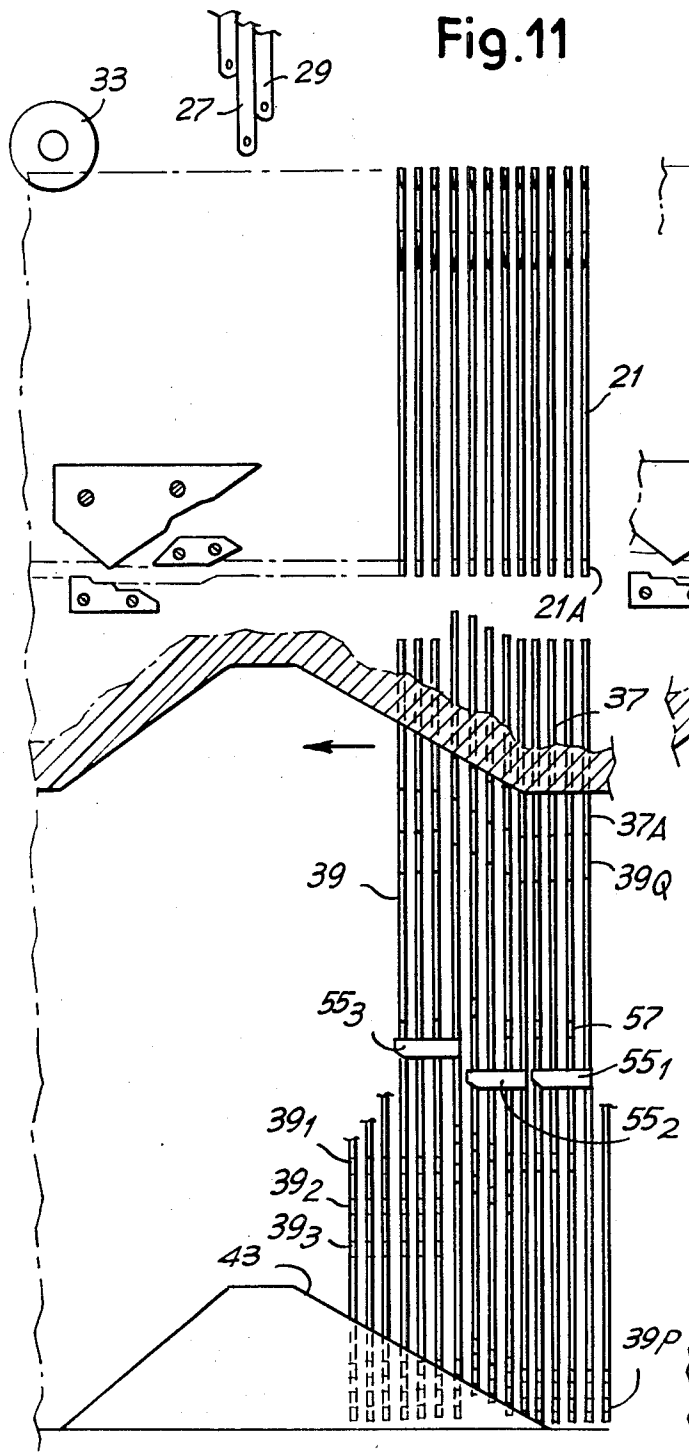

Fig.12

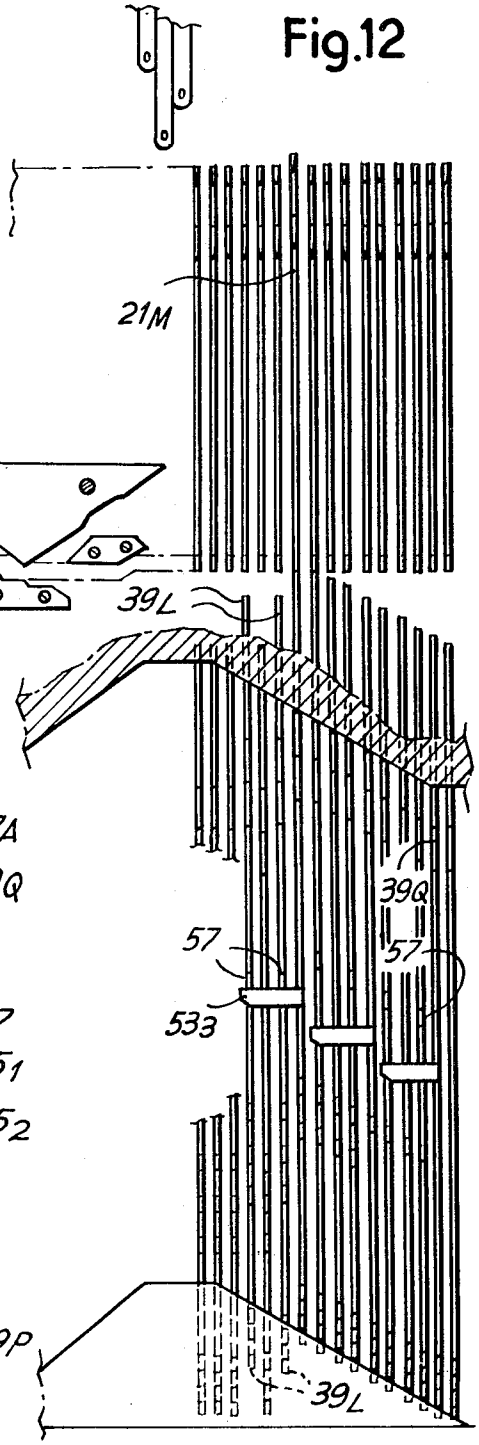

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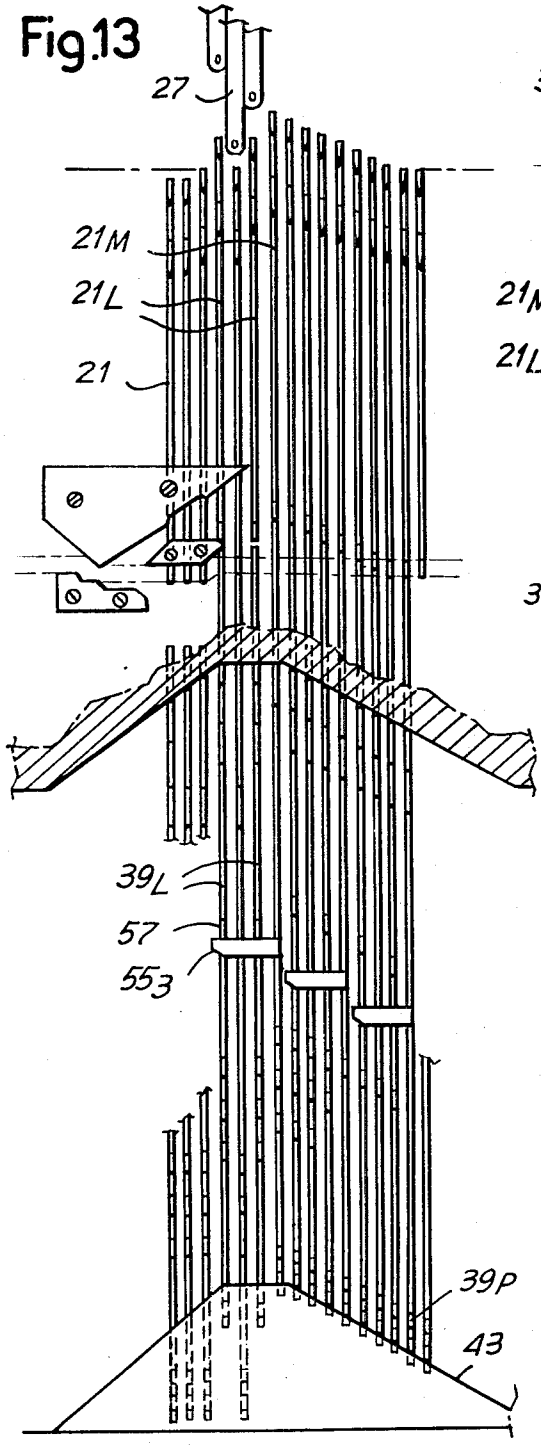
Fig.13



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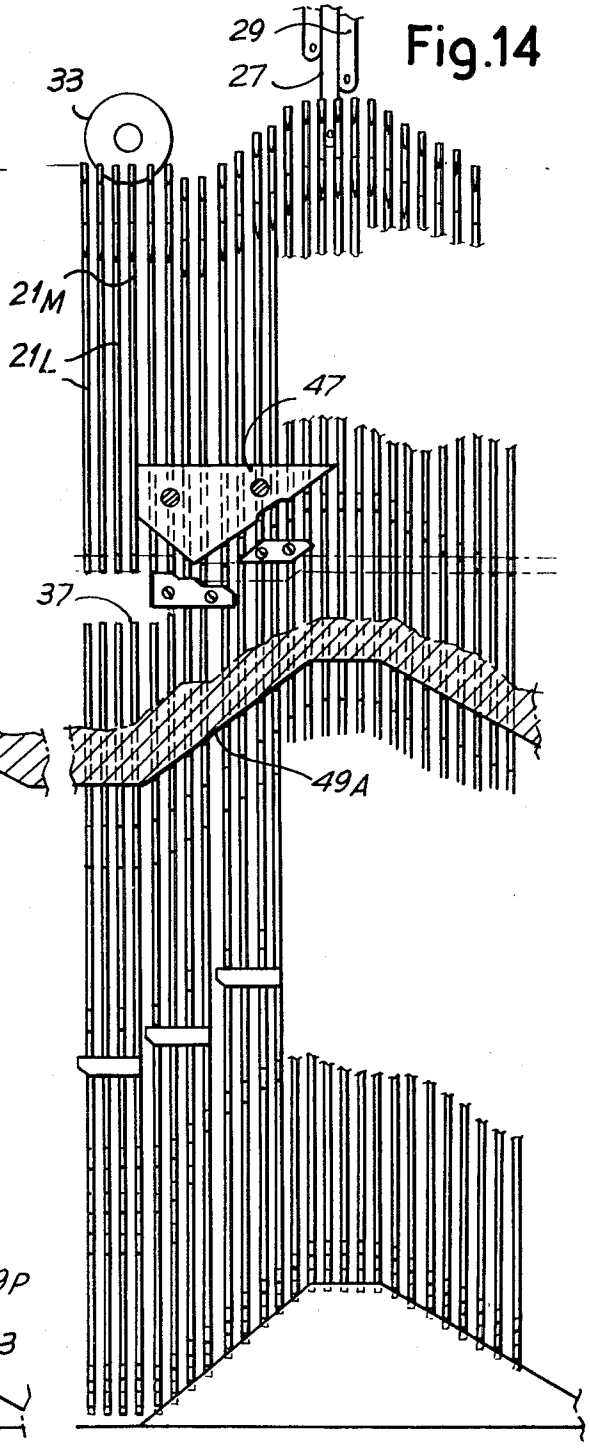

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Fig. 15

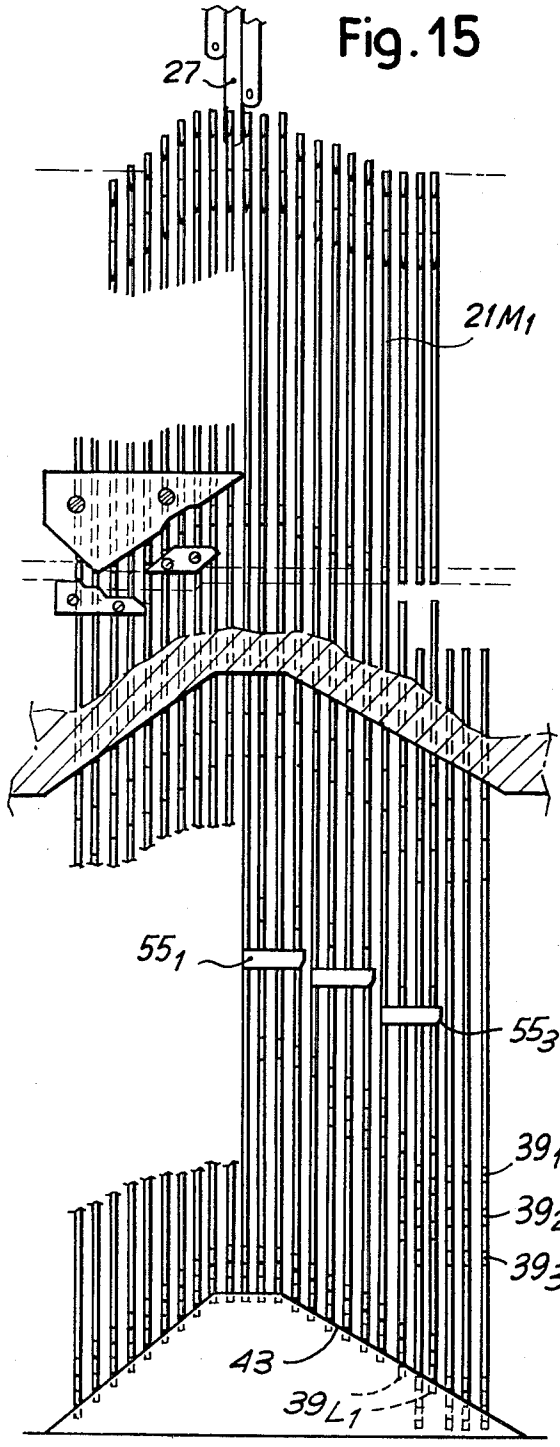

Fig. 16

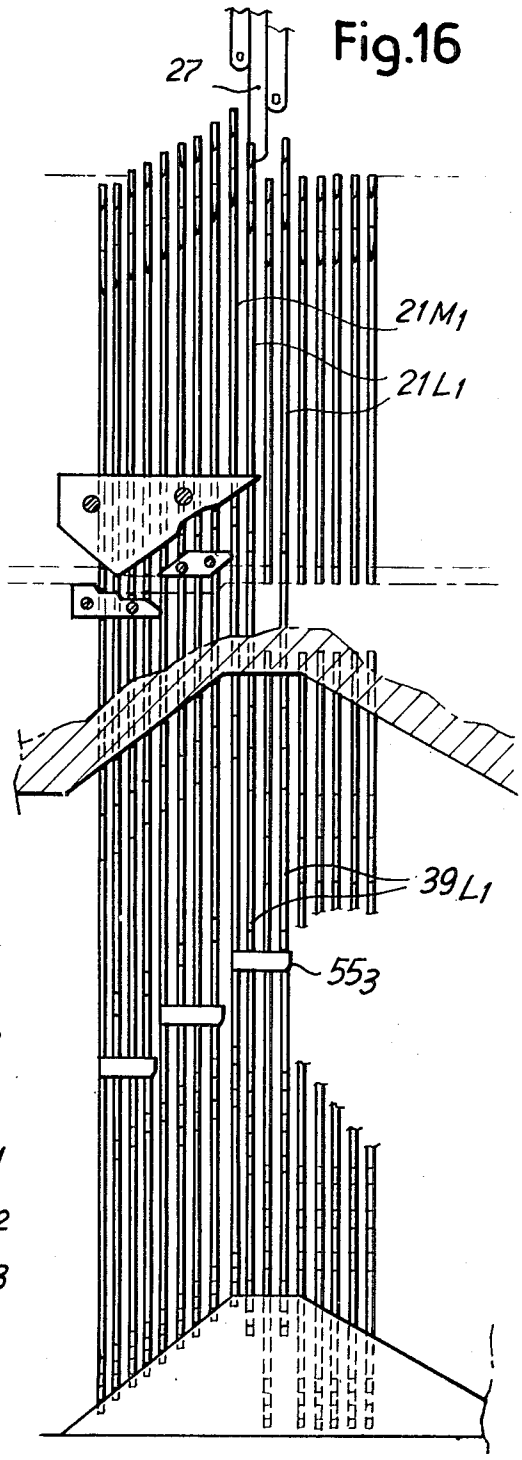

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Fig. 17

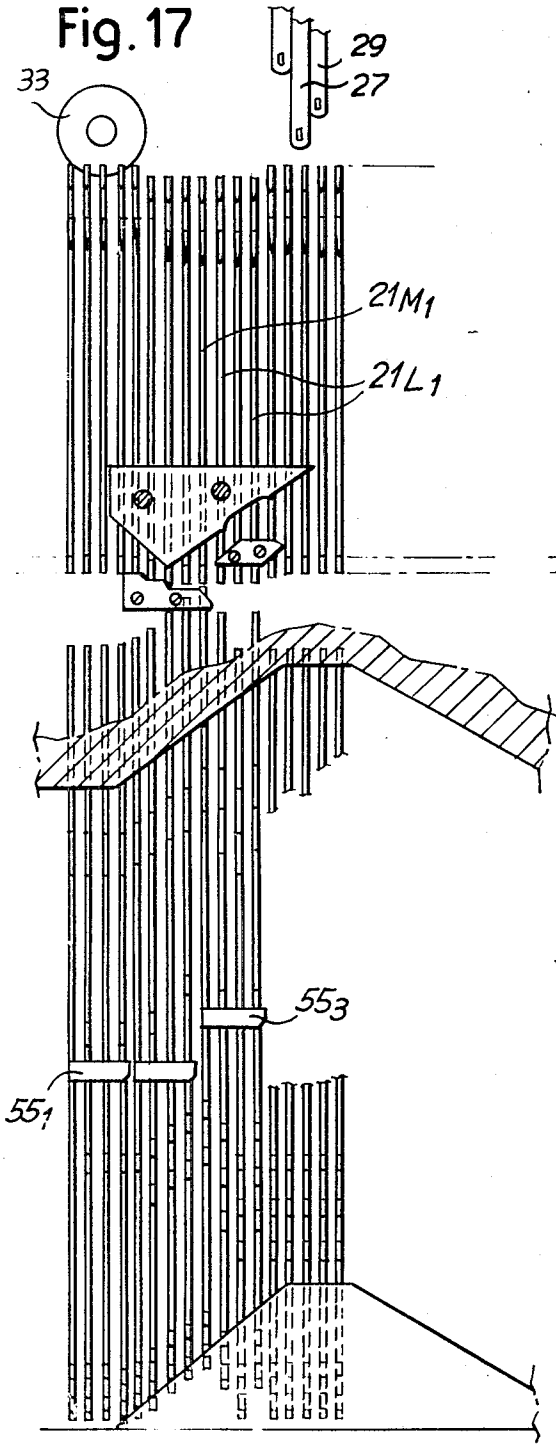

Fig. 18

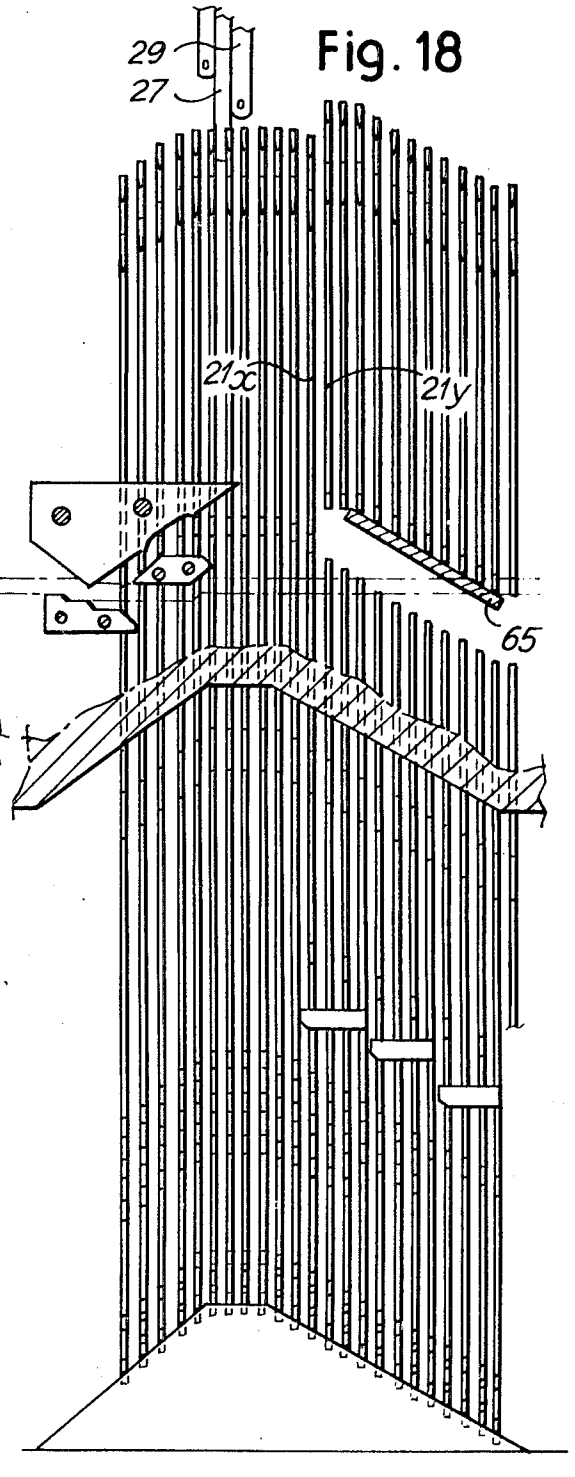

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Fig. 19

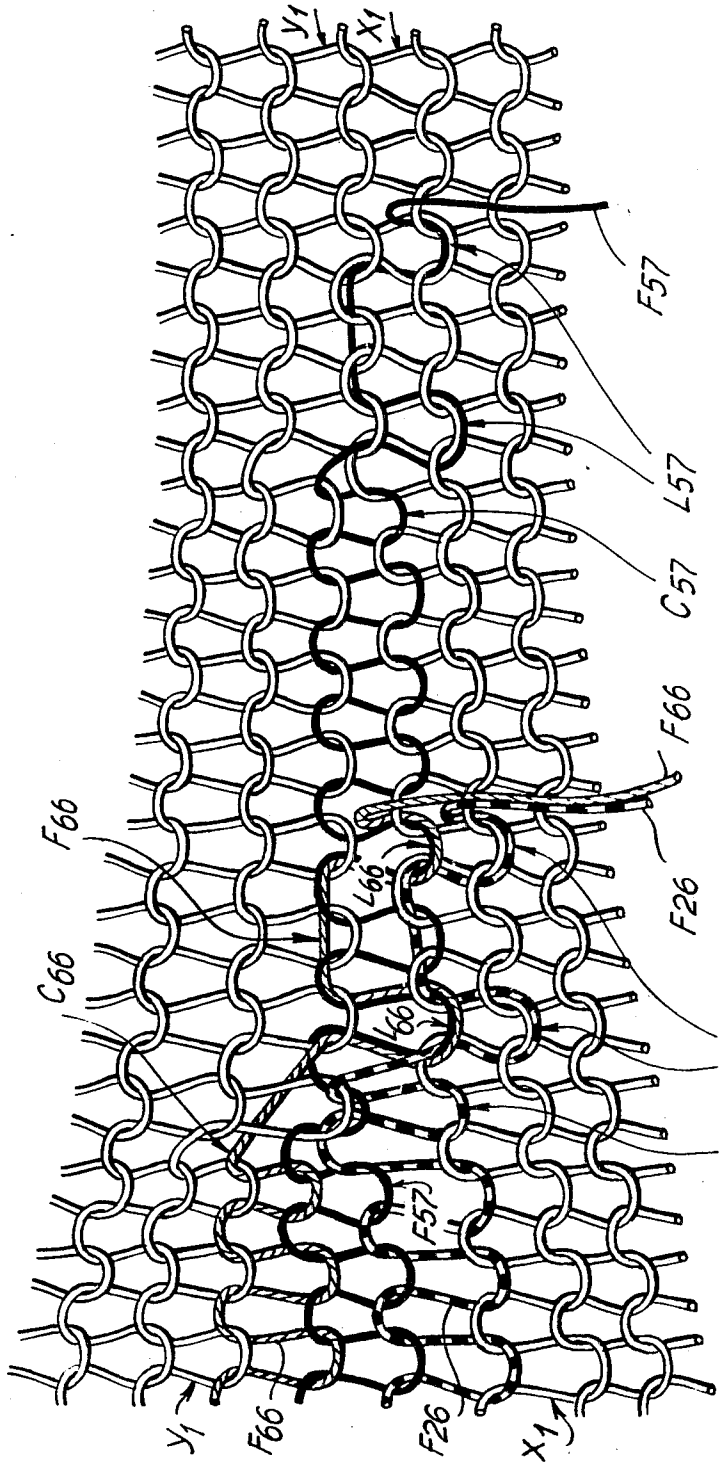

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Fig. 20

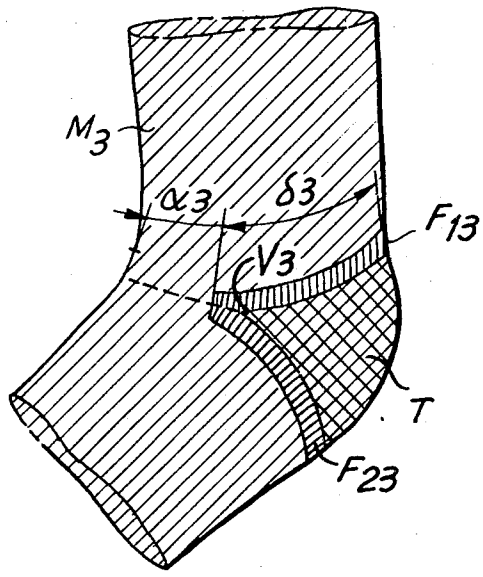
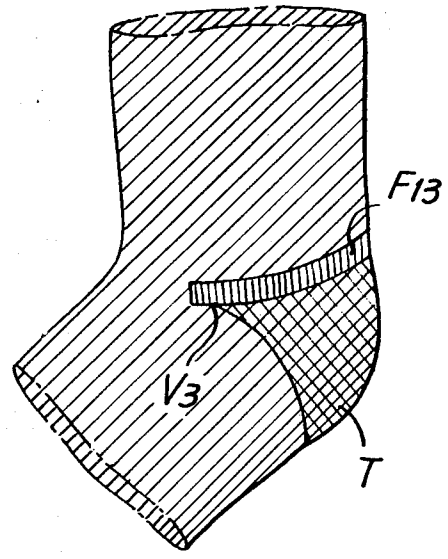


Fig. 21



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SEAMLESS STOCKING AND METHOD OF KNITTING POCKETS THEREIN

This application is a continuation-in-part of my copending U.S. Pat. application Ser. No. 364,178 filed May 1, 1964, now abandoned, and a continuation of U.S. Pat. application Ser. No. 726,374 filed May 3, 1968, now abandoned.

The invention concerns a method of knitting tubular fabric with integral pockets.

When seamless, articles such as stockings, socks and other tubular articles are knit on circular knitting machines, it is often necessary to form one or more seamless-fashioned pockets, for example, the heel of a sock or stocking. Heretofore in forming a pocket in tubular knit fabric it has been general practice to operate a circular knitting machine by reciprocating the needle cylinder to form successive courses of stitches while the cylinder alternately swings in opposite directions. During each swing of the needle cylinder, partial courses are knit on different numbers of needles to obtain the desired shaping of the pocket. When a pocket is formed in this way by alternately reversing direction of movement of the needle cylinder, a number of objectionable conditions are encountered. One of the most important objections is that speed of production is materially slowed, since a massive needle cylinder, which must be repeatedly reversed, cannot operate as fast as one which is driven continuously in one direction. Another objection is the necessity of providing rather complex mechanisms to effect alternate reversal of rotation of the needle cylinder. These complex mechanisms are quite costly, troublesome to install, difficult to service, and subject to malfunction and loss of precise adjustment. Highly skilled technicians must be in constant attendance to keep these mechanisms in efficient working order. Labor time spent in servicing and repair is very costly and loss of production while the machine is idle and under repair and adjustment is highly objectionable. Still another disadvantage encountered is that the necessary repeated reversals of the massive needle cylinder causes vibrations of other delicate parts of the machine so that they fall out of adjustment or require frequent servicing, repair and replacement. These objectionable conditions and disadvantages have long been recognized, but until now it has not been possible to avoid or overcome them in conventional circular knitting machines.

One expedient which has been resorted to has been to knit a tubular fabric without a pocket on a circular knitting machine in which the needle cylinder rotates in one direction only. The fabric is knit of a yarn which has thermoplastic properties. After the tubular article, such as a stocking has been knitted, the article, while it is out of the knitting machine, is mounted on a form having the desired shape and is heated to form a heel, toe or other pocket part. This process is of course limited only to thermoplastic yarns, and even here it has not proven wholly satisfactory because of the extra manufacturing steps involved, because the setting does not always remain permanent during subsequent use of the article, and because the expanded pocket part is weaker and its stretched stitches are less dense than other parts of the fabric. If the stretched part is a heel of a stocking, this part which should be thicker and denser than other parts, is actually rendered thinner and more fragile than other parts.

The present invention is directed to overcoming the above and other difficulties and disadvantages of prior methods of making pockets in tubular knit fabrics, by knitting the tubular fabric and forming the desired pockets during knitting while the needle cylinder is rotated continuously in only one direction. The process can be performed with yarns of any type. The shaped pockets which result are integral with the remainder of the fabric; and they have the desired strength of fabric and density of stitches. Since the needle cylinder rotates continuously in one direction only, repeated reversals of drive with all their attendant objections and disadvantages are avoided.

According to the invention, while the needle cylinder is rotating continuously in one direction, certain needles in a working arc are raised to pick up the yarn or thread and form stitches for the pocket, while other needles which normally work in an adjacent arc do not pick up the yarn. The working arc is periodically lengthened or shortened by insertion and release from work of needles at opposite ends of the same arc. The yarn engaged in remaining needles in the working arc is anchored to the fabric and is cut close to the end of the arc so that the cut end of yarn does not visibly project from the fabric at the end of the arc.

The invention will be explained in further detail in connection with the drawings, wherein:

FIG. 1 is a schematic diagram of a needle operation employed in forming a pocket part such as a heel of a sock or stocking.

FIG. 2 is a fragmentary side view showing part of a tubular stocking with the courses of the heel pocket being shown diagrammatically.

FIG. 3 is a side view of the upper end portions of a plurality of needles shown in different elevated positions.

FIG. 4 is a fragmentary side view of a stocking with heel and part of a toe formed according to the present invention.

FIG. 5 is a schematic diagram of the distribution of needle-control butts arranged around a needle cylinder so as to form pockets such as a heel and toe of a stocking.

FIG. 6 is a schematic diagram showing how the control butt layouts of FIGS. *6a* and *6b* are to be viewed together.

FIGS. *6a* and *6b* show diagrammatically, on an enlarged scale, flat planar developments of arrangements of needle selection butts of two halves of a needle cylinder set up for forming a heel pocket and a toe pocket of a stocking.

FIG. 7 is an enlarged side view showing in flat planar development part of a needle cylinder with parts of needles, jacks and control cams.

FIG. 8 is a fragmentary longitudinal sectional view of the needle cylinder and associated parts, taken on line VIII—VIII of FIG. 7, with one needle shown in raised position.

FIG. 9 is a sectional view similar to the lower portion of FIG. 8, with the needle shown in lowered position.

FIG. 10 is a fragmentary cross-sectional view taken on line X—X of FIG. 7, with jacks different from those illustrated in FIG. 7.

FIGS. 11–17 are views similar to FIG. 7, showing the parts in different positions at different stages of a method according to the invention, while a pocket is being knitted.

FIG. 18 is another view similar to FIG. 7 showing how needles and jacks are arranged to form a reinforcing marginal strip adjacent to a knitted pocket.

FIG. 19 is a greatly magnified view of a portion of a heel of a stocking formed by the present method.

FIG. 20 is a side view, partially diagrammatic in form, of a portion of a stocking formed with a heel having two marginal reinforcing strips as made by the present invention.

FIG. 21 is a view similar to FIG. 20, showing a heel having one marginal reinforcing strip as made by the present invention.

In the following description of the invention, the method will first be described in general terms, and then will be described in detail with particular reference to working parts of a circular knitting machine.

Referring first to FIG. 1, there is shown diagrammatically a series of straight, crosshatched lines representing partial courses of stitches formed in a circular knitting machine in which its needle cylinder rotates continuously in one direction. The partial courses have different lengths in accordance with the method of the present invention. Thus length A represents the length of a minimum number of needles in the working or operating arc of needles involved in knitting a minimum length of partial course to form a pocket, and may for example, utilize 84 needles in a 400-needle knitting machine. Lengths B represent two portions of arcs extending beyond ends of length A to define the maximum number of needles in

the working or operating arc of needles involved in knitting a maximum length of partial course in forming a pocket. Pocket T of tubular knit fabric M, shown in FIG. 2, may be a pocket which is formed by knitted partial courses of different lengths indicated in FIG. 1.

In both FIGS. 1 and 2 there is shown the last complete circular course X_1–X_2 formed just before the start of formation of pocket T. When formation of the pocket starts there is begun the knitting of partial courses extending circumferentially less than 360° around the tubular fabric M. However, the needle cylinder continues to rotate continuously in one direction. During formation of the pocket T certain needles which have formed the stitches of the complete circular course X_1–X_2 remain engaged with these stitches and do not pick up the yarn. Other needles which were active in the knitting of course X_1–X_2 and remain active to form the partial courses of the pocket.

During the first revolution of the needle cylinder following formation of complete circular course X_1–X_2, a first partially circular or partial course C_1—C_1 is formed having the minimum length A between opposite ends C_1—C_1. Only about 84 adjacent needles for example are used to make this first partial course C_1—C_1. The other needles remain engaged with the stitches of complete circular course X_1–X_2 and do not pick up the yarn. The first partial course is thus anchored or engaged to part of course X_1–X_2. The yarn is cut free at opposite ends C_1 of course C_1—C_1 at points I, I while the needle cylinder continues rotation in one direction. After completing course C_1—C_1 the needle cylinder goes on to complete its revolution without any further stitch formation in this revolution. During the next or second revolution of the needle cylinder, the same needles which formed course C_1—C_1 are lifted again and in addition further needles engaged with course X_1–X_2 are activated to form lengths B_1 of the second partial course C_2—C_2. Partial course C_2—C_2 is longer than partial course C_1—C_1 by length B_1 at each end of partial course C_1—C_1. The opposite ends C_2 of partial course C_2—C_2 are engaged with corresponding portions of complete circular course X_1–X_2 just beyond the stitches engaged by ends C_1 of partial course C_1—C_1. The yarn is cut at points II, II when anchoring of the trailing end C_2 of partial course C_2—C_2 is completed.

During the third revolution following information of circular course X_1–X_2, third partial course C_3—C_3 is formed. This course is longer than partial course C_2—C_2 by lengths B_2. Ends C_3 of this third partial course of pocket T are attached to portions of complete course X_1–X_2 just beyond the end points of attachment II, II of ends C_2 of partial course C_2—C_2. The same needles as formed partial course C_2—C_2 are used to form partial course C_3—C_3 and in addition further needles are activated from complete course X_1–X_2 at opposite ends of partial course C_2—C_2 to form the opposite ends of course partial C_3—C_3. The yarn is cut at end points III, III of course partial C_3—C_3.

During the fourth and fifth revolutions of the needle cylinder, successively longer partial courses C_4—C_4 and C_5—C_5 are formed by activating further needles from course X_1–X_2 and using them to form ends C_4 and C_5 of partial courses C_4—C_4 and C_5—C_5, respectively. Ends C_4 and C_5 of the partial courses are anchored to complete course X_1–X_2 and then the yarn is cut at end points IV and V as each partial course is completed. Partial course C_4—C_4 is longer than partial course C_3—C_3 by lengths B_3 and partial course C_5—C_5 is longer than partial course C_4—C_4 by lengths B_4.

During the further revolutions of the needle cylinder a series of four partial courses C_{11}—C_{11}, C_{12}—C_{12}, C_{13}—C_{13} and C_{14}—C_{14} of stitches is started. They have lengths respectively equal to partial courses C_1—C_1 to C_4—C_4 and terminate in ends C_{11}, C_{12}, C_{13} and C_{14} respectively. The sixth partial course C_{11}—C_{11} is centered on and attached to the fifth partial course C_5—C_5 and the yarn is cut at points I, I. The seventh partial course C_{12}—C_{12} is longer than the sixth partial course by two times length B_1. Opposite ends C_{12} of this partial course are attached to partial course C_5—C_5 just beyond the points of attachment of ends of the sixth partial course C_{11}—C_{11}. The yarn is cut at points II, II. The eighth partial course C_{13}—C_{13} is longer than the seventh partial course by two lengths B_2 and its ends C_{13} are attached to the fifth partial course C_5—C_5 just beyond the points of attachment of ends C_{12}, and the yarn is cut at points III, III. The ninth partial course C_{14}—C_{14} is longer than the eighth partial course by two lengths B_3. Its ends C_{14} are attached to the fifth partial course C_5—C_5 just beyond the points of attachment of ends C_{13}, and the yarn is cut at points IV—IV. Except for attachment of their opposite ends to partial course C_5—C_5 the successive sixth through ninth courses are attached to each other.

In the 10th, 11th and 12th revolutions three partial courses C_{21}—C_{21} to C_{23}—C_{23} are formed equal in length to partial courses C_1—C_1 to C_3—C_3, respectively. The entire 10th partial course C_{21}—C_{21} is centered on and attached to the ninth partial course and the yarn is cut at points I, I. The 11th partial course C_{22}—C_{22} has opposite ends C_{22} extending beyond ends C_{21} of the 10th partial course by twice length B_2 and these ends C_{22} are attached to the ninth partial course just beyond the points of attachment of ends C_{21}. Then the yarn is cut at points II, II. The 12th partial course C_{23}—C_{23} has opposite ends C_{23} extending beyond ends C_{22} of the 11th partial course and these ends C_{23} are attached to the ninth partial course just beyond the points of attachment of ends C_{22}. The 13th partial course C_{24}–C_{26} is longer than partial course C_{23}—C_{23}. Its center part is attached to the 12th partial course but lengths B_3 of this 13th partial course are attached to the ninth partial course C_{14}—C_{14}, lengths B_4 are attached to the fifth partial course C_5—C_5 and lengths B_5 of ends C_{24}–C_{26} are attached to complete circular course X_1–X_2. The attachment is made to complete course X_1–X_2 because the 13th partial course is longer than the next shorter partial course C_5—C_5 by lengths B_5. Ends of partial course C_{24}—C_{24} are cut at points VI, VI. After each partial course of stitches is completed, the yarn is cut. Cutting of the yarn and leaving the needles down makes it possible to continue revolving the needle cylinder without any further knitting during the revolution and without having to reverse the needle cylinder as has been the conventional method heretofore. Thus, the needle cylinder revolves continuously in one direction at high speed.

The process continues as above described. Each shorter partial course is centered on and wholly attached to a next preceding longer partial course. Each longer partial course has a center portion attached to a next preceding shorter partial course and its ends are attached to the nearest preceding longer partial course. Each longer partial course which is longer than any preceding partial course is attached at its ends to the last preceding complete circular course X_1–X_2. Thus, referring to FIG. 1, ends C_5, C_{24}, C_{57} of the fifth, 13th 26th courses are attached in succession to complete circular course X_1–X_2. Partial course ends C_{31}, C_{32}, C_{33} and C_{34} are attached to the 13th course C_{24}—C_{24}. Partial course ends C_{41}, C_{42}, C_{43} and C_{44} are attached to the 18th partial course C_{35}. Ends of partial courses C_{51}, C_{52}, C_{53} are attached to the 22th partial course C_{44}—C_{44}. Ends of courses C_{61}, C_{62}, C_{63} and C_{66} are attached to the 26th partial course C_{57}—C_{57}. End points VII, VII of the longest partial course C_{57}—C_{57} are cut after ends C_{57} are attached to complete circular course X_1–X_2.

By the method thus far described partial courses of different lengths are knitted to form a pocket such as pocket T shown in FIGS. 2 and 4. The pocket has tapered ends F_{19} due to alignment of points I through VII which correspond to end points of attachment of the seven different lengths of courses. These end points are represented by lines of dots in FIGS. 2. Actually these end points where the yarn has been cut close to the last stitch in each partial course are almost invisible in the finished fabric which improves the appearance of the finished product.

It should be noted that after a series of partial courses of increasing length is formed, such as partial courses C_1—C_1 through C_5—C_5, C_{11}—C_{11} through C_{14}—C_{14}, etc., there is provided an abrupt reduction in length following the longest par-

tial course in the series. As one example, after the long partial course C_{24}—C_{24} there is started a series beginning with partial course C_{31}—C_{31} of minimum length. The partial courses having the longest lengths at the ends of the several series such as partial courses C_5—C_5, C_{14}—C_{14}, C_{24}—C_{24}, C_{35}—C_{35}, C_{44}—C_{44}, C_{57}—C_{57} and C_{66}—C_{66} are mostly different in length with no two of the longest courses of the same length directly adjacent to each other. By this arrangement it is possible to effect positive connection or binding of the partial courses of stitches to each other and at the same time the desired shape of pocket is formed, even though the yarn is cut at the ends of each partial course, and even though the needle cylinder rotates continuously in one direction so that all partial courses are knitted in the same direction from end to end.

After one-half the pocket is formed according to the schedule shown in FIG. 1, the formation of the pocket is completed by following the schedule but in reverse order starting from partial course C_{66}—C_{66} and ending with partial course C_1—C_1. As in the first half of the pocket, all partial courses are attached to adjacent partial courses and the yarn is cut close to end points of attachment I through VII. In this way a pocket of stable form is constructed.

In order to form partial courses of stitches to form other sizes and shapes of pockets, the needles which are to be operated in the partial courses C_n—C_n, where n is any integral number, are raised to pick up the yarn or thread in one or more feeds while those needles which are not operated are not raised and thus do not pick up the yarn. Before the start and after the end of a partial course of stitches, some needles which are not knitting are raised only partially (to tuck level) without losing their engagement with the previously formed stitch, but in such manner as to pick up the yarn at the ends of the partial course being formed to connect it and thus insure that end stitches of the new-formed partial course are anchored securely. When the last partial course completing the pocket is knitted, formation of complete circular courses begins again starting with circular course Y_1–Y_2 shown in FIG. 2.

FIG. 4 shows the lower portion of a stocking M knitted to form a heel, foot and toe. After the leg of the stocking is formed the pocket T is knitted to form a heel; then the foot M_0 is formed of circular courses ending at a circular or cylindrical portion P_1; and finally a toe pocket P_2 is formed. Both pockets T and P_2 are formed by the method described above with all courses knitted in the same direction as the needle cylinder rotates in one direction. The pocket P_2 can be knitted of coarser yarn than other parts of the stocking. Edges BP_1 and BP_2 of pocket P_2 will subsequently be sewn to each other to complete closure and formation of the toe of the stocking.

The method generally described above will now be further explained with particular reference to the operation of needles and associated parts.

In FIG. 3. The arrow directed to the left indicates the direction of movement of the needle cylinder carrying needles N_1—N_{3a}. Yarn F_1 is used to form the partial courses of stitches to produce pockets such as pockets T and P_2. Needles N_1 are inactive and are kept lowered and engaged with previous stitches M_1. Needles N_2 are raised to clearing level and form a partial course of stitches by means of yarn F_1 which is picked up by these needles. Needles N_3 are raised only partly to tuck level and serve to pick up the yarn F_1 without knitting a stitch. Needles N_1 retain stitches M_1 such as those of course X_1–X_2 in FIGS. 1 and 2. Needles N_2 clear stitches M_2 under their latches L_2 to form a new stitch. Needles N_3 are raised slightly so as not to release stitches M_3 under tags L_3, but they are raised sufficiently to pick up yarn F_1 to connect it to stitches M_3.

Instead of raising the needles to different levels as shown in FIG. 3, it is possible to arrange a yarn guide to feed yarn F_1 by cyclically raising and lowering it as it is fed to the several needles of the working arc, to form partial courses of pockets as described. However, the performance of the method will be described in connection with a needle cylinder having needles which are raised and lowered in predetermined sequence. Reference is therefore now made to FIG. 5 through FIG. 17 in which an arrangement for forming two pockets in tubular fabric is described.

In FIGS. 8, 9 and 10, there is shown a rotatable needle cylinder 11 which has a sinker bed 13 surrounded by a stationary sinker cap 15. A dial bed 17 is coaxial with and supported internally of the upper part of the needle cylinder. This dial bed rotates in coordination with needle cylinder 11. A fixed dial cap 19 overlays dial bed 17. Needle cylinder 11 has longitudinal external grooves best shown in FIG. 10 extending all around the cylinder. In these grooves are slidably housed individual latch needles 21, each provided with a lower butt 21A. The butts 21A have two different lengths for reasons described blow. In the sinker bed 13 are radial grooves in which slide sinkers 23. These sinkers are operated by tracks or cams in fixed sinker cap 15. Dial bed 17 has radial grooves in which are disposed transfer hooks 25.

Two yarn guides 27 and 29 are carried by outer structural parts of the machine. These yarn guides can be respectively lowered to feed yarn or thread to the needles or they can be raised to stop the feed. A circular knife 33 is carried by dial cap 19 for cutting the yarn. Other types of knives or yarn cutting or shearing devices can be provided such as shown in U.S. Pat. Nos. 3,100,977; 3,113,443; and 3,006,173. The yarn-cutting device is capable of cutting the yarn near the first stitch which is formed when a yarn guide is lowered to feed a selected yarn to the needles, and of cutting the yarn near the last stitch which is formed at the end of course when the yarn guide is raised to cease the feed of the selected yarn to the needles. The selected yarn is retained for cutting by stopping means such as a yarn clamp 35. Alternatively, means such as an air suction system described in U.S. Pat. No. 3,050,970 can be used to hold the yarn during cutting. For the sake of clarity in the drawing, the yarn clamp 35 is shown angularly closer to the yarn guides than is actually required in practice.

Under each needle 21 in the same groove of the needle cylinder is an intermediate jack 37 with a lower butt 37A. Under each jack 37 in each groove of the needle cylinder is a lower or selector jack 39. Jack 39 is oscillatable to effect selection of needles for operation in a predetermined sequence. Each selector jack 39 oscillates around a rocking point 41 which is the junction point of two lengths of the internal edge of the groove in which the jack is located. By comparing FIGS. 8 and 9, it will be noted that there are two possible positions of jack 39. In one position, as shown in FIG. 8, the jack 39 reaches a fixed raising cam 43. A lower butt 39K of the jack is engaged by the cam 43. Thus the jack 39 is brought up to raise the intermediate jack 37 and the associated needle 21. When a jack 39 is moved to the position of FIG. 9, the butt 39K passes inside cam 43 and is not raised. In the section of grooves between point 41 and the lower end thereof where the butt 39K is located, each selector jack 39 has a series of butts hereinafter described which are used selectively to obtain the arrangement of FIG. 9. An upper butt 39Q serves to rock the lower ends of the jacks to the position shown in FIG. 8. A pushout cam 45 acts on the butts 39Q when the jacks 39 are located at a short distance from cam 43. Cam 45 rocks all the jacks 39 into the position shown in FIG. 8. If this arrangement is not changed before the jacks reach cam 43, all the needles are raised and continuous tubular plain knitting is formed. FIG. 7 illustrates the path of the needles for forming plain mesh or knitting. The needles 21 are raised to cleaning level via jacks 37 and jacks 39 according to the profile of cam 43. The raised needles pick up the yarn or thread from the yarn guide 27 or 29 and then the needles are lowered by action of stitch cam 47 striking butts 21A. Stitch cam 47 cooperates with center cam 47A and landing cam 47B to the lower level needle to form the stitch and knit while casting off the previous stitch. The jacks 37 are lowered by action on the butts 37A of a downwardly inclined cam portion 49A of a ring cam 49. The jacks 37 also relower the selector jacks 39.

The formation of plain mesh stitches as described may be repeated at other angular positions where there is a yarn feed

and cams corresponding to those described. It is possible to form tuck stitches instead of plain mesh stitches by appropriate selection of needles. The selection can be made by butts on jacks 37 or by butts on the selector jacks 39.

The arrangement for forming a pocket such as pockets T or P_2 of FIG. 4 will now be described. In FIGS. 6*a* and 6*b* taken together as indicated by FIG. 6, there is shown an arrangement of butts of jacks 39 included between the oscillation or rocking point shown in FIG. 8 and the lowermost butt 39K, set up to form the partial courses of stitches required in forming a pocket, such as partial courses C_1—C_1 through C_{66}—C_{66} of FIG. 1. In order to simplify the drawing there is indicated an arrangement of butts to obtain partial courses of stitches of only seven different lengths such as indicated in FIG. 1. However, it is possible to provide for a greater number of partial course lengths if desired or required.

In FIGS. 6*a* and 6*b*, there are indicated arranged in seven horizontal rows of different lengths the butts 39_1–39_7. Selector cams 51_1 to 51_7 are provided for acting on the several rows of butts 39_1–39_7, respectively. These cams are located at an initial length of profile of cam 43 shown in FIGS. 7 and 11–18. Some of the cams are shown in FIGS. 7–18 while others are omitted for the sake of simplifying the drawings and to facilitate explanation. Also only three of the seven rows of butts, namely butts 39_1, 39_2 and 39_3 are shown in FIGS. 7–18 for the sake of simplification. When one of cams 51_1–51_7, cam 51_3 for example, as shown in FIG. 9, is urged or pressed inwardly (i.e. to the left looking at the drawing), the associated row of butts 39_3, the jacks 39 are urged into the position shown in FIG. 9 and are not raised by cam 43. Similarly, where the others of butts 39_1 and 39_7 are concerned, insertion of a corresponding cam 51_1 to 51_7 prevents raising of the needles. However, where no butt is present to be acted on by a cam, the jack 39 is raised by cam 43. Butts 39_T located below butts 39_7 are arranged in a row which occupies slightly more than half the circumference of the needle cylinder. Butts 39_P located below butts 39_T are arranged in a row which occupies slightly more than half the circumference of the needle cylinder on the side opposite from butts 39_T. Butts 39_P and 39_T serve to prevent the needles from being raised. A cam 53_T acts radially on the row of butts 39_T when pocket T is being formed. Cam 53_P acts radially on butts 39_P when pocket P_2 is being formed. Cams 53_T and 53_P are located at an initial part of the profile of cam 43.

The jacks 39 located at the ends of the arcuate rows of butts 39_1 to 39_7 are provided with tangentially extending butts 55_1 to 55_7, respectively. The arcuate rows of butts 39_1 to 39_7 control the needles in the working arcs which form the partial courses of a pocket T or P_2. The tangential butts are located to overlie three of the jacks 39 adjacent and outside a working arc where there are no butts 39_1 to 39_7. The first and third of the said three jacks 39 are provided with a butt 57 at a short distance above the tangential butts 55_1 to 55_7. The length of the tangential butts is smaller than each of distances B_1–B_6 of FIG. 1, i.e. the minimum displacement of each upper course from a lower one, so that adjacent tangential butts do not interfere with each other when the jacks are moved.

In the arrangement indicated in FIGS. 5, 6*a* and 6*b*, an arc α where there are no butts 39_1 to 39_7, is flanked by two arcs β_1 and β_2 where rows of butts 39_1 to 39_7 end, and there are present tangential butts 55_1 to 55_7. The arcs α, β_1, β_2 in the assembly occupy approximately 180° of the circumferential development of the needle cylinder. Then there are two arcs γ_1, γ_2 adjacent to which are two symmetrical arcs ϵ_1 and ϵ_2 flanking an arc δ. The arcs α and δ are symmetric with respect to a diameter taken vertically through the center of FIG. 5. The half-circle corresponding to the angles β_2–α–β_1 correspond to the forming of the toe pocket P_2. The arcs γ_1, γ_2 correspond to two intermediate needle zones, which are not involved in forming the heel or toe pockets T, P_2. The total arc defined by arcs ϵ_1–δ–ϵ_2 is the arc involved in forming heel pocket T and is located in a position diametrically opposed to the total arc defined by arcs β_1–α–β_2 which are involved in forming the toe pocket P_2. Rows of butts 39_1 to 39_7 having several lengths are located in both total arcs.

The butts 39_T serve to exclude those jacks and needles assigned for forming of the toe pocket when the butts 39_T operate. These butts are located in a zone relative to the toe pocket, that is in the zone corresponding to the arcs. Thus, by advancing cam 53_T during the forming of the heel pocket T, the butt selection is annulled and the raising of all needles which pertain to the arcs γ_1–β_2–α–β_1–γ_2 is annulled. In a similar fashion, butts 39_P are located in the zone corresponding to the arcs γ_1–ϵ_1–δ–ϵ_2–γ_2 where the heel pocket P_2 is formed. The presence of butts 39_P in these arcs causes neutralization of the jack selection in the zone pertinent to the forming of the heel pocket T while toe pocket P_2 is being formed. The cam 53_P acts on these butts 39_P.

The end butts 39_T may be extended also partially into the zone of arcs ϵ_1, ϵ_2. The end butts 39_P may also be extended partially into the zone of arcs β_2–α–β_1. In FIGS. 6 and 6*a* the arrow F_{60} denotes a position of a feed-yarn guide and the adjacent position of cams 51_1 to 51_7 is also shown.

When a heel pocket T is to be knitted according to the diagram of FIG. 1, after a tubular fabric has been knitted up to a complete circular course X_1–X_2, cam 53_T is inserted and this cam prevents the raising of the needles 21 in the arc γ_1–β_2–α–β_1–γ_2 where a toe pocket P_2 would be formed. During the first subsequent revolution of the needle cylinder the cam 51_1 is inserted. At the level of cam 51_1 the working arc of butts is shortest and this corresponds to the length of the shortest partial course C_1—C_1 of the diagram of FIG. 1. Thus, the first partial course of stitches C_1—C_1 is formed. During the second revolution of needle cylinder, cam 51_2 is inserted and the next longer row of butts of jacks 39 are actuated to form the next longer partial course C_2—C_2. In similar fashion insertion of cam 51_3 causes formation of partial course C_3—C_3; insertion of cam 51_4 causes formation of partial course C_4—C_4; and insertion of cam 51_5 causes formation of partial course C_5—C_5. During the sixth revolution, cam 51_1 is inserted again to form partial course C_{11}—C_{11} which is the same in length as partial course C_1—C_1. Cam 51_2 is inserted during the seventh revolution to form partial course C_{12}—C_{12}, and so on. The insertion of any one of the cams 51_1—51_7 results in formation of a partial course of appropriate length according to the diagram of FIG. 1.

In order to clarify the mode of operation in which needle selections are made by operation of butts 39_1 to 39_7, reference will be made to FIGS. 11 to 17. These figures illustrate the particular stages of working of an arc of needles to form a particular partial course such as course C_3—C_3 or C_{13}—C_{13} when cam 51_3 is inserted to act on butts 39_3. The stages shown in FIGS. 11 to 17 are those involved in forming heel pocket T. The butts 39_T which annul the controls pertinent to toe pocket P_2 are also shown.

In FIG. 11 there is shown the stage wherein the first jack 39 which lacks a butt 39_3 and thus is unaffected by cam 51_3, has climbed cam 43. This is the seventh jack 39 from the left in FIG. 11. This jack is raised a distance equal to the distance from tangential butt 55_3 to butt 57. The tangential butt 55_3 has thus reached the level of two butts 57 of the fourth and sixth jacks intersected by it. Some of the jacks 39, following the fourth jack, such as the eighth to 12th jacks from the left in FIG. 11, are also shown progressively raised since they are up on the inclined cam 43.

In FIG. 12, the further raising of the jacks on the cam is shown. Butt 55_3 has begun to raise the two jacks 39_L which bear butts 57. These two jacks are raised a distance less than those following. The jack bearing tangential butt 55_3 begins to raise needle 21_M which will be the first one to form the first stitch of the partial course.

In FIG. 13, needle 21_M which corresponds to the jack with tangential butt 55_3 and without a butt 39_3, has reached the maximum height imposed by cam 43. Needle 21_M clears the stitch and is disposed to pick up the yarn from yarn guide 27. The subsequent needles do the same. The position of needle

21_M is that corresponding to the most elevated needles N_2 of FIG. 3. The two needles 21_L partly raised by jacks 39_L are in their turn raised by tangential butt 55_3 and arrive at tuck level to pick up the yarn but do not clear the stitch. The position of the two needles 21_L is that of the partially raised needles N_2 of FIG. 3. The needles 21 which are not shown raised in FIG. 13 correspond to the lowermost needles N_1 of FIG. 3.

FIG. 14 shows an intermediate stage in forming the partial course. Stitch cam 47 lowers the needles to form the stitch with the picked up yarn or thread after having cleared the previous stitch. The two needles 21_L which were not totally raised hold the yarn picked up from the yarn guide 27 and later connect it to the previous stitch. Jacks 37 are lowered by the cam portion 49A and these jacks in turn relower the raised jacks 39.

In FIG. 15 there is shown a stage wherein the partial course of stitches is about to be finished. The jack 39 provided with tangential butt 55_3, here represented as the last without a butt 39_3, is raised by cam 43 and is about to begin raising the last needle 21_{M1} which will complete the partial course. Butt 55_3 partially raises butts 57 corresponding to the two jacks 39_{L1}.

In FIG. 16 needle 21_{M1} is at the maximum or clearing level. It has dropped the previous stitch under its latch and has picked up the yarn from the yarn guide 27. The two needles 21_{L1} here shown are raised by jacks 39_{L1} raised in turn by butt 55_3. These needles are raised just enough not to clear the previous stitch but high enough to pick up the yarn so that the yarn will be held in the hooks and later connected to the stitch previously formed by the needles 21_{L1}. The other needles subsequent to needles 21_{M1} are not raised.

In FIG. 17 there is shown the stage immediately after the end of knitting of the partial course of stitches whose formation has just been described. During the starting of formation of the partial course, the yarn of the yarn guide 27 was picked up by the first needle 21_M and was connected by the needles 21_L, shown in FIGS. 13 and 14, and at the same time the knife 33 sheared the yarn at the beginning of the partial course. Again, as needle 21_{M1} has formed the last stitch of the course and while the yarn is held by the last two needles 21_{L1}, shown in FIG. 17, knife 33 shears the yarn.

During the continuous rotation of the needle cylinder while tubular fabric is being formed and while partial courses are being formed, the yarn guide 27 remains in its feed position. The heel pocket T however may be formed with more yarns or threads arriving from other feeds. In such an arrangement the stages of FIGS. 11 to 17 will be repeated at the other feed positions. The arrows F_{60} and F_{62} in FIGS. 6, 6*a* and 6*b* indicate a second possible yarn-feed position and cams 51_X for the second feed correspond to cams 51_1 to 51_7 already described.

In FIG. 19 there is shown a cusplike zone of a pocket such as tapered zone F_{19} shown in FIG. 2 and shown on a greatly magnified scale in said FIG. 19. First should be noted point C_{57} where long partial course C_{57}—C_{57}, as shown in FIG. 1, begins and two points C_{26} and C_{66} are where the two shorter partial courses C_{26}—C_{26} and C_{66}—C_{66} begin. Course C_{57}—C_{57} is formed by yarn or thread F_{57} which is connected in plated relationship to two stitches L_{57} shown in FIG. 19, which are the regular stitches of the complete circular course S_1. Course C_{26}—C_{26} is formed by yarn or thread F_{26} which is connected in plated relationship to two stitches L_{26}. Course C_{66}—C_{66} is formed by yarn or thread F_{66} which is connected in plated relationship to two stitches L_{66}. By the arrangement of the tangential butts and by the plated connection of the yarn or thread by needles 21_L, 21_{L1} (FIG. 17) at stitches L_{57}, L_{26}, L_{66} to stitches of an adjacent course, the yarn is securely anchored. The yarn is then sheared at this end of the partial course.

The same selection cams which act on the butts 39_1 to 39_7 for forming the heel pocket T may be used for forming the toe pocket P_3 of FIG. 4. The operation is the same as that for forming the heel pocket with the difference that cam 54_P is inserted to act on the butts 39_P instead of the cam 53_T which acts on butts 39_T for forming the heel pocket.

Sometimes the sharp cusplike pocket end F_{19}, as shown in FIG. 2, and also shown on a large scale in FIG. 19, may be objectionably visible if the yarn forming the pocket T is different from the yarn forming the remainder of the tubular fabric. It is possible to avoid presentation of a visible cusplike pocket portion. One way this can be done is indicated in FIG. 20. Two knitted fabric bands or strips F_{13} and F_{23} are formed adjacent to the pocket T during the formation of the circular courses of stitches of tubular fabric M_3. FIG. 21 shows another way of concealing the sharp cusplike pocket end by providing just the one strip or band F_{13}. In either way, the strips or bands are formed so as to extend slightly beyond the apex V_3 of the pocket. Due to the widths of bands F_{13} and F_{23} each apical end of the pocket appears to have the width of both bands F_{13} and F_{23} in FIG. 20, or the width of band F_{13} alone in FIG. 21 and the appearance of sharp, cusplike pocket ends is avoided. Strips or bands F_{13} and F_{23} are formed by a supplementary or reinforcing yarn or thread added to the yarn which forms the tubular fabric M_3. In FIG. 20, the strip F_{13} is formed along twice the length of the arc δ_3 while remainder of the circumference which is twice the length of arc α_3 is made of the regular yarn without supplementary thread.

FIG. 18 shows a way to form the strips or bands F_{13}, F_{23} by adding a supplementary yarn or thread to the needles which operate in the arcuate zone of pocket T. In FIG. 18, the needle 21_Y and those needles shown to the left of this needle are controlled in the manner already described in connection with FIG. 7 to form tubular fabric by use of yarn fed from yarn guide 27. The butts 21_A of these needles (see FIG. 8) are short. Needle 21_Y located to the right of needle 21_X and the other needles shown to the right of needle 21_Y for the length of twice arc δ_3 have longer butts 21_A than those of needle 21_X and of the needles to the left of needle 21_X. When a strip or band F_{13} or F_{23} is to be formed, cam 65 shown withdrawn in FIG. 8 is inserted partly as shown in dotted lines in FIG. 9 to act only on the needles having longer butts 21_A. In this way the needles with the longer butts 21_A are raised by cam 65 more than previous needles as shown in FIG. 9. The needles so raised will engage the yarn of yarn guide 27. These raised needles will also be high enough to engage the supplementary yarn of yarn guide 29 which is located slightly higher than yarn guide 27 (see FIG. 18). Thus, raised needle 21_Y and the other raised needles to the right of needle 21_Y form stitches with both the yarn of yarn guide 27 and the reinforcing yarn of yarn guide 29 for the length of twice arc δ_3, to knit the strip or band F_{13} or F_{23}. When cam 65 is extracted as shown in FIG. 8, stitches are formed with only the single yarn supplied by yarn guide 27.

Although the method has been described in connection with formation of plain stitches, it is possible to practice the method with formation of tuck stitches. Selection of needles to form tuck stitches will be done by suitable engagement of butts on jacks 37 or 39, or by provision of other jacks in the grooves of the needle cylinder.

While I have shown and described what I believe to be the best embodiments of my invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A method of knitting a tubular hosiery blank including at least one shaped pocket on a circular knitting machine including a circle of needles supported for vertical movement in a continuously rotating needle cylinder, and at least one knitting station including means to feed yarns to selected needles, said method comprising the steps of

a. feeding yarn to and forming stitch loops on all of said needles to form a plurality of complete circular courses of stitches defining a first section of said tubular hosiery blank,

b. knitting said shaped pocket entirely of partial courses by

1. feeding yarn to and forming stitch loops on a group of said needles on one side of said needle cylinder and forming a plurality of successive partial courses with

continued rotation of said needle cylinder, and while varying the length of the successive partial courses being knit,

2. engaging the yarn in the hook of at least one needle at opposite sides of the needles knitting each of said partial courses, and holding the yarn in the hook while knitting each partial course,

3. cutting the yarn at the opposite ends of each partial course and adjacent the needle holding the yarn, and

4. knitting the yarn held on the needle in plated relationship with the yarn forming a stitch loop during the knitting of the next successive partial course to prevent the cut end of the yarn from pulling out of the fabric, and

c. again feeding yarn to and forming stitch loops on all of said needles to form a plurality of complete courses of stitches defining a second section of said tubular hosiery blank.

2. A method of knitting a tubular hosiery fabric blank according to claim **1** wherein said circular knitting machine includes a selector jack positioned beneath each of said needles, the selector jacks corresponding to the needles which form the endmost stitches of each partial course of said pocket including a tangential butt engageable with and operable on at least one adjacent selector jack, and including the step of actuating said selector jacks to cause certain of said selector jacks with said tangential butts to be raised to raise the corresponding needles knitting said partial courses sufficiently to pick up and knit the yarn, and to cause said tangential butts to partially raise said adjacent selector jacks and the corresponding needles a sufficient distance to pick up and hold the yarn in the hook thereof until said yarn is subsequently knit in plated relationship with the yarn forming a stitch loop in the next successive partial course.

3. A method according to claim **1** including the step of knitting a plurality of the last complete courses of said first section of said blank while knitting a reinforcing yarn in plated relationship with said yarn and on a group of adjacent needles which exceeds the maximum number of needles knitted partial courses of said pocket to form a reinforcing strip in said first fabric section and adjacent one end of said pocket with opposite ends extending beyond opposite ends of said pocket.

4. In a method according to claim **3** including the step of knitting a plurality of the first complete courses of said second section of said blank while knitting a reinforcing yarn in plated relationship with said yarn and on a group of adjacent needles corresponding in number to the needles knitting the reinforcing yarn in said first fabric section to form a second reinforcing strip adjacent the opposite end of said pocket, the corresponding portions of said first and second reinforcing strips being joined together adjacent opposite sides of said pocket.

5. A seamless stocking including at least one shaped pocket formed in an area between sections of the stocking knit entirely of complete courses, said shaped pocket being knit entirely of partial courses successively varying in length, the yarn of each successive partial course being cut at opposite ends, and the yarn of each partial course being knit in plated relationship with at least one stitch loop of an immediately adjacent partial course to prevent pulling out of the cut ends of yarn.

6. A seamless stocking according to claim **5** wherein the yarn of each partial course is knit in plated relationship with two stitch loops of an immediately adjacent partial course, and wherein said two stitch loops are spaced apart by a single stitch loop knit of a single yarn.