Oct. 30, 1945. A. E. PAGE ET AL 2,387,769

CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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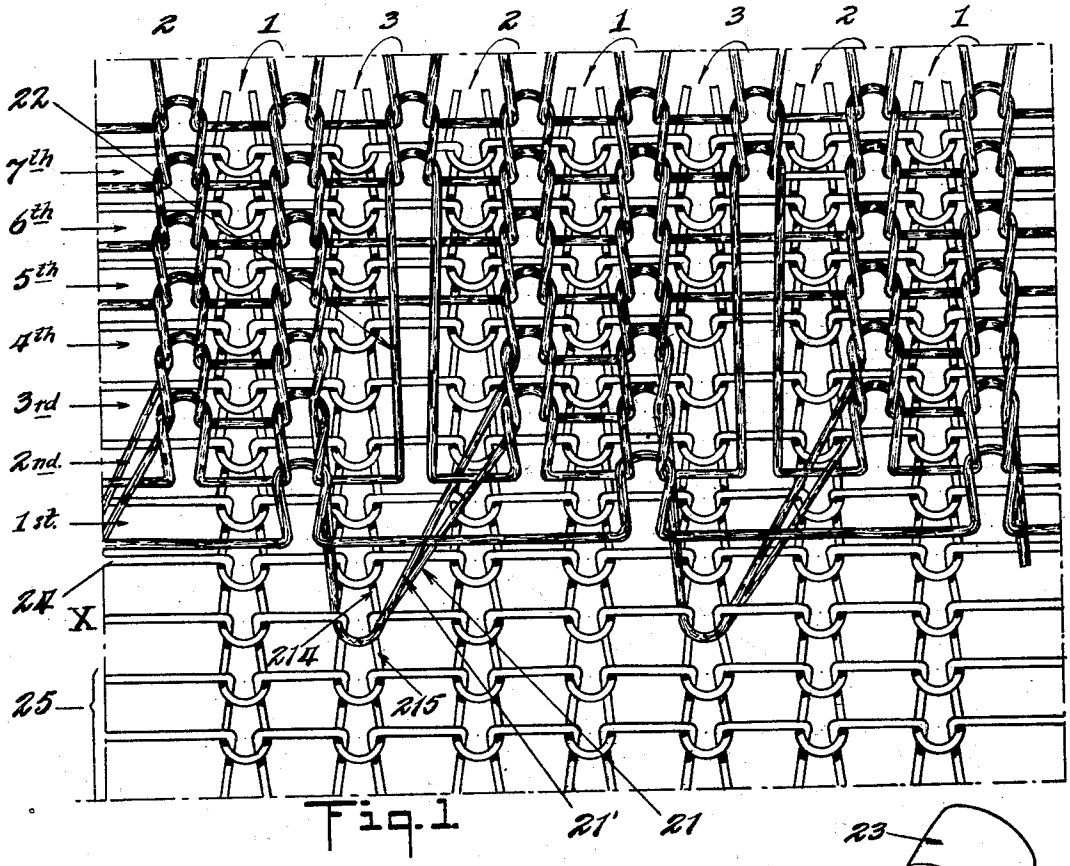


Fig. 1.

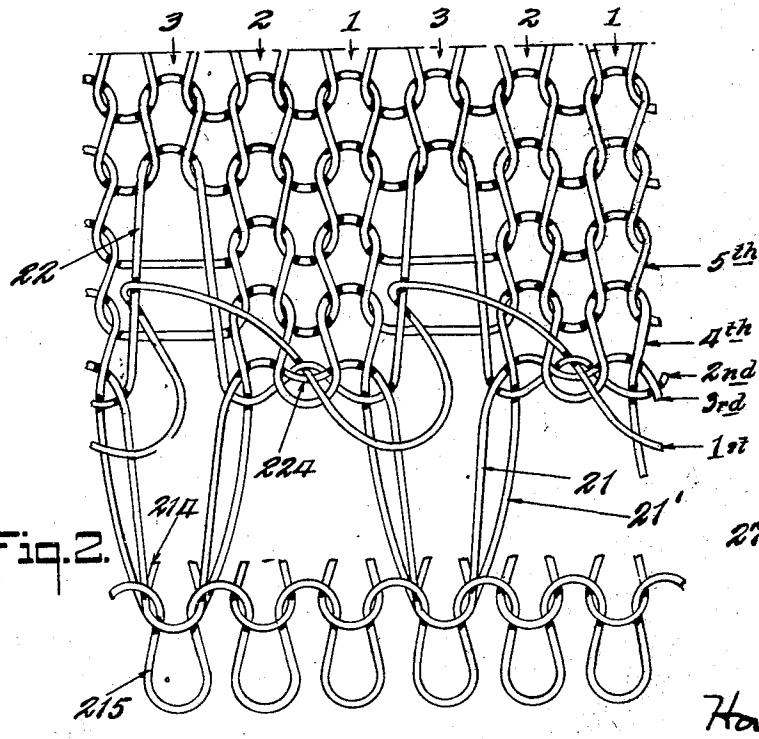


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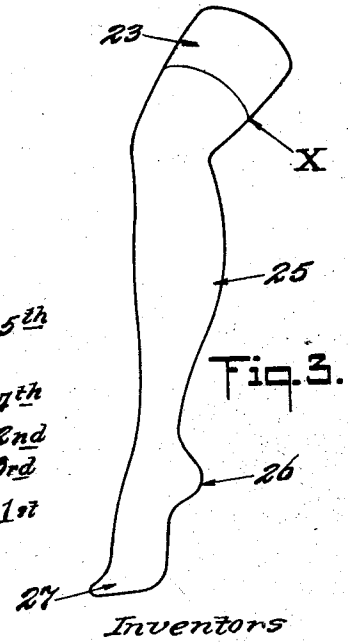


Fig. 3.

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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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Fig. 2.

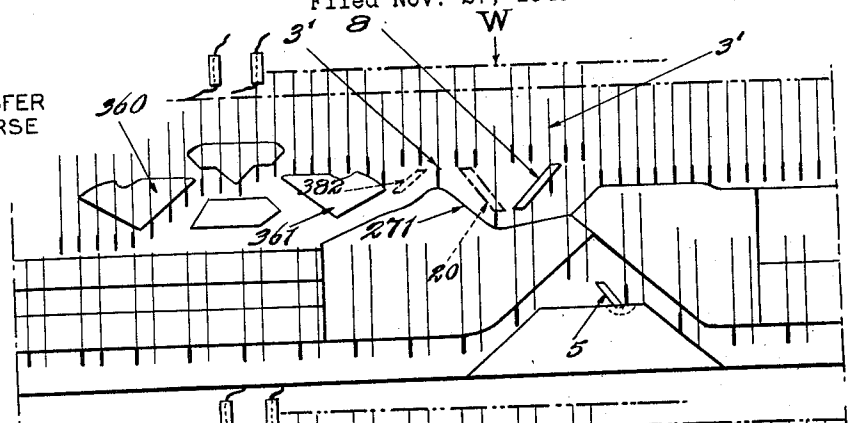


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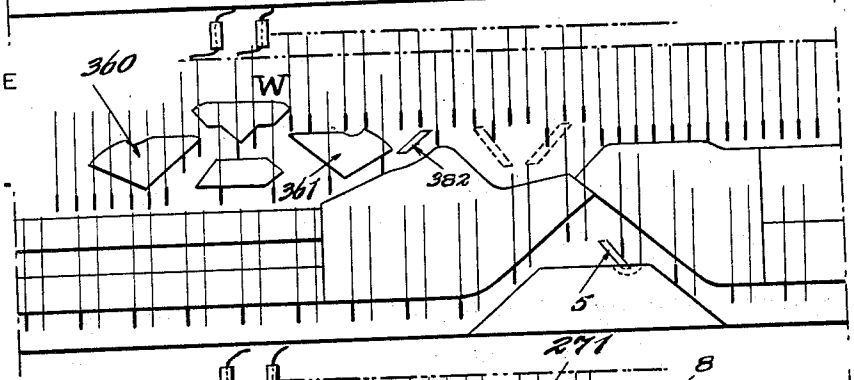


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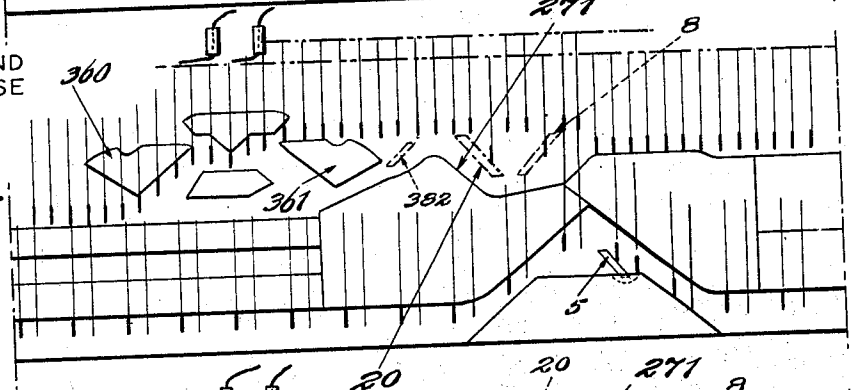
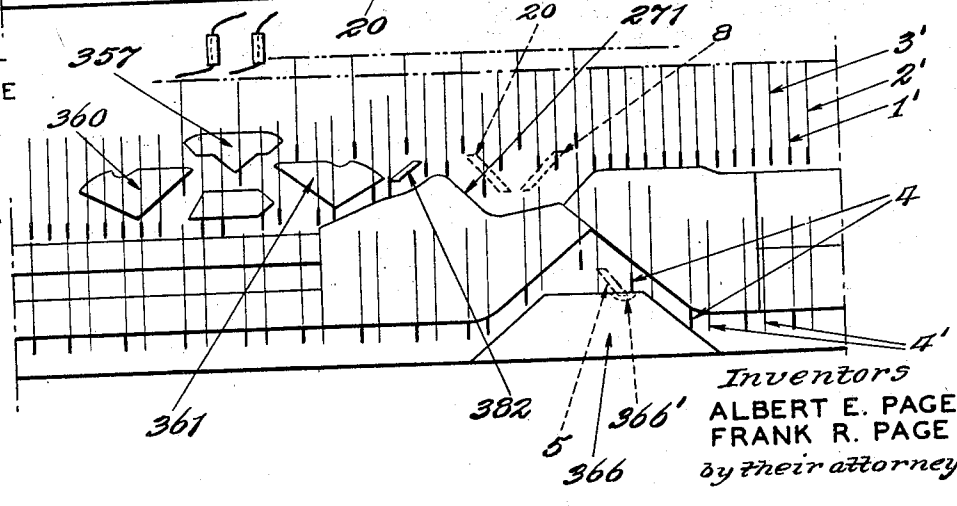


Fig. 4.



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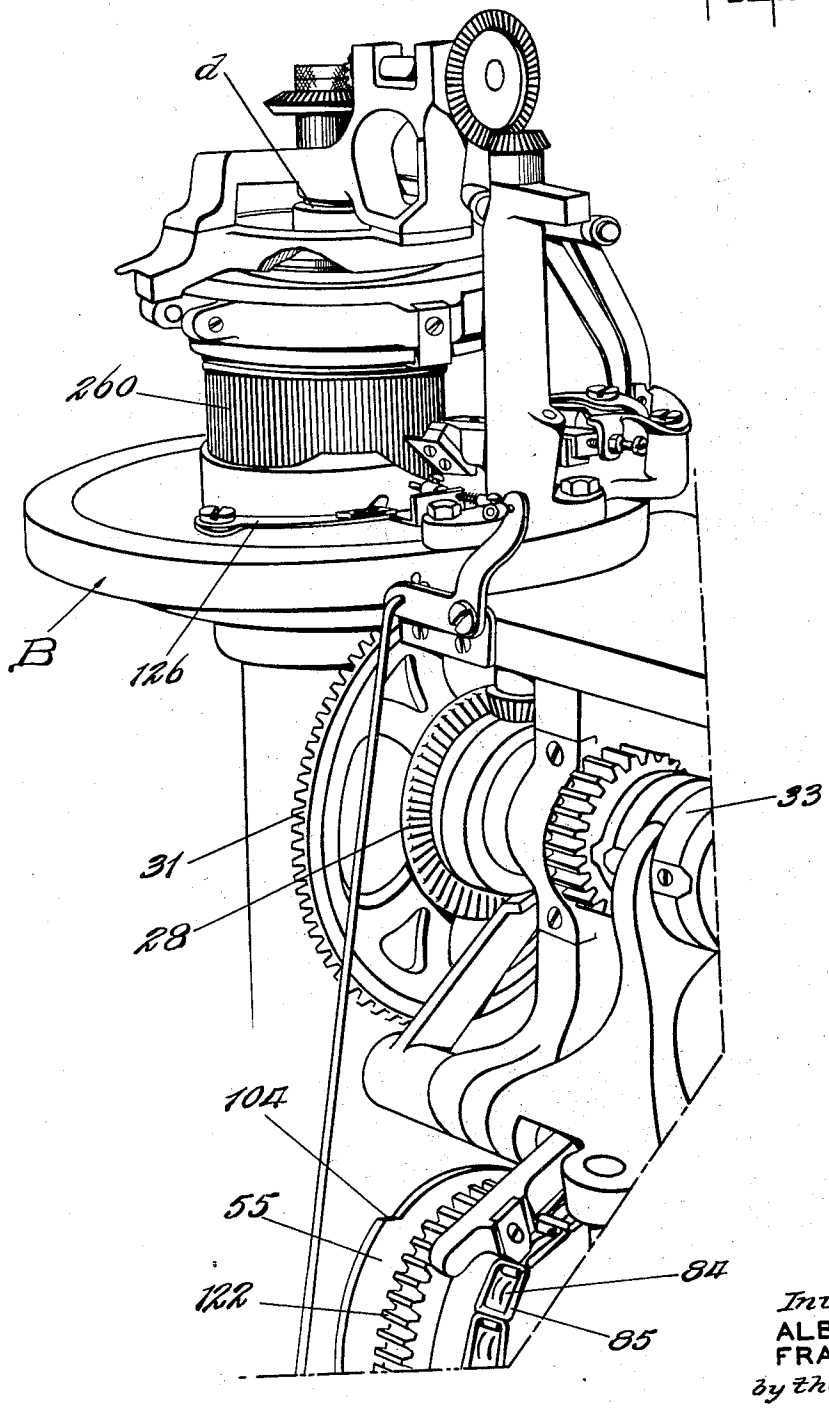
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Fig. 8.



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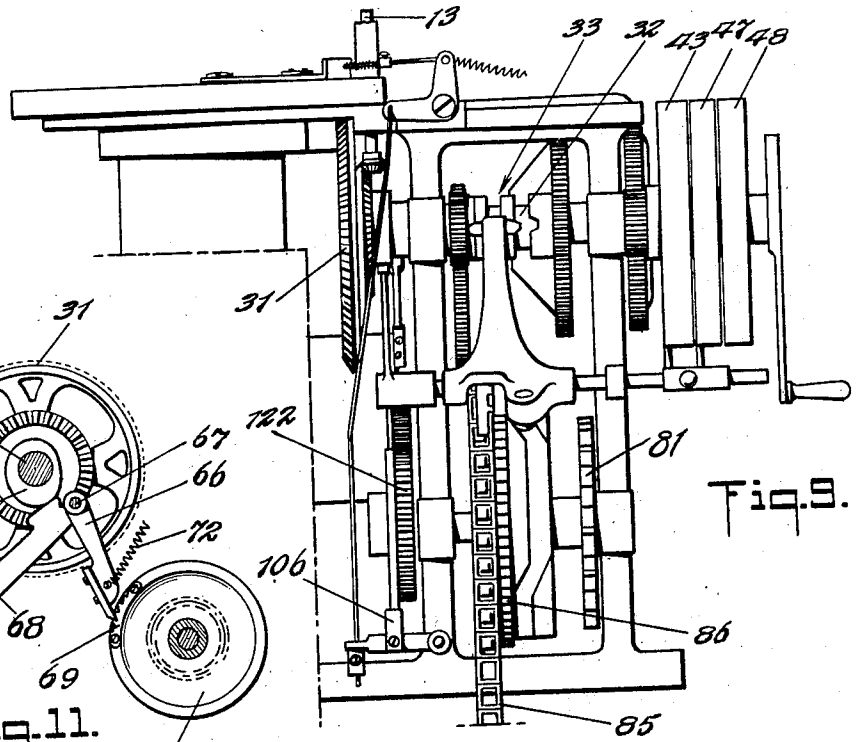


Fig. 9.

Fig. 11.

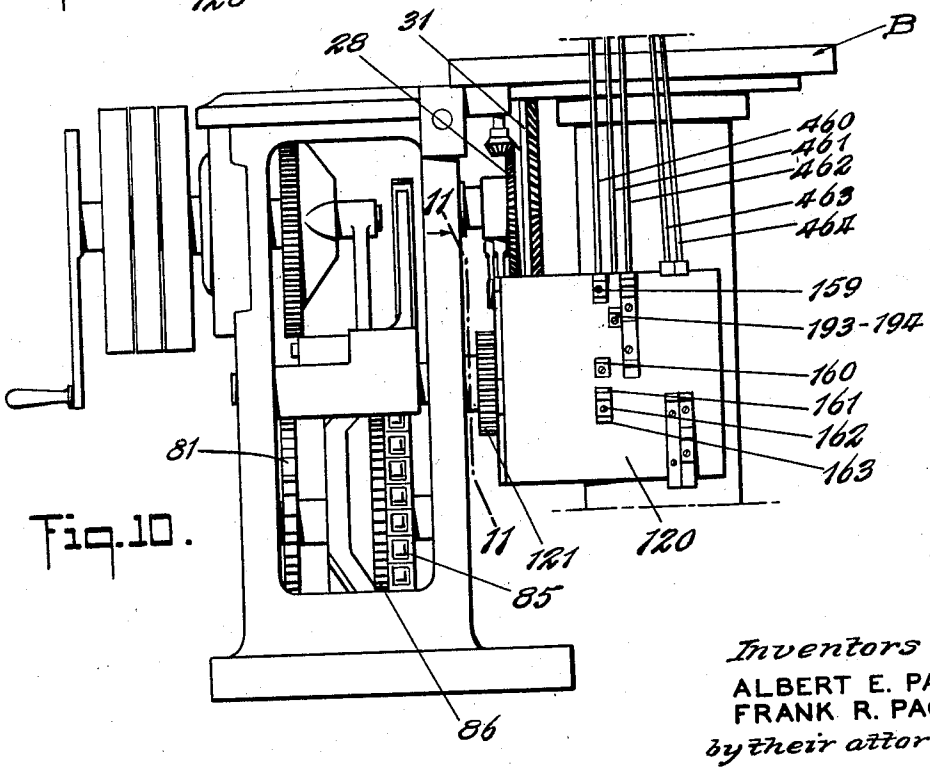


Fig. 10.

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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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Fig. 38.

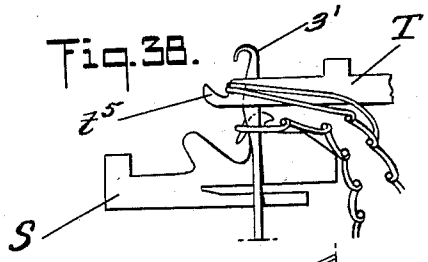


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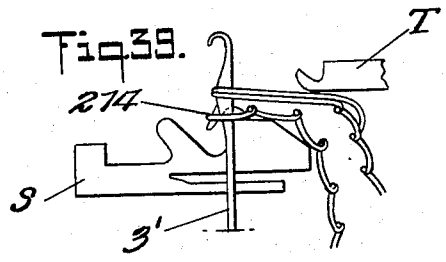


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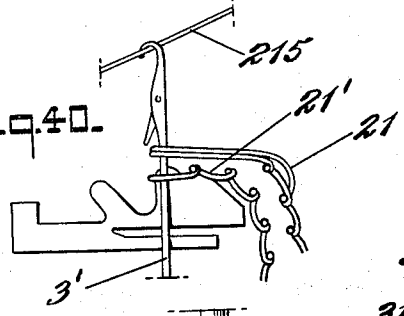


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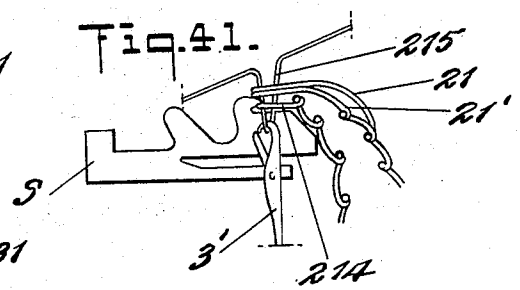
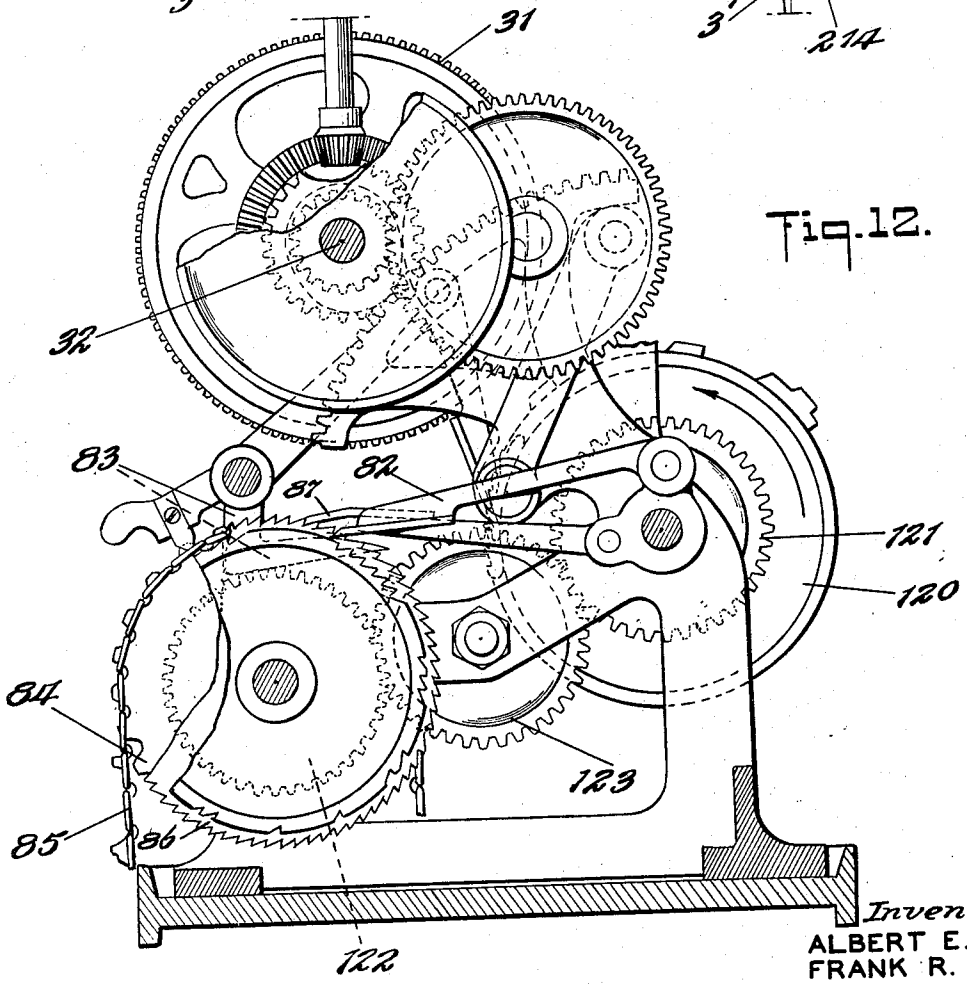


Fig. 12.



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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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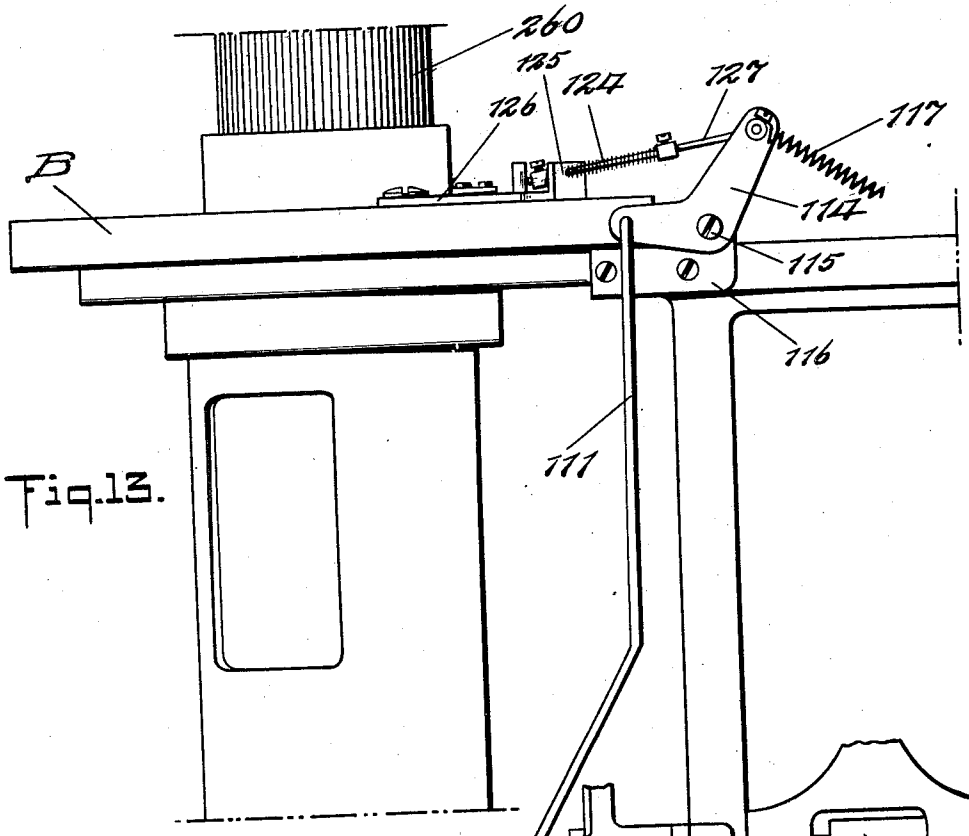


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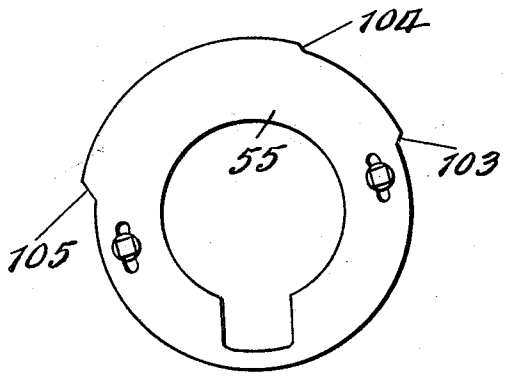
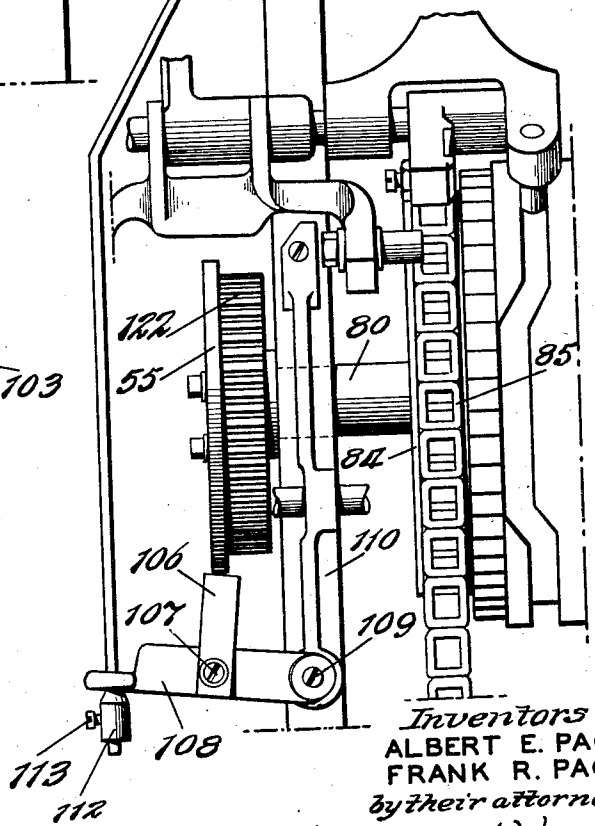


Fig. 14



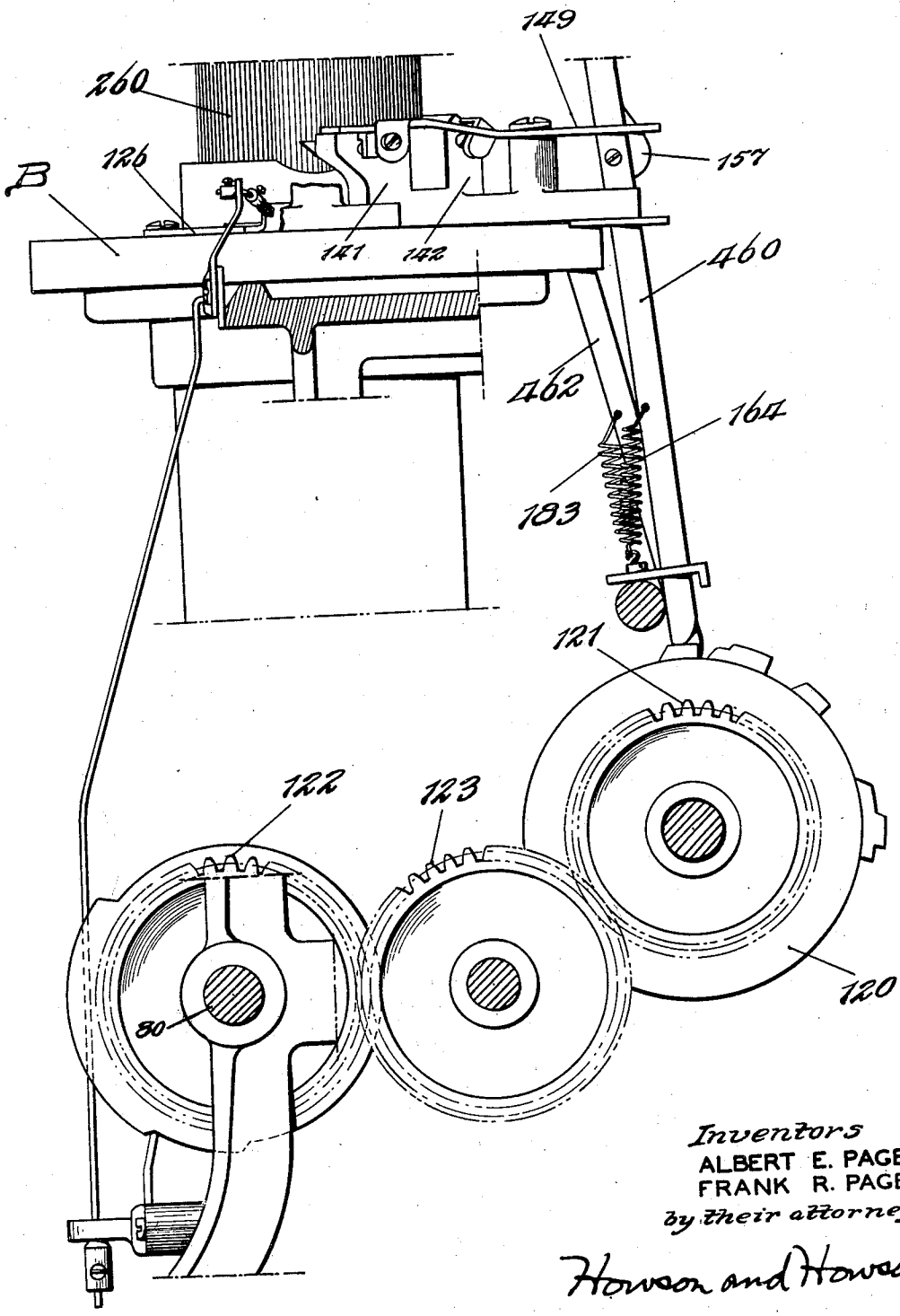
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Fig. 15.



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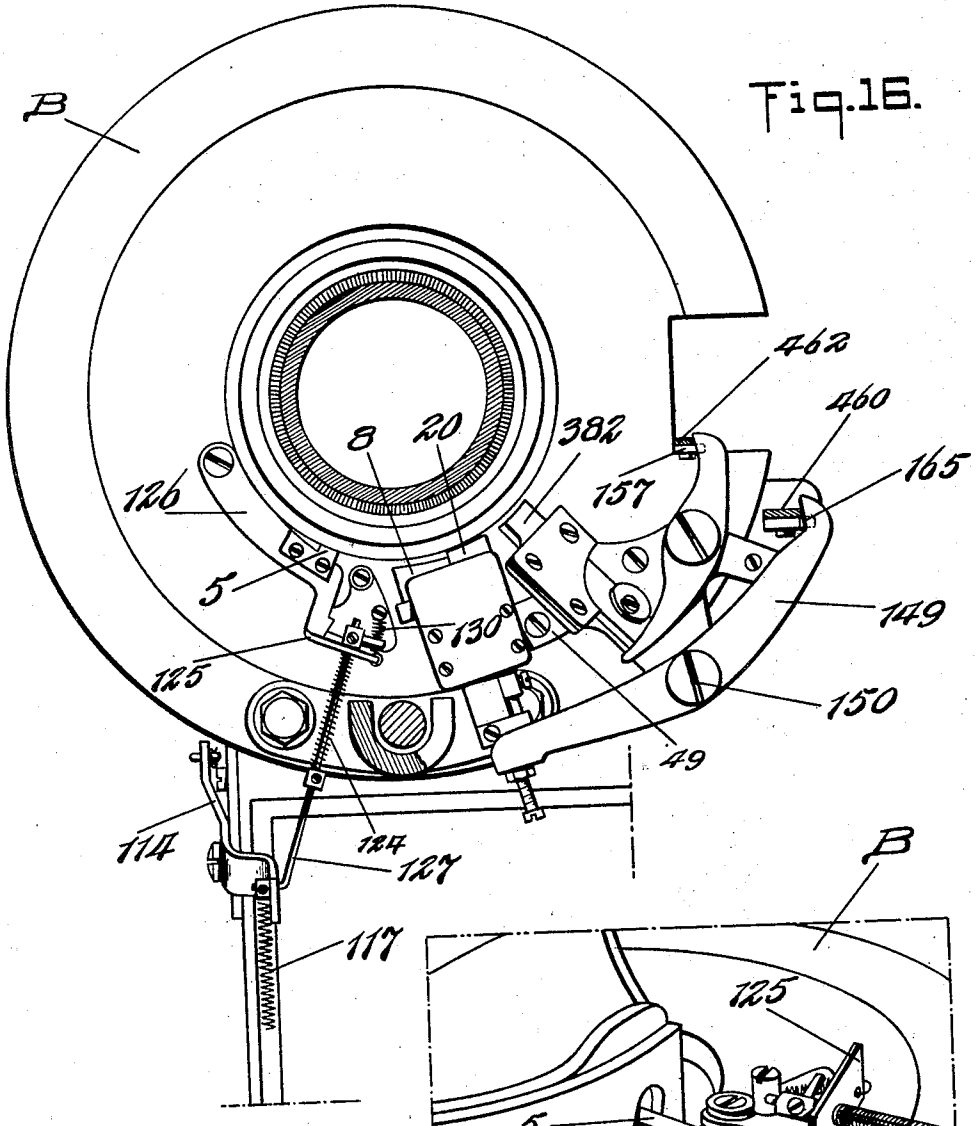


Fig. 16.

Fig. 17.

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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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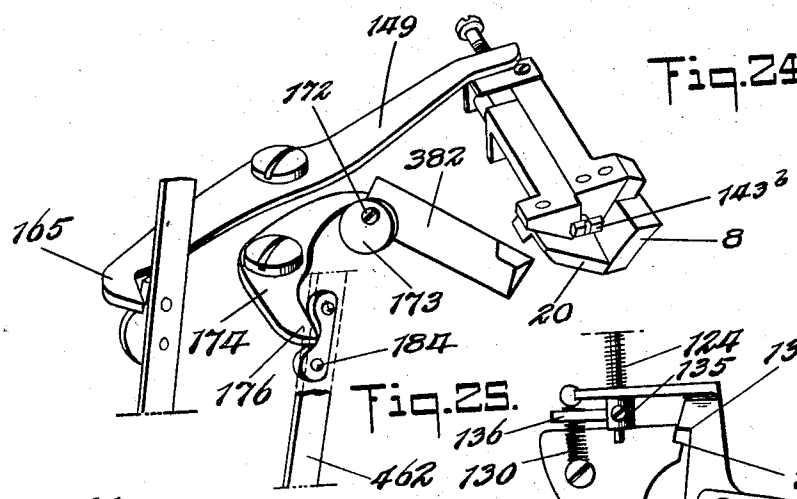


Fig. 24.

Fig. 25.

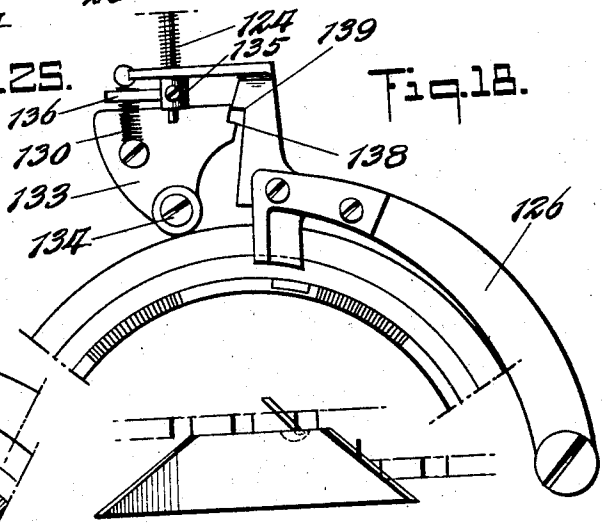


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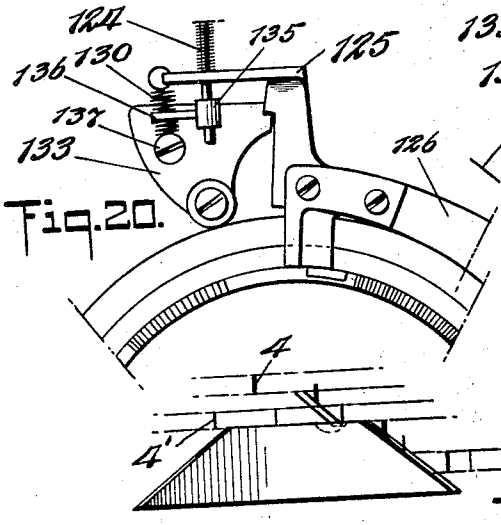


Fig. 20.

Fig. 19.

Fig. 21.

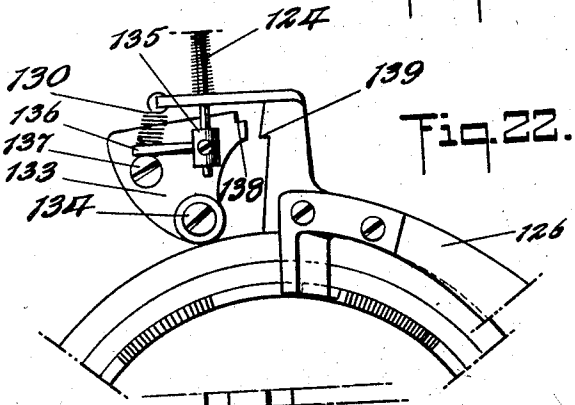


Fig. 22.

Fig. 23.

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Fig. 26.

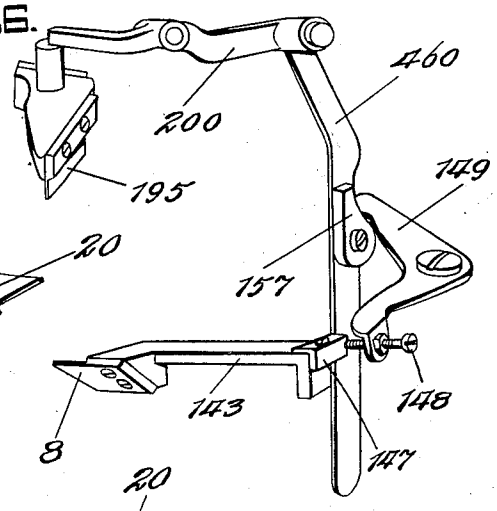
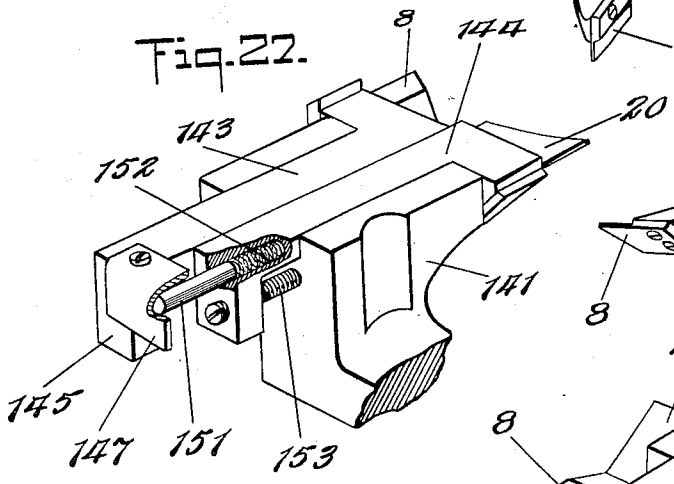
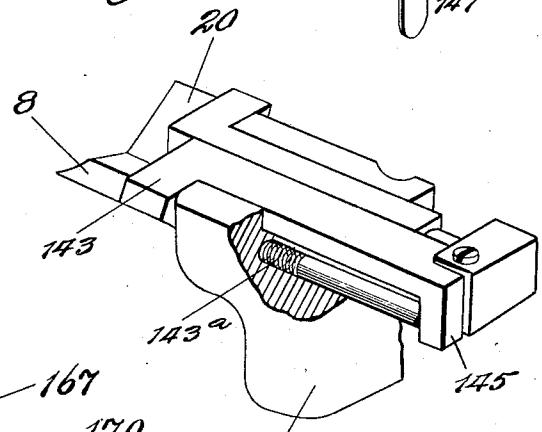


Fig. 22.





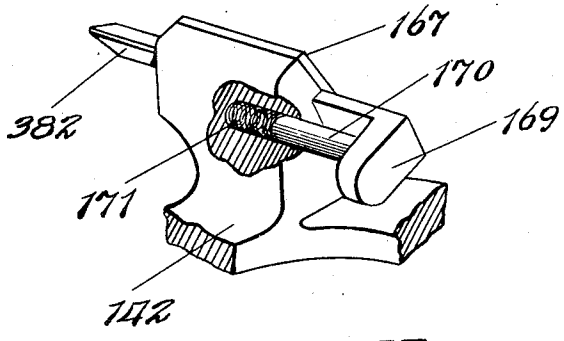


Fig. 28.

Fig. 29.

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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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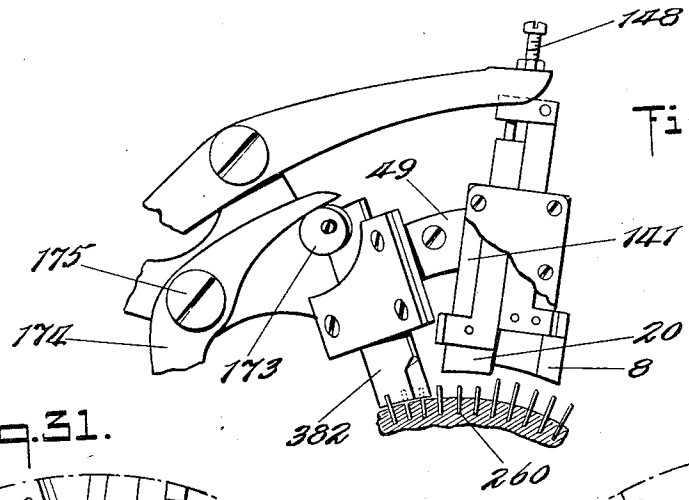


Fig. 30.

Fig. 31.

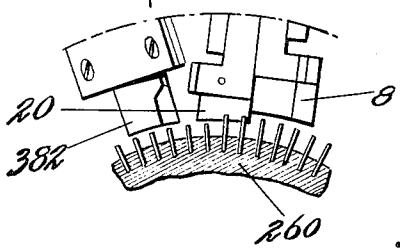


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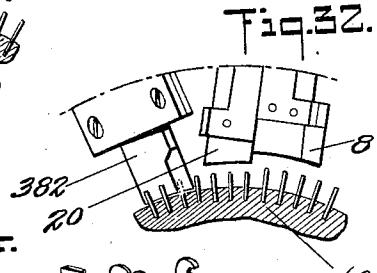


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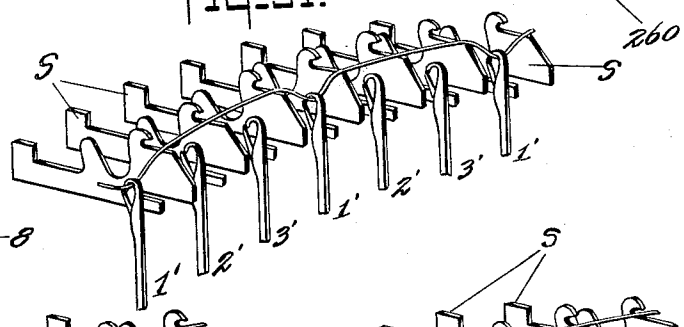


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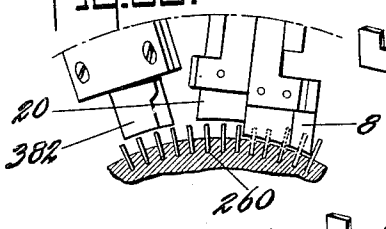


Fig. 36

Fig. 35.

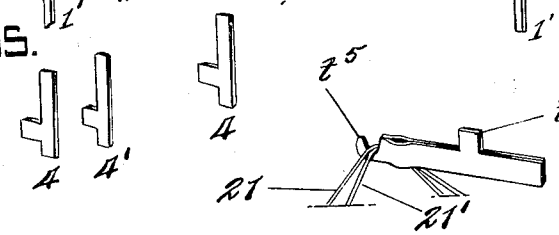


Fig. 37.

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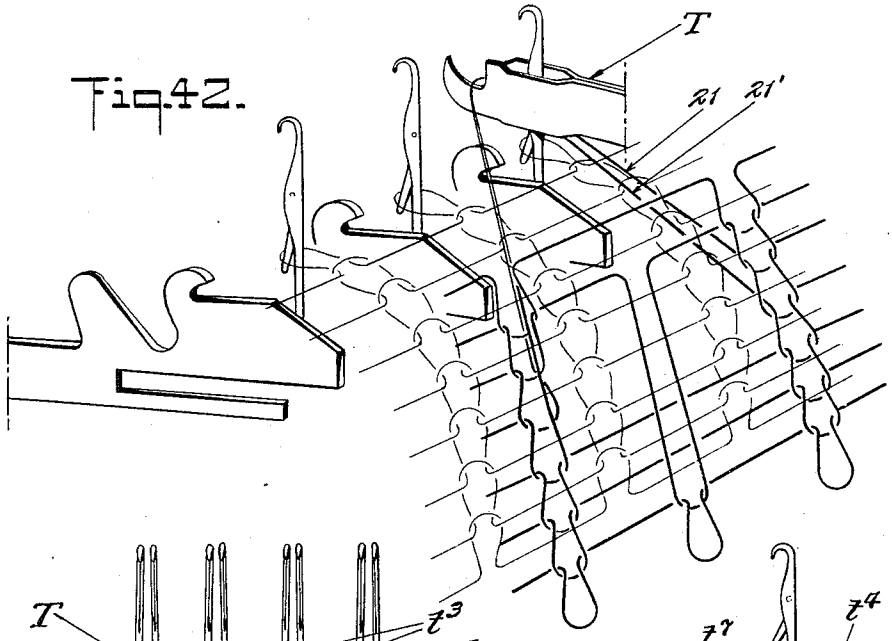
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Fig.42.



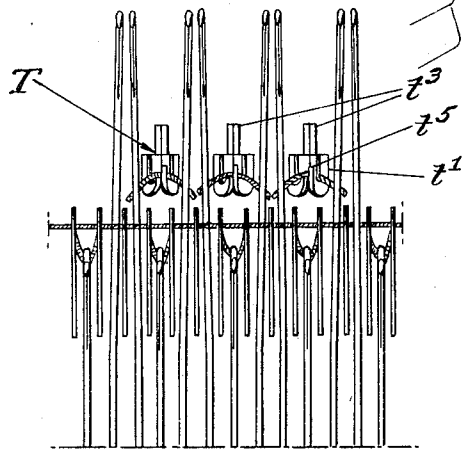


Fig.50

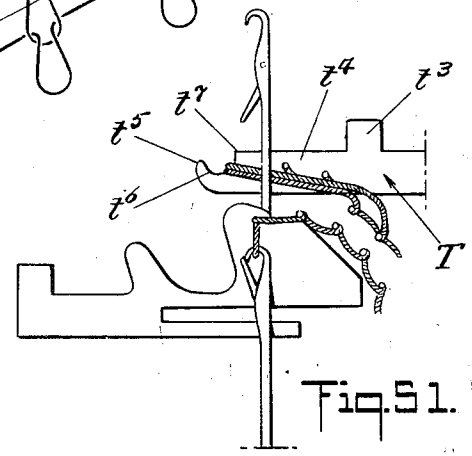


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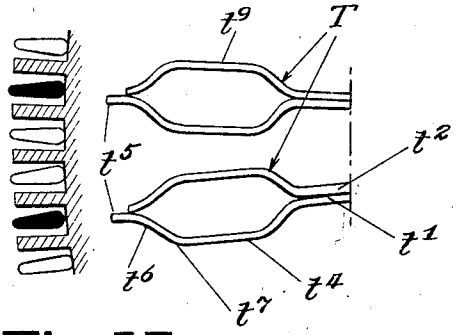


Fig.52.

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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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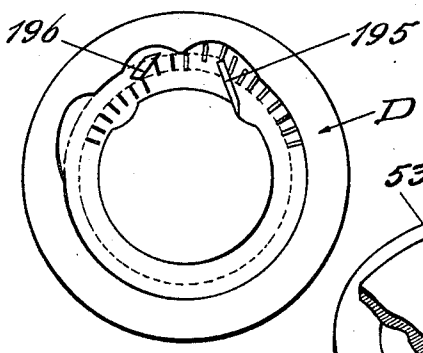


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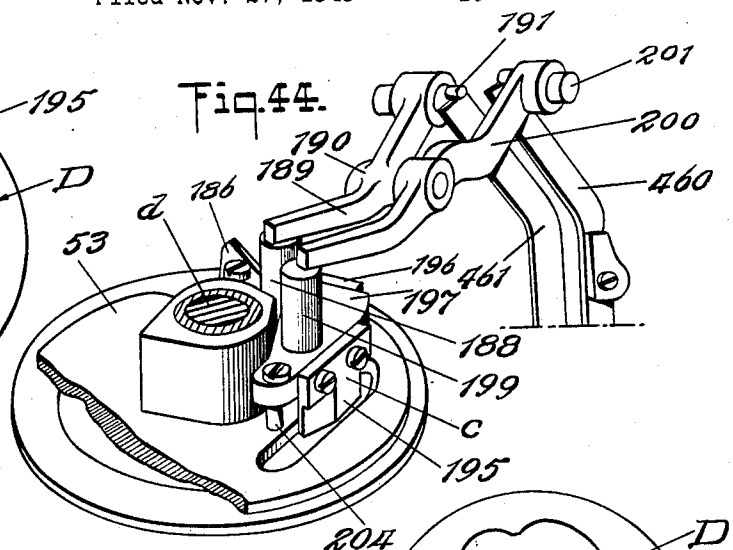


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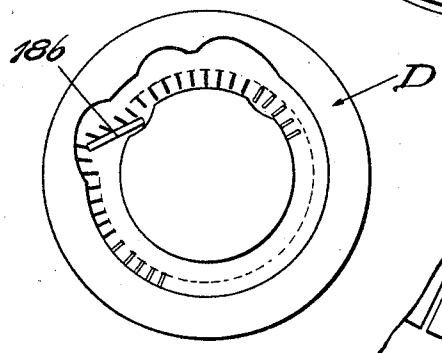


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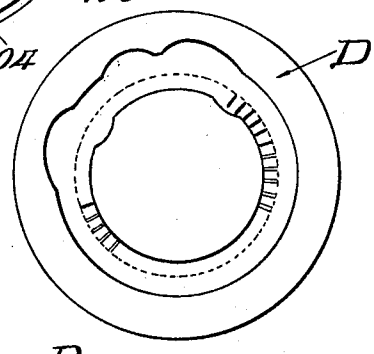


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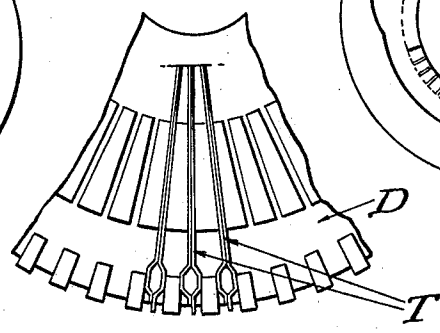


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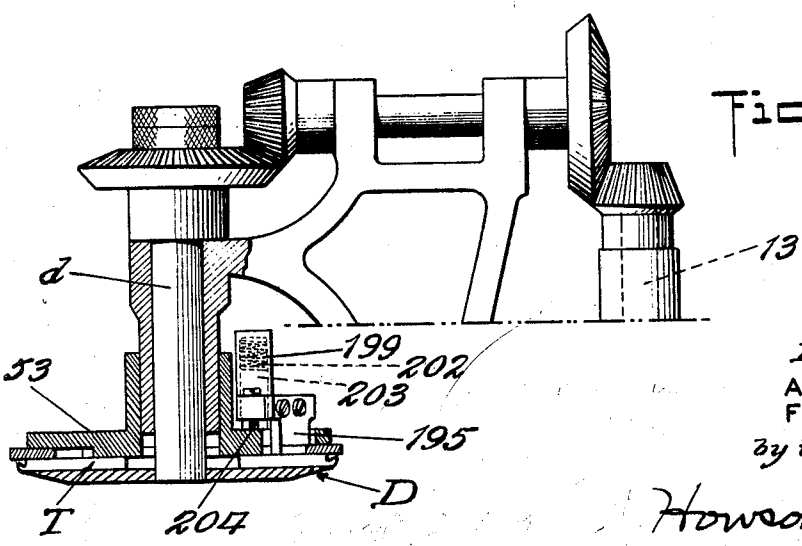


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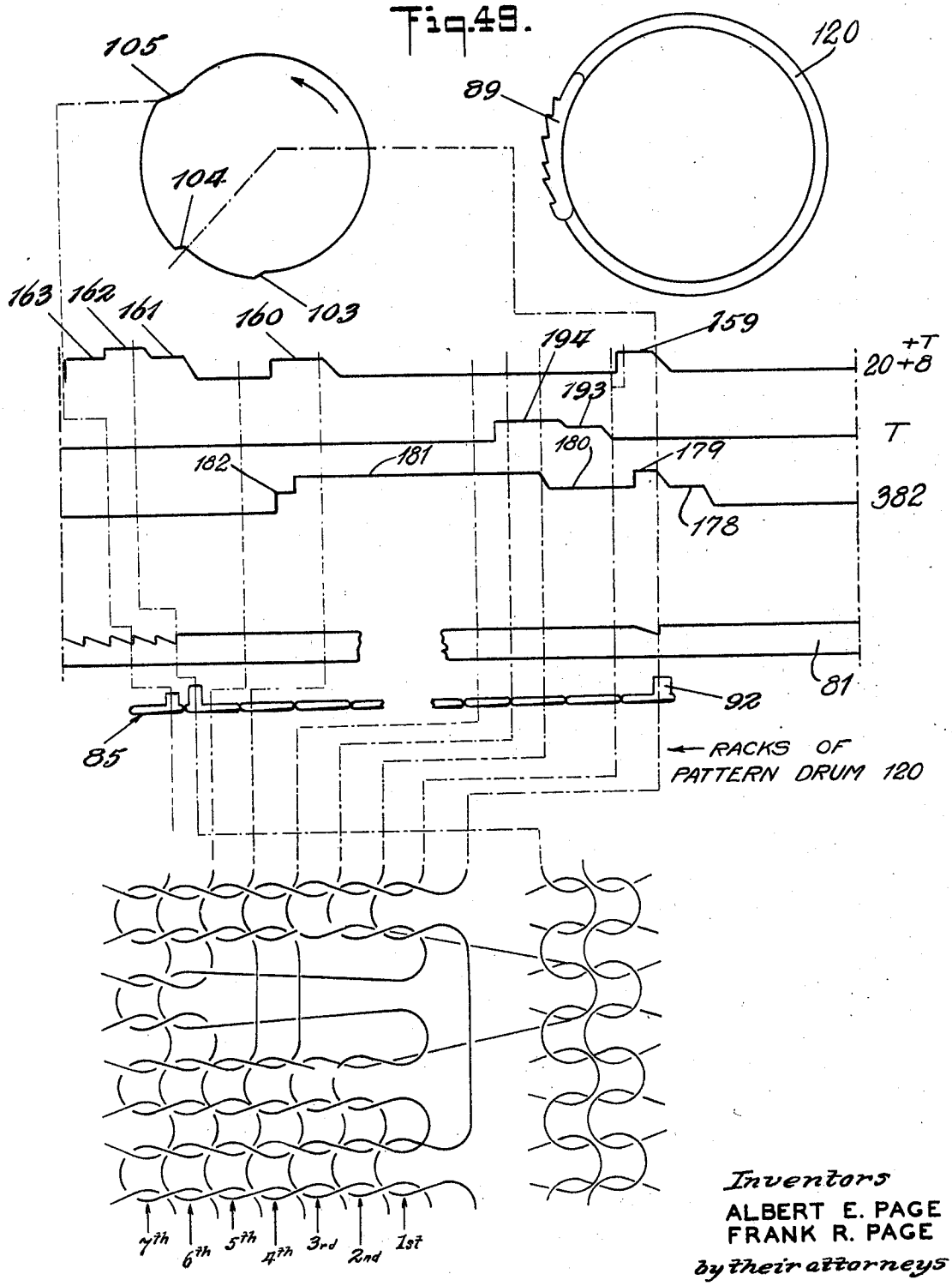
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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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Fig. 48.



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CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

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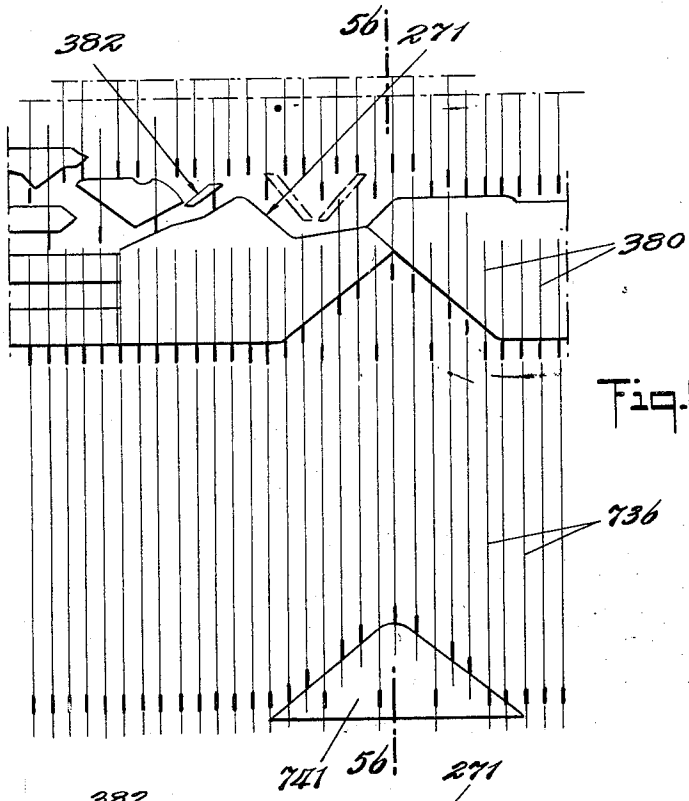


Fig. 55

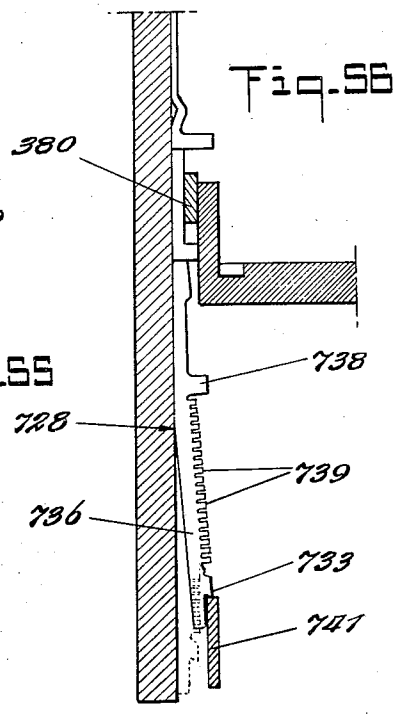


Fig. 56

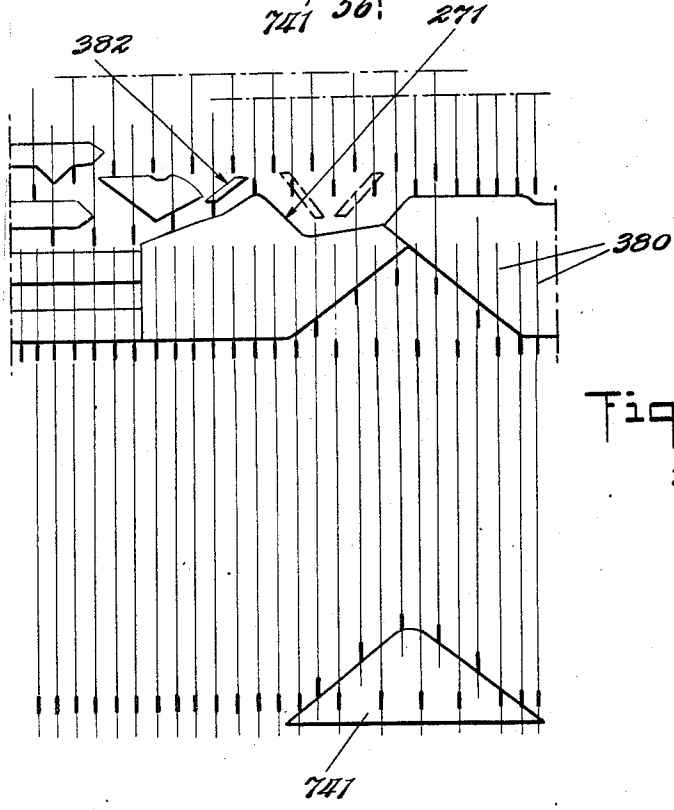


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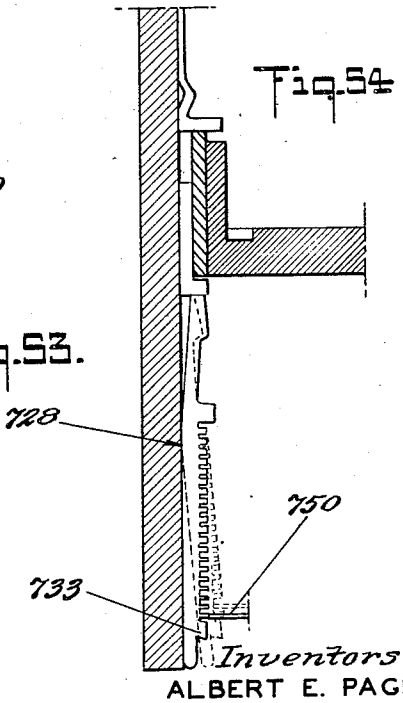


Fig. 54

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Patented Oct. 30, 1945 2,387,769

UNITED STATES PATENT OFFICE

2,387,769

CIRCULAR KNITTING MACHINE AND METHOD OF OPERATING SAME

Albert E. Page and Frank R. Page, Laconia, N. H., assignors to Scott & Williams, Incorporated, Laconia, N. H., a corporation of Massachusetts

Application November 27, 1943, Serial No. 512,001

21 Claims. (Cl. 66—41)

This invention relates to circular knitting machines and method of operating same, and more particularly to a machine having a dial containing elements adapted to participate in the transfer of loops, as for example, in the formation of an inturned welt on hosiery. One object of the invention is to provide means whereby there is proper transfer of loops from the transfer implements to the needles. It is characteristic of a machine made in accordance with our invention that the needles assist in maintaining the registry between the transfer implements and the needles during transfer of loops.

The present invention is an improvement on the patent to Robert W. Scott No. 1,282,958, dated October 29, 1918, for "Machine for knitting welted and other fabrics." As shown in that patent, the fabric can be started up from the bare needles and the making of the automatic inturned welt at the upper end of the stocking is accomplished with the aid of transfer implements T mounted radially in a dial D. It has been found when it is desired to make a very fine gauge fabric, that the number of transfer implements T is increased to the point where there is insufficient room at the center of the dial for the tails of all the transfer implements. We have found a method of avoiding this obstacle with the use of one transfer implement not more frequently than for every third needle. However, it has also been found that transfer implements do not always maintain their registry with the needles when projected for the transfer operation, and missed stitches result.

The means for maintaining the registry between the transfer implements and loops and the needles to receive the loops is one of the principal objects of this invention. It is of interest to note that this is done without introducing any new knitting elements in the machine. The basic features of the present invention are applicable to a machine of any gauge making any kind of a transferred stitch. Other objects of the invention will be described in the subsequent parts of the specification.

In the drawings:

Fig. 1 is a diagrammatic view of part of the stitches of an inturned welt made on a machine constructed and manipulated in accordance with the present invention, the stitches being arranged so as to show their concatenation;

Fig. 2 is a fragmentary view of the stocking top of Fig. 1, showing the novel welt loops and the actual relation of the stitches associated therewith;

Fig. 3 is a view in outline of the stocking such as contains the inturned welt of Fig. 1;

Fig. 4 is a development of the needles, jacks and needle-operating cams of a machine adapted to make the fabric of Fig. 1, looking outward from the center of the machine, showing the parts during the making of the first course of the welt;

Fig. 5 is a view similar to Fig. 4, showing the parts during the second course when all the needles take yarn.

Fig. 6 is a view similar to Figs. 4 and 5, showing the parts during the third, fourth, fifth and sixth courses when two out of three needles take yarn;

Fig. 7 is a view similar to Figs. 4, 5 and 6, showing the parts during the course where the loops are being transferred from the transfer bits to the needles;

Fig. 8 is a view in perspective of part of the front of a circular knitting machine constructed in accordance with our present invention;

Fig. 9 is a view in front elevation showing the pattern chain and main driving mechanism of the machine of Fig. 8;

Fig. 10 is a view in rear elevation of the driving mechanism, also showing the main pattern drum;

Fig. 11 is a view in vertical section taken on the line 11—11 of Fig. 10, showing auxiliary means for racking the main pattern drum;

Fig. 12 is a view in elevation from the right side of the machine, the frame and other parts having been removed in order to show the pattern chain, pattern drum and associated driving means;

Fig. 13 is a view in elevation taken from the front of the machine, showing the mechanism for controlling the insertion of the jack cam shown in Figs. 4–7;

Fig. 14 is a face view of the disk cam controlling the movements of the jack cam;

Fig. 15 is a view in elevation from the right side of the machine, showing only the main pattern drum and certain parts controlled therefrom, including the jack cam control parts;

Fig. 16 is a plan view of the bedplate of the machine showing part of the jack cam and needle cam controlling mechanisms;

Fig. 17 is a view in perspective of the mounting of the jack cam itself;

Fig. 18 is a plan view of the jack cam and the means by which the depth of its insertion is controlled, with the jack cam in retracted position;

Fig. 19 is a view in elevation of the jack cam and its relation to the raising of the jack butts, corresponding to Fig. 18;

Fig. 20 is a view similar to Fig. 18, showing the jack cam partially inserted so as to raise the long butt jacks during the first course of knitting;

Fig. 21 is a view in elevation corresponding to Fig. 20, showing the interaction of the jack cam with the jack butts during the first course;

Fig. 22 is a plan view similar to Figs. 18 and 20, but showing the jack cam inserted all the way where it elevates both the long and short butt jacks;

Fig. 23 is a view corresponding to Fig. 22 but in elevation, showing the interaction of the jack cam with the jack butts when thus fully inserted;

Fig. 24 is a perspective view of three of the needle elevating and depressing cams which cooperate with the jack cam to produce the necessary selections of stitches during the first few courses of knitting, and also showing the levers and thrust rods connecting those cams to the main pattern drum;

Fig. 25 is a view similar to Fig. 24, in perspective, showing a needle dividing cam which cooperates with the jack cam and the cams of Fig. 24;

Fig. 26 is a view in perspective of the needle depressing cam of Fig. 24 and a cam acting on the butts of the transfer implements in the dial during the knitting of the transfer course, together with the levers which control said cams;

Fig. 27 is a detailed view, in perspective, of the needle elevating and depressing cams of Fig. 24, showing the manner of mounting to give their interrelated insertions and withdrawals;

Fig. 28 is another view in perspective of the parts of Fig. 27, showing the mounting partly broken away, taken from the side of the needle depressing cam;

Fig. 29 is a view in perspective of the needle dividing cam of Fig. 25, showing the mounting of the same partially broken away to further illustrate its manner of insertion;

Fig. 30 is a plan view of the various needle cams of Figs. 26 to 29 assembled in the positions which they occupy during the knitting of the first course as shown in Fig. 4;

Fig. 31 is a view of the cams of Fig. 30 and their relation to the needle butts, showing their positions during the making of the second course as shown in Fig. 5;

Fig. 32 is a view similar to Fig. 31, showing the cams in the position they occupy during the knitting of the third and succeeding courses as shown in Fig. 6;

Fig. 33 is a view similar to Figs. 31 and 32, showing the cams positioned for the knitting of the transfer course as shown in Fig. 7;

Fig. 34 is a diagrammatic view in perspective of the needles and sinkers, showing the engagement of the yarn in the hooks, the needles being shown more particularly in the position they occupy after being levelled off at the extreme left of Fig. 4;

Fig. 35 is a view similar to Fig. 34, but showing the parts in their condition after the knitting of the second course shown in Fig. 5, the associated jacks being indicated in part underneath three of the needles;

Fig. 36 is a view similar to Figs. 34 and 35, after the knitting of the third course shown in Fig. 6, and showing the transfer elements T engaging the yarn for the first time;

Fig. 37 is a fragmentary view showing in more detail the engagement of the plurality of loops by the transfer element during the fourth course of knitting;

Figs. 38, 39, 40 and 41 are a series of views in side elevation, showing the relative positions of the sinkers, transfer elements, needles and associated yarn loops and stitches at various points in the knitting; Fig. 38 showing the relative positions of the parts as the needle rises through the yarn loops held by the transfer implements T; Fig. 39 showing the needle still further elevated and the transfer implement withdrawn out of action; Fig. 40 showing a still later phase of the knitting cycle where the welt loops from the transfer implement have been cleared below the needle latch and the hook of the needle has engaged yarn for the knitting of the transfer course; Fig. 41 illustrating the last phase of the knitting of the transfer course where the needle has drawn yarn through the welt loops and the previous course loop;

Fig. 42 is a fragmentary diagrammatic view in perspective illustrating the relation of the sinkers, needles, transfer implements and yarn loops just preceding the knitting of the transfer course, the needles and sinkers being shown widely separated for the sake of clarity;

Fig. 43 is a view in side elevation, partly in section, of the driving connection for the dial carrying the transfer implements, the parts shown in this view being directly above and associated with those shown in Fig. 9;

Fig. 44 is a view in perspective from above showing the means which control the cams that act upon the transfer implements;

Fig. 45 is a plan view with the dial cap plate removed, showing the pathway of the butts on the transfer implements when retracted;

Fig. 46 is a view similar to Fig. 45, but showing the path of the butts of the transfer implements when projected to the position corresponding to Figs. 6 and 36;

Fig. 47 is a view similar to Figs. 45 and 46, but showing other cams operating upon the butts of the transfer implements to project them at the time of transfer, and corresponding to Figs. 7 and 42;

Fig. 48 is a plan view of a fragment of the dial, showing the slots in which the welt implements slide;

Fig. 49 is a diagram showing the timed relation to each other and the fabric, of the movements of the various cams involved in knitting the courses of the welt of Fig. 1;

Fig. 50 is an enlarged view in elevation of a few of the transfer bits and needles at the time of projection of the transfer implements, this view showing the dimensions of the parts and novel centering action of the present invention;

Fig. 51 is a view in side elevation of the parts of Fig. 50;

Fig. 52 is a view on a still further enlarged scale, showing the relative dimensions of the transfer implements and needles, and the spacing of the latter;

Figs. 53 to 56, inclusive, illustrate a modification of the machine of Figs. 4 to 52, in which the needles are selected for the making of the transferred stitches by a form of pattern jack; Fig. 53 being a development of the paths of the butts of the pattern jacks, short jacks and needle butts

for the knitting of the first course corresponding to Fig. 4; Fig. 54 being a view in vertical section of the pattern jacks in selected and non-selected positions on any course, taken at the point where the selecting cam is operating on them; Fig. 55 being a view similar to Fig. 53 but at the third course, the non-elevated needles being those corresponding to the jackless needles of Figs. 4 to 7; and Fig. 56 being a view in vertical section similar to Fig. 54, taken at the time the jacks are being raised on any course, and corresponding to Fig. 6 and to line **56—56** of Fig. 55. In Figs. 53 and 55 cams **8** and **20** are indicated by dot-and-dash lines but are inactive in those figures.

General construction of machine and fabric

The general construction of the machine in which this invention is embodied in the drawings is as follows. There is the usual revolving needle cylinder **260** mounted in the bedplate B and rotated or oscillated from the usual pulleys **43** or **47** required for the making of stockings. The mechanism for driving the needle cylinder as required includes the clutch **33** on the main drive shaft **32** which causes either reciprocatory or rotary movement of the main bevel gear **31** according to whether the clutch is in its left or right position, as seen in Fig. 9. The main bevel gear **31** meshes with the main head gear ring (not shown) which surrounds and is fixed to the needle cylinder. The shifting of the clutch between rotary and reciprocatory position is caused under the control of a pattern chain **85**, in the same general way as shown in the patent to Robert W. Scott No. 1,148,055, dated July 27, 1915. This pattern chain is carried on a sprocket wheel **84** to which is fixed a ratchet wheel **86** racked ahead by a chain pawl **87** (Fig. 12). The varying heights of the chain links actuate a chain pawl controller **83** which controls the movements of the main pawl **82** transmitted to the main rack wheel **81** and thence to a gear **122**. The pattern chain not only causes shifting of the clutch but also the timing of many movements of the needle cams, etc., through the intermediary of the main pattern drum **120** by means of gears **121**, **122**, **123**.

The embodiment of the invention shown in Figs. 4 to 52, inclusive, and the embodiment of Figs. 53 to 56, inclusive, each contains a circular dial D containing transfer instrumentalities T, which latter elements we shall hereinafter call transfer bits. As in the Scott Patent 1,282,958, above referred to, and as shown in Figs. 48, 50, 51 and 52 of our application, these transfer bits slide radially in and out across the periphery of the dial for the purpose of taking bights of yarn, holding them, and subsequently transferring them to the corresponding needles in the cylinder. The rotation of the dial in synchronism with the needle cylinder is obtained from the dial driving bevel gear **28**, the vertical dial driving shaft **13** and the usual bevel gears, shaft and dial spindle *d* shown in Figs. 8, 9 and 43. The main pattern drum **120** (Fig. 10) has on it cams adapted to actuate various elements in the head of the machine by means of thrust bars **460**, **461**, **462**, but certain of the cam movements are obtained from the rotation of the shaft **80** carrying the pattern chain and its rack wheel **81**, as will be hereinafter described. The main pattern drum also serves to raise and lower the yarn fingers by means of thrust rods **463**, **464** into and out of operative relation with the needles and transfer bits, in a well-known manner.

As is usual in independent needle circular hosiery machines, the needles are divided into two consecutive series of long and short butt needles, the long butts being referred to ordinarily as the instep needles and the short butts as the heel needles. Assuming that the machine is of a sufficiently fine gauge to have 480 needles, 240 of them will therefore be long butt and 240 short butt needles, these groups being subdivided as usual. The machine has the usual sinkers S.

To assist in understanding our novel machine, we will now give a brief description of the fabric produced and which forms the subject-matter of our application filed of even date herewith, for "Knit fabric and method of making same," Serial No. 512,000. In this application we have shown in Fig. 3 the outline of a stocking adapted to contain our invention, the automatic inturned welt **23** being separated from the leg **25** by a transfer course X and the leg terminating in a heel **26** and toe **27**. The novel parts of the fabric relate to the transferred stitches which form part of this automatic inturned welt and the machine which we are showing and describing is adapted to make this stocking starting up from the bare needles. It should be noted, however, that the machine can be employed to form any kind of a transferred stitch. For instance, it is possible to make a fabric having a fancy appearance by means of transferred stitches, or to make one with laterally transferred stitches if desired. It should also be understood that while the invention is peculiarly useful in machines of very fine gauge, it can be used to advantage in any gauge. As shown in Figs. 1 and 2, there are three kinds of wales in the welt, numbered **1**, **2** and **3** (reading from right to left). The needle knitting a wale such as **1** is a needle **1'** having a jack with a long butt, while wale **2** is knit by a needle **2'** having under it a jack with a short butt, and wale **3** is knit by needle **3'** having no jack under it at all. The long butt jacks are shown in Figs. 4 to 7 and 35 with the reference character **4**, while the short butt jacks are indicated by reference character **4'**. It might be noted that the stitches shown in Figs. 1 and 2 are partial duplicates of each other, the difference in appearance of the fabrics being due to the fact that in Fig. 1 the showing is diagrammatic with the wales of one thickness of the welt offset in order to make the wales of the other thickness more visible; while in Fig. 2 the second thickness is omitted and the stitches are shown in the distorted form which they take incidental to the strain caused by the transfer loops. It will be apparent from this figure that the formation of normal-shaped knitted loops is not obvious until the knitting of the third or fourth course, due in part to these transfer loops **21** and **21'**. As shown in Fig. 2, the yarn of the first course assumes a wavy formation but the elongated loops **22** in the second course retain their identity due to not being cast off from needles until the knitting of the seventh course. The transfer loops **21** and **21'** are knitted respectively in the third and fourth courses and are interlaced with the loops **22**. As shown in Fig. 2, each arm of a loop **22** passes under the yarn from the third course loop **21** and over the fourth course loop **21'**. The end of each arm of the loop **22** then passes under both the third and fourth course yarns and emerges in the next sinker wale, giving more or less the appearance of a knot **224** where the first course yarn is threaded under the yarn

from the loop 22. The yarn of the loop 22 repeats this cycle throughout the entire circumference of the stocking.

It will be noted from Fig. 2 that the transfer loops 21' of the fourth course are bent out laterally beyond the third course loops 21 by reason of the crossing of the leg of the loop 22 in opposite directions by the third and fourth course yarn at the beginning of the loops 21, 21'. This bowing out of the loops 21' assists materially in filling up the space between the adjacent transfer loops and it is also found that the knot formation 224 serves to keep this bowed formation.

One reason for having a plurality of transfer loops made—and in separate courses—is that it occasionally happens a single transfer loop is not shed by the transfer element when taken by the needle. This is closely related to the maintenance of registry between transfer bits and needles. We have discovered that if a plurality of welt courses are knit so that there are two or more welt loops 21, 21' on each transfer element, no mistransfers occur and the needle will be able to force the loops off the transfer element successfully. We have also found that due to the crossed, bowed and knotted formation above described with relation to the legs of the transfer loops, there is a binding at the point where the legs of the loops join the fabric which resists the pull of the transfer element and assists in their removal therefrom. Furthermore, having separate course transfer loops seems to prevent the loops slipping off the transfer elements or bits in advance of the proper time.

Finally, to assist in understanding the operation of the machine now to be described, we note that in the first course of the welt described only the needles 1' having long butt jacks under them take yarn, namely, every third needle. In the second course all needles take yarn. In the third course two out of three needles take yarn and also the transfer elements or bits. The needles which are inactive are the ones corresponding to the bits, namely, the jackless needles 3'. Beginning with the seventh course, all needles take yarn.

Jack cams

In the example given in Figs. 4 to 52 of the drawings, every third needle has a long butt jack 4 and one of each of the two remaining needles has a short butt jack 4' (see Figs. 4 to 7 and the lower part of Fig. 35). These jacks are used in connection with the starting of the fabric and the making of the transfer. As shown in Figs. 4 to 7, there is a special cam path for the butts of the jacks and the raising of the jacks is caused in part by a stationary cam 366. There is a depression 366' in the top of this cam (Fig. 4) and in it is located the lower end of a radially movable jack raising cam 5. This cam is adapted to be moved into operative relation with the long butt jacks only, both the long and short butt jacks, or out of action with relation to both kinds of jacks. The purpose of the depression 366' in the upper surface of the fixed cam 366 in which the lower end of the jack cam 5 seats is to avoid the possibility of jack butts striking against the leading edge of the cam 5 and breaking.

This jack cam 5 is mounted on a lever 126 pivoted on bedplate B and is moved by the mechanism shown in Figs. 8 and 13 to 16 inclusive. This mechanism is actuated by the disk cam 55 which can be bolted on the drum driving gear 122 mounted on the end of the pattern chain shaft 80 (as shown in Fig. 13). The periphery of this disk cam has three heights, the lowest portion leading by a cam 103 to the intermediate level which in turn leads to the high part of the disk by cam surface 104, and the high part returning to the lowest portion by slope 105 (Fig. 14). These surfaces are read by a lug 106 fastened by a screw 107 to a lever 108, which lever is pivoted at 109 to an upright 110 (Fig. 13). The pivotal movements of the lever 108 transmitted by the lug 106 are in turn transmitted to bell crank lever 114, pivoted at 115 to a plate 116 on the bedplate B, by means of a wire link 111 passing through an eye in the end of the arm 108. The projecting lower end of the link 111 terminates in a collar 112 adjustably fixed on the link by a set screw 113. This link is attached to one end of the bell crank lever 114 and to the other end of the bell crank lever is connected a tension spring 117 fastened to the frame of the machine in such a manner as to maintain the lug 106 in contact with the periphery of the disk 55. Also fastened to the upper end of the bell crank lever are the means for transmitting movement to the jack cam 5, these consisting of a rod 127 taking through an upturned end 125 of the lever 126 on the bedplate B. There is a tension spring 130 fastened to the free end of the arm 126 and to an upstanding pin 137 on a detent plate 133, the purpose of this spring and the manner of its mounting being shown more fully in Figs. 18, 20 and 22. It will be noted that there is also a compression spring 124 on the rod 127 maintaining a compression between the upturned end 125 of the lever 126 and the rod by means of a set screw. In this way the disk cam 55 can exercise compression of the spring 124 on the rod against a detent now to be described. The detent is shown in Figs. 18, 20 and 22 and acts to fix the exact intermediate position of the cam 5. It consists of a detent plate 133 pivoted at 134 to the bedplate B. There is a notch or hook portion 138 in this detent which engages a corresponding hook 139 on the lever 126, the parts being of such dimensions that when these two notches are engaged with each other the cam 5 is in its intermediate position shown in Figs. 20 and 21, where it engages the long butt jacks 4 but not the short butt jacks 4'. It will be noted that there is a collar 135 fast on the end of the rod 127 projecting through the upturned end 125 of the lever 126. Extending laterally from the collar 135 is an arm 136 lying in the path of the upstanding pin 137 on the detent to which the tension spring 130 is fastened. It will be noted that with respect to the line of movement of the rod 127, the pin 137 is on the opposite side of the pivot point 134 of the detent plate from the notch 138.

Reviewing the operation of this control of jack cam 5, in Fig. 18 the cam is shown retracted in the position where it engages neither the long jack butts nor the short jack butts, all of which butts move up the fixed cam 366 and past cam 5. At this time the lug 106 is in engagement with the lowest cam surface of the cam disk 55. When it is desired to bring the jack cam into engagement with the butts of the long butt jacks, the advancing movements of the pattern chain cause the lug 106 to ride up the cam surface 103 to the intermediate level of the periphery of the disk, which pulls down on the rod 111, causing the rod 127 to be pushed toward the arm 126 and compress the spring 124. The compression of this spring exerts a force upon lever 126 almost

radially inward of the machine, pushing the notch 139 on the arm 126 toward the needle cylinder to the position shown in Fig. 20. The tension spring 130 holds the notch 138 of the detent plate 133 in the path of the notch 139, this definitely holding the cam 5 in its partially inserted position where it engages the long butt jacks. The short butt jacks still pass the cam 5. When rotation of the pattern chain shaft causes the lug 106 to ride up the cam surface 104 onto the high part of the periphery of the disk 55, thereby tipping the bell crank lever 114, the rod 127 is pushed further toward the needle cylinder. This brings the arm 136 of the collar 135 on the end of the rod into contact with the pin 137 on the detent and the arm pushes the detent plate in a counterclockwise direction. This disengages the notch 138 in the detent from the notch 139 in the lever 126, and the lever 126, under the pressure of spring 124, swings the jack cam 5 into its fully inserted position, as shown in Figs. 22 and 23. Now both the long and short butt jacks are raised to their fully elevated position by the cam 5.

During the knitting of the first course, which is indicated in the fabric of Fig. 1 by the designation "1st" and which occurs during the time that the parts are in the position of Fig. 4, this cam 5 is inserted half way, which is the position shown in Figs. 20 and 21. During the knitting of the second and subsequent courses, up to and including the transfer course, this cam 5 is inserted all the way, as shown in Figs. 22 and 23. When, after the transfer course, the cam 5 is retracted out of engagement with all jack butts to the position shown in Figs. 18 and 19, this movement is effected by further rotation of the disk cam 55 which causes the lug 106 to drop off the high surface down the slope 105, the lug then resting on the lowermost surface. The tension spring 117 on the bell crank lever then pulls the rod 111 upwardly and retracts the cam 5, the detent thereby being reset to the position shown in Fig. 18 with the help of spring 130 but maintaining the lug 106 in contact with the periphery of the disk 55.

Special needle selecting cams 382, 20 and 8

The length of the needle jacks when they travel up jack cam 5 is sufficient to raise the needles in the cylinder slots with them to such an elevation that the needles are cleared and the needle butts ride over the leading stitch cam 361. Each needle, therefore, takes yarn, passes under the top center cam 357 and down under the following stitch cam 360. If a jack merely rides up the fixed cam 366 without going up the movable cam 5, it does not rise far enough to disturb the elevation of its needle. In Figs. 4 to 7, where a cam is fully retracted we have shown it dotted, for the sake of simplicity. Where a cam is shown with dot-and-dash lines, it is intended to mean that the cam is partially inserted and will act on long butts. Where a cam is shown in solid lines it is intended to indicate that it is fully inserted. With this as a background, we will now describe the special cams acting directly on the butts of the needles and their interaction with the jack and other needle cams.

The three most important special needle cams are the lowering cam 382, the raising cam 20 and the special lowering cam 8. During the knitting of the first course when the jack cam 5 is raising the long butt jacks only and therefore raising only every third needle, the needles which are not raised by their jacks come in at normal level past cams 8 and 20, which are retracted. These needles are engaged by cam 382. This cam, therefore, lowers two out of three needles below the leading stitch cam 361, so that two needles out of three are not raised to clear level and only the needles having long butt jacks 4 take yarn. As shown in Figs. 1 and 4, therefore, loops are drawn in only every third wale of the fabric.

As can be seen from Fig. 1, it is desired to draw loops in all the wales in the second course—namely, wales 1, 2 and 3. Therefore cam 20 is inserted part way and cam 382 retracted, cam 20 serving to clear all the long butt needles not already cleared by jack cam 5, while the others are raised by cam 271, and all the needles take yarn and pass under the top center cam 357. Actually, cam 382 need be withdrawn only half way during the knitting of this course, since the cam 20 meets and raises the long butt needles before they reach cam 382 and therefore no needles are influenced by cam 382 in the second course. This partly inserted position of lowering cam 382 in the second course is necessary for the purpose of making it possible to get it all the way in in the succeeding courses without missing half a course or smashing needle butts. The jack cam 5 must raise both long and short butt jacks on the third and succeeding courses and it is convenient to insert it all the way during the second course. The needles are all raised by cams 20, 271 and 361 anyway.

In the third and any other succeeding make-up courses, it will be noted from Fig. 1 that it is desired to draw loops in only two out of three wales and to continue to hold loops in every third wale. This holding is done by the jackless needles 3', as will be hereinafter referred to. As far as the needles are concerned, therefore, in the third, fourth, fifth and sixth courses of the example shown in Figs. 1 and 2, all the needles except the jackless ones are raised into action. This is done in part by the jack cam 5, which continues to raise both the long and short butt jacks and their corresponding needles, and by the now fully inserted cam 382 which draws down the jackless needles, cam 20 having been withdrawn again and cam 8 still being retracted. After the make-up courses all the needles knit up to the transfer course with cams 8, 20 and 382 retracted. During the knitting of the sixth course, while the short butt needles are passing the raising cam 20, the cam is inserted half way. This is the usual preliminary protective move to permit withdrawal of the lowering cam 382 during the first part of the seventh course without causing depression of the long butt jackless needles by cam 382. After cam 382 is retracted, cam 20 is also retracted.

Cam 8 functions in a novel manner during the transfer course. This is a draw-down cam but it is located at such an early position in the knitting cycle that the needles can be raised again before reaching the knitting point. Thus in the transfer course cam 8 is inserted so that the needles go under cam 20 and 382 remains retracted. The purpose of inserting cam 8 is to lower the jackless needles 3' so that the transfer bits T can be projected above them. The needles then are raised through the bits to take the yarn at the knitting point. These jackless needles, after being lowered by cam 8, are raised again by the fixed cam 271 and leading stitch cam 361 to a level where they are cleared through the transfer bits, take the loops from the bits, and take

yarn and knit at the knitting point. This projection of the transfer bits over the jackless needles in the transfer course is shown in Fig. 47, and the raising of the needles through them is shown in Figs. 38 and 40.

As above described, therefore, the cam **8** functions only during the knitting of the transfer course, while the cam **20** functions during the second and seventh courses of knitting. Cams **8**, **20** and **382** are all mounted on a bracket **49** (Fig. 16), said cams being slidable radially for the purpose of making the needle selection during the knitting of the courses above described. The manner of mounting these three cams and their sequence of operation are shown in Figs. 16 and 24 to 33 inclusive. Although functionally separate, cams **20** and **8** are mechanically interconnected. In the first place, it will be noted that cams **20** and **8** are mounted on an upright **141** of the bracket **49**, which in turn is mounted on the bedplate B. The cam **382** is mounted on another arm of the bracket **49**, namely, an upright **142** (Figs. 16 and 29). Taking first the upright **141** carrying the cams **20** and **8**, it will be seen from Figs. 27 and 28 that the upper surface of the upright is recessed to receive two slides **143**, **144** which carry the cams **8** and **20**, respectively. The free and independent radial movement of these two slides with relation to the needle cylinder is limited by the parts next described. We will first follow through the mechanism controlling cam **8**, and then the additional parts peculiar to the operation of cam **20**. The outer end of the slide **143** carrying the cam **8** is bent downwardly at **145** and this outer end carries an angle plate **147** lying opposite the back end of the slide **144** which carries the cam **20**. As can be seen in Figs. 16 and 26, the insertion of cam **8** is caused through a lever **149** pivoted at point **150** on the main bracket **49**. The further end of the lever **149** has a more or less hook-shaped extremity **165** which rests against the outer edge of a vertically disposed cam **157** on a thrust rod **460**. This thrust rod is normally maintained in contact with the surface of the main pattern drum **120** by means of tension spring **164** (Fig. 15), the thrust rod riding over cams **159**, **160**, **161**, **162** and **163** as the pattern drum revolves (Fig. 10). The exact degree of insertion of cam **8** is adjusted by means of a set screw **148** in the end of lever **149** which overlies the plate **147** on the back end of the slide **143** (Fig. 26). The adjustment of the parts in such that, as shown in Figs. 30 and 31, the first insertion at the point where cam **20** engages needle butts does not cause cam **8** to engage the needle butts. Further insertion, as for example, by high cam **162** shown in Fig. 49, brings cam **8** into operative relation with the needle butts (Fig. 33). This, it will be noted, fits in with the sequence of operation in Figs. 4 to 7, where, in the second course, cam **20** had to be inserted but cam **8** was not inserted until the transfer course.

Turning now to the details of mounting of the cam **20** as shown in Figs. 27 and 28, it will be noted that the slide **144** has a coiled spring **152** in a longitudinal recess inside of it, the forward end of which rests against the end of the recess and the rear end of which is engaged by a pin **151**. This pin passes out of the rear end of the slide **144** and rests against the angle plate **147** carried by the slide **143** belonging to lowering cam **8**. There is also a screw **153** carried by an ear on the rear end of the slide **144** and projecting inwardly beyond the ear to limit the radially inward movement of the raising cam **20**. It therefore follows that when the lever **149** pushes the slide **143** radially inward, the pin **151** pushing against the coil spring **152** will cause inward movement of the raising cam **20** until the screw **153** comes against the outer face of the upright **141**, after which further movement by the lever **149** will cause inward movement of only the slide **143** carrying the lowering cam **8**, the screw **153** preventing further inward movement of the raising cam **20**. Upon release of the cams **8** and **20** by the operating lever **149**, a spring **143***a* on upright **141** engaging the pin in contact with the downward extension **145** of the slide **143** (Fig. 28), effects retraction of the cam **8**. A screw **143***b* (shown immediately above the cams **20** and **8** in Fig. 24) attached to the slide **143** engages a face of the slide **144**, as shown in Fig. 24, the retracting force of the spring **143***a* through the said screw effecting retraction of the cam **20**.

The lowering cam **382**, which must be inserted during the first course of knitting and the third to sixth courses, but retracted during the second and transfer course X, is also controlled from the main pattern drum but by a different series of cams, namely, the third row of cams in Fig. 49. Cams **178**, **180** and **182** cause partial insertion of the cam **382**, while cams **179** and **181** cause its insertion all the way. As shown, for example, in Figs. 15 and 29, the cam **382** is carried on an upright **142** to the right of the upright **141** carrying the cams **20** and **8**, as viewed from the front of the machine (see Fig. 16).

A plate **167** holds the cam in the upright and the rear end of the cam terminates in a downwardly bent abutment **169** spaced rearwardly of the upright **142**. Lying longitudinally of the cam in the upright **142** is a compression spring **171**, the forward end of which engages the solid metal of the upright and the rear end of which engages a pin **170** projecting outwardly into engagement with the abutment **169** at the rear of the cam. This coiled spring **171** urges the cam **382** outwardly away from the needle cylinder, there being a pin (not shown) on the underside of the cam **382** engaging against the forward face of the upright **142** to act as a stop and limit the radially outward movement of the cam. The inward movements of this lowering cam **382** are transmitted to it through a disk abutment **173** fastened on the outer end of the cam by a screw **172**. This abutment permits adjustment of the position of the needle cam. The abutment is engaged by one end of a lever **174** (Fig. 25) pivoted on the bracket **49** at the point **175**, the other end of this lever terminating in a flat or hooked end **176** which engages a cam **184** mounted on the upper end of a thrust rod **462** (Fig. 25). As shown in Fig. 15, this thrust rod tends to be maintained in its downward position by a tension spring **183** and the lower end of the thrust rod lies in the path of the cams **178** to **182** of Fig. 49 on the main pattern drum, as above described.

Transfer bits

As shown in the drawings, such for example as Figs. 37 to 42 and 50 to 52, the transfer bits T perform two functions when properly integrated with the needles. Thus during the knitting of the third and fourth courses they are projected to engage welt loops **21**, **21'** in their hook-shaped ends. These loops are held by the transfer bits during the knitting of the welt on all the needles. Their second function is that after the welt has been knitted they are again projected, permitting

their companion jackless needles to rise through the loops 21, 21' and the bits then hand the loops over to the needles (Figs. 38, 39). These implements may be of any desired form adapted to receive, hold and release bights of yarn, but we have illustrated them as each composed of two flat bodies t^1, t^2 having actuating butts t^3 and return bends t^4, t^9. The part t^1 has a point t^5 having behind it a notch t^6 and a shoulder t^7. The part t^2 is similar except in two respects, namely, that the bend t^9 therein is symmetrically opposite to that of the bend t^4 of the implement t^1, and that it preferably does not have the point t^5 but has the notch t^6. These parts are preferably made of thin resilient sheet steel and may or may not be fastened together. Each pair lies in its own groove, as can be seen, for example, in Fig. 48. We find that in fine-gauge machines these transfer bits, at their point of maximum thickness (namely, at the bends t^4, t^9) are approximately .037'' in width, which, as shown in Fig. 50, may be almost equal to or preferably slightly greater than the distance between the adjacent faces of two needles in the needle cylinder. When there is added to this dimension the thickness of the yarn loop lying in the hook of the transfer bit, the dimension of the elements which have to go between two adjacent needles spaced one apart is greater than the spacing of those needles, for the purpose which we will now describe.

We have found that it is desirable to provide means for insuring that the transfer bit is properly centered over the needle to which the loops are to be transferred in order that there be no chance of the needle rising "outside" the transfer bit and therefore not getting the loop. By this is meant that the needle does not rise between the two parts of the transfer but to the outside of one of the parts. It is particularly important in fine-gauge machines not to have the needle off-center where both the needles and the transfer bits are thin and flexible so that it is possible for a little side-play or bending when the needle and transfer bit are extended, or a fractional error in construction of either element to cause the parts to be improperly engaged. It has even been found that pressure on the tail of part of a transfer bit will sometimes cause it to tip or tilt and cause a misengagement of the parts. We have discovered means to insure proper centering of the parts without the introduction of any additional elements in the machine. For this purpose the needles in the slots on either side of the needle which is to receive the loop are raised and dimensioned so that they have a snug fit with the widest portion of the transfer bit. In this way they hold the transfer bit properly centered over the needle. At the time this centering is done, there are of course one or more loops 21, 21' in the hook of the transfer bit, the yarn extending down outside the transfer bit on each side. This can be made to tilt the adjacent needles as shown in Fig. 50, even if the snug fit referred to was not enough to cause them to tilt, thereby providing the wedging action or centering above referred to. The yarn extending down outside the bit on each side comes between the sides of the bit and the adjacent needles. If the yarn is approximately .001½'' in thickness, this may be compensated for by the side play of the needles in their slots. This play may be about .001½''. In any case the yarn on each side of the bit adds to the effective width of the bit. For an example of the approximate dimensions which give this figure, it has been found in one knitting machine having what is known as a 3¾'' diameter cylinder with 480 needles, that transfer bits approximately .037'' in width at their widest point will crowd the needles on each side thereof because the space between such needles is slightly less than .037''. In this case the thickness of the needles is approximately .0105'' where they engage the bits, and .0125'' where they seat within the slots. One typical yarn would be .0015''. With dimensions in this general neighborhood, the bending of the needles is not so great as to result in permanent distortion or conflict between adjacent needles.

It is necessary to have at least two needles between adjacent transfer bits in order that the needle on each side of a bit may be bent away. As already intimated, the centering needles must be raised in advance of the needle which is to pass through the transfer bit, but the bit can be advanced before the centering needles, or vice versa. In the example shown in the drawings, jack cam 5 is employed for this purpose.

Cams for transfer bits

The cams in the dial which operate the transfer bits are shown in Figs. 44 to 49. Fig. 45, which is a view looking down on the dial with the dial cap removed, shows the positions of the butts of the transfer bits prior to the knitting of the third course. Just prior to the third course, when the bits with short butts are passing under cam 186 (shown in Fig. 46), that cam is inserted half way and when the long butts begin to pass the cam, it is moved all the way down to move the oncoming short butt bits out to the periphery of the cam space inside the dial. Cam 186 remains in operative position and the transfer bits remain projected throughout the third and fourth courses, the projected position being such that the bits take a bight of yarn on each revolution (see Fig. 36). The cam which projects the bits when they are to transfer the loops to the needles is cam 195 (shown in Fig. 47), and the cam 196 shown in that figure is effective to retract the bits after the stitches have been transferred.

These transfer bit operating cams are operated from the main pattern drum. The cam 186 which projects the transfer bits initially moves vertically through a recess or slot in the dial cap 53, the cam being carried on a vertical pin 188. The pin, and therefore the cam, are normally kept elevated by the usual coiled spring (not shown) and are depressed by means of a lever 189 pivoted at 190. The rear end of this lever has a pin 191 therein which lies in engagement with the upper end of a thrust rod 461 which lies in the path of drum cams 193, 194 on the main pattern drum (Figs. 10 and 44). The thrust rod 461 can be kept in its downward position by a tension spring similar to tension spring 164 on a thrust rod 460. The low drum cam 193 pushes the cam 186 into the path of the long butts while the short butts are passing, and the higher cam 194 pushes the cam 186 down further to engage both the long and short butts.

The cams 195 and 196 which project and retract the transfer bits at the time of transfer are both carried by a block 197 on the dial cap 53, which block is movable vertically by a pin 199 in engagement with one arm of a pivoted lever 200. The rear end of this pivoted lever has a pin 201 engaging the upper end of the thrust rod 460 (see Figs. 15, 26 and 44) which also controls the special needle cam 8. When the lower end of the

thrust rod 460 is on the low drum cam 161, the cam 195 moves into position where it engages the long butt transfer bits and the higher cam 162 depresses the cam 195 to a position where it would engage the short butt transfer bits as well. The two cams 195 and 196 are moved in unison. The pin 199, forming part of the cam block 197, is hollow and seats over a pin 203 (Fig. 43). This pin is also hollow for the greater portion of its length, the lower end thereof being fast to the dial cap 53. A coiled spring 202 is seated within the hollow pin 199 and also within the upper portion of the pin 203, being compressible between the top portion of the pin 199 and the solid seat portion of the hollow pin 203. Upon the lever 200 being rocked by the thrust bar 460, engaging one arm of the said lever, the other arm of the lever presses downwardly on top of pin 199, compressing the coiled spring 202 and thereby depressing the cams 195 and 196, the block 197 and cams thereon being guided in their movements by pins, such as pin 204, fastened to the dial cap 53.

It may be considered preferable in order to conserve space on the surface of the main pattern drum 120 to allow the transfer cams 195 and 196 to remain in their projected path shown in Fig. 47 during four courses. During the last three of these courses the jackless needles 3' which are to receive the transfer loops move up through their transfer bits, as illustrated in Figs. 38–42. The transfer, however, occurs on the first course and the subsequent manipulations do not necessarily perform any function other than the insuring of the transfer of all the welt loops to the needles.

The usual means for racking the main pattern drum 120 are such that the drum may be moved ahead once every four courses. However, during the knitting of the selvage courses in a stocking such as shown in the drawings, it may be necessary to vary the action of the needle and jack cams more frequently, and to accomplish this there is an auxiliary racking mechanism such as shown in Fig. 11. This comprises an auxiliary racking segment 69 affixed to the end of the main pattern drum 120. To operate this segment there is a pawl 66 pivoted at a point 67 on the end of main arm 68. This main arm 68 in turn is pivoted to a fixed point on the machine. There is a tension spring 72 fastened to one end of the pawl 66 which tends to hold the pawl in engagement with the racking segment 69 and which also serves to keep the arm 68 in engagement with an eccentric cam 91 on the main drive shaft. It will be apparent that rotation of that shaft will bring the cam 91 into contact with the arm 68 and cause the main pattern drum to be advanced one tooth. In the construction shown in the drawings the main pattern drum 120 is racked or advanced about six times for a total of six courses by the periodic engagements of the pawl 66 with the racking segment 69, since the drive shaft rotates once for each revolution of the needle cylinder. As shown in Fig. 49, there is a pattern chain link having a lug 92 thereon which permits pawl 82 to actuate the main rack wheel 81 and thereby advances the parts to the position in which the auxiliary pawl 66 will go into action.

Timing of movements of the cams for the jacks, needles and transfer bits

The individual parts controlling the cams for the jacks, needles and transfer bits as far as concerns the setting up courses in the transfer operations having been described, we will now explain the relative timing and operation of the devices, with more particular reference to such figures of the drawings as Fig. 49.

As hereinbefore stated, preparatory to the second course of knitting, the lug 92 on the pattern chain has caused the auxiliary racking pawl 66 to be in a position to engage the first tooth of the auxiliary racking segment 69.

The first move of the main pattern drum 120 having been caused by the main pawl, the parts are brought to the position shown in the dot-and-dash line at the right of the figure, leading from the first course of the fabric. The jack cam 5, under the influence of the intermediate height of the disk cam 55 located between the cam surfaces 103, 104, has been inserted half way, raising the long butt jacks. During this first course of knitting the needle lowering cam 382 under the influence of drum cam 179 is all the way in and engaging all needle butts not raised by the jack cam 5. In this way only the needles corresponding to the long butt jacks, namely, every third needle, take yarn and knit, the other two needles, namely, the ones with short butt jacks, and the jackless needles being drawn down under the lowering cam 382 and the leading stitch cam 361. The needles which take yarn do not knit or knock over stitches through previous stitches inasmuch as the needles had no previous stitches in their hooks.

During the latter part of the first move, before the knitting of the first course has been completed, the raising cam 20 is moved into operative position (Fig. 5). It becomes effective on the second course.

On the second move of the pattern drum (the first move caused by the auxiliary racking means), this cam 20 starts to elevate all the long butt needles to clear and take yarn but the short butt needles are elevated by the fixed cam surface 271 at a later point and are cleared by the leading stitch cam. The cam 382 is partially withdrawn in order to miss the short butt needles on the second course. In this way all the needles draw loops in the second course (see Fig. 1). At the end of the course the cam 20 is withdrawn as the thrust rod 460 comes off cam 159. The jack cam 5 moves all the way in at this time by virtue of the lug 106 riding up the cam surface 104 onto the high part of the periphery of the disk.

On the third rack, the cam 382 is moved all the way in by drum cam 181 and thrust rod 462 in time to engage both the long and short butt jackless needles in the third course. This draws all jackless needles down out of action in the third, fourth, fifth and sixth courses. The thrust rod 460 for the needle cams 20 and 8 rode off the drum cam 159 at the end of the second move and as a consequence cams 20 and 8 are out during the third and all succeeding courses up to the beginning of the sixth course (see bifurcated dot-and-dash line in Fig. 49). Actually, therefore, it is the jack cam 5 which raises all the jacks and the needles corresponding to them at this time, and the jackless needles are led under the leading stitch cam 361 by the cam 382. On the second rack the drum cam 193, acting through thrust rod 461, moved the dial cam 186 down into the path of the transfer bits having short butts. On the third rack the thrust rod 461 is raised still higher onto the drum cam 194 which causes a downward movement of the dial cam 186 into a position of engagement with all the butts of the transfer bits which therefore advance into a position to take the yarn, as shown in Fig. 36.

The fourth rack of the main pattern drum causes no change in the cams operating the needles, jacks and transfer bits, but for the fifth course of knitting there is a change. This change relates to the transfer bits which now follow the outside wall of their raceway, as shown in Fig. 46. but are not projected by cam **186** which is completely withdrawn owing to the thrust rod **461** coming off the drum cam **194** at the beginning of the fifth move. This leaves the bits partially retracted. These transfer bits now have two separate welt loops in their hooks, one from the third course and one from the fourth course of knitting. During the knitting of the fifth and sixth courses we prefer to have the yarn float in the wales where the jackless needles are located in order that there be no strain on the yarn immediately after the taking of the transfer loops by the transfer bits. If the jackless needles were to engage yarn and knit during the fifth course the yarn would occasionally break. During the knitting of the sixth course while the short butt needles are passing the cam **20**, the cam is moved into a position where it will contact the long butt needles as the thrust rod **460** rides up onto the drum cam **160**.

While these needles are riding up cam **20** during the first part of the seventh course, the cam **382** is partially withdrawn by rod **462** dropping off cam **181** onto cam **182** so as not to lower the short butt jackless needles. All of the needles are now knitting. For the seventh course cam **8** remains withdrawn and the raising cam **20** raises the long butt needles to pass above the cam **382** and the short butt needles are raised by the jack raising cam **5** and leading stitch cam **361**. During the knitting of this course the long loops **22** (Fig. 2) engaged in the hooks of the jackless needles **3'** while the second course was being knit are cast off their needles so that these long loops extend across several courses. They are drawn through loops of the seventh course. During the last half of the seventh move of the pattern drum the retraction of cam **382** is completed and cam **20** is retracted as the thrust rod **460** drops off the drum cam **160** onto the surface of the drum, the cam **20** having served the purpose of enabling cam **382** to get out of action and yet insure knitting on all the long butt needles. Any subsequent courses prior to the transfer courses are repetitions of the knitting at the end of this course, namely, one in which cam **5** is all the way in and cams **8**, **20** and **382** are all out of action.

As soon as all these courses which are desired have been knitted (they may be called welt courses), another rack on the main drum is caused but this time by the main rack pawl. The parts are now brought to the position shown in Fig. 7, the lowering cam **8** being advanced first against the short butts by drum **161** elevating the thrust rod **460** and then all the way in to lower all the jackless needles by riding up on the drum cam **162**. This is the first time that this transfer cam **8** has been inserted all the way. It will be seen that the jackless needles **3'** which are not raised are those corresponding to the transfer bits and that the point at which they are lowered by the cam **8** is well in advance even of the position of cam **382**.

Simultaneously with the movement of the cam **8** the dial cam **195** is lowered into the path of the long butt transfer bits and then all the way in to engage all the butts, thus projecting them at an early point, as shown in Fig. 47. Another view of the position of the transfer bits at this time is shown in Fig. 38. The relative positions of cams **8** and **20** are shown in Fig. 33, the cam **20** having been held back from the path of the short butt needles by the screw **153** coming into engagement with the outer face of the upright **141**, as shown in Fig. 27. Thus, as already stated, the jackless needles are depressed by the cam **8** while the transfer bits are moved forward over those depressed needles. The novel construction and manipulation insuring registry between the depressed jackless needle and its transfer bit occur at the point marked "W" in Fig. 7. At this point the needles with jacks on either side of each jackless needle have been raised by jack cam **5**, the jackless needle having been lowered by cam **8** and the transfer bit having been projected by cam **195**, with the result that the needles with jacks center the transfer bit, as shown for example in Figs. 50, 51. This maintains the loops in the transfer bits in alignment with the needles, thus insuring that the jackless needles will rise through the bends or bows t^4, t^9 of the transfer bits. The fixed cam **271** then raises the jackless needles to an elevation where they are cleared by the leading stitch cam **361** (cam **382** being fully retracted), and these jackless needles rise and fall, assuming the positions shown in Figs. 39, 40 and 41, in succession.

About this time there is a ninth rack on the main pattern drum initiated by the last chain lug marked by a dot-and-dash line on the left in Fig. 49, namely, after the jackless needles have risen through the loops on the transfer bits to the position shown in Fig. 40 and the transfer bits are retracted. Jack cam **5** is also retracted by lug **106** riding down slope **105**. The dial cam **195** is partially retracted during the passage of the long butts on the transfer bits by the thrust rod **460** dropping off the cam **162** onto the cam **163** (Figs. 26 and 49). During the subsequent passage of the short butt transfer bits the retraction is completed by the thrust rod dropping off the drum cam **163** onto the surface of the drum, the dial cam **196** pushing in the bits. In the meantime the top center cam **357** and stitch cam **361** cause the jackless needles to pass through the usual knitting wave along with all the other needles and the transfer operation is completed with a new yarn **215** being drawn through the two single course welt loops **21**, **21'**, as well as through the previous stitch **214**, thus forming a stitch in the leg course shown in Fig. 1 at the point marked "X."

Modified needle selection—Figs. 53–56

In Figs. 4 to 7, inclusive, the needle selection for the selvage and transfer is effected by short jacks. Views 53–56 disclose a modification in which a pattern jack permitting freer and more varied needle selection is shown. Otherwise the construction and operation are the same as that in Figs. 4–52. This needle selection is substantially the same as that shown in the patent to A. E. Page, No. 1,969,853, dated August 14, 1934, with more particular reference to Fig. 6 of the drawings of that patent. Underneath the short jack **380** which underlies each needle is provided a pattern jack **736** which is adapted to rock about point **728** midway of its length. When the lower end is rocked out, raising butt **733** engages a stationary cam **741** which raises the jack **736** and therefore the short jack and the needle. When the lower end of the jack is not so rocked out, or having been rocked out is pushed in again, it misses the cam **741**, as shown by dotted lines in Fig. 56, and the jack is not raised. The first

step in making a selection is for all the pattern jacks to have their lower ends rocked out, namely, to the full line position of Fig. 56. This is being caused by a cam similar to cam **747** in Fig. 6 of the above-mentioned Page patent. There are a number of selecting butts **739** between the resetting butt **738** acted on by the resetting cam and the raising butt **733**. As it appears in Fig. 54, the jack has the full complement of these butts but in actual use certain of these butts would be removed to permit selective control of the jacks, the desired selection depending upon the type of fabric to be knitted. In Fig. 56 one of the selecting butts has been removed.

In Fig. 56 we have shown how the removal of a butt affects the selection of the jack. The jack shown in this figure in solid lines is minus one of its teeth and therefore has not had its lower end pushed back out of action by the cam **750** shown in Fig. 54. It therefore engages the raising cam **741**. In Fig. 54, on the contrary, the lowermost butt **739** has not been removed and therefore the selecting cam **750** has rocked the jack from the dotted to the solid line position so that its lower end is now radially inward and will miss the cam **741** of Fig. 56. Thus it will be seen that the needles, the lower ends of whose pattern jacks are still rocked outwardly when they reach the cam **741**, will be raised to a level where they can clear the leading stitch cam and take yarn and knit. Cams **271** and **382** of Figs. 4–7 also appear in Figs. 53 and 55 and in those figures have the same functions that they did in Figs. 4–7. It might be noted that in Figs. 53 and 55 the upper dot-and-dash lines illustrate the highest point of movement of the hooks of the needles raised by cam **741** or cam **20**, corresponding to those raised by cam **5** or cam **20**, in the case of Figs. 4–7; whereas the lower of the two dot-and-dash lines in these various figures illustrates the position of the hooks of the needles at normal level.

For the first course of knitting every other needle is elevated to take yarn in its hook; for the second course of knitting all of the needles are elevated to take yarn in their hooks, the needles that took yarn for the first course drawing bights through or around the first course yarn at the wales pertaining to such needles. For the third course of knitting two-thirds of the needles are elevated (including the needles elevated during the knitting of the first course), such elevated needles taking yarn in their hooks, the needles elevated during the knitting of the first course drawing loops through second course loops or bights of yarn, the other needles drawing bights of yarn around or through the second course yarn. As described in connection with Fig. 6, the transfer bits are advanced (third course) over every third needle, as the needles are being depressed by the clearing cam **361**. Knitting thereafter proceeds in the manner disclosed in connection with the description of the selection of Figs. 4 to 7. In other words, the variation in the needle selection is effected during the knitting of the first course (Fig. 53), the needles thereafter (in the form disclosed in Figs. 53 to 56 inclusive) following the course sequence of selection disclosed in Figs. 4 to 7 and responding to the course-by-course description pertaining thereto.

In the foregoing method of knitting, the course immediately following the third course or a following course is, preferably, knitted by every other needle only, the yarn floating across intervening needles. The needles knitting this course may be the needles that took yarn for the first course. Alternatively, every other needle may tuck, e. g., by a method similar to that disclosed in the Costello Patent 976,555, dated November 22, 1910. In either case, a run-stop course is formed, subsequent to the knitting of which following courses are or may be knitted by all of the needles. The run-stop course may be duplicated thereafter during the knitting of the welt or leg courses of the stocking.

Wherever in the foregoing specification or appended claims reference is made to the knitting of courses by all of the needles, such language is not intended to preclude the knitting of special, e. g., ornamental, stitches through the whole or part of any given course.

In summary it will be seen that the invention provides a simple means and method of insuring accurate transfers of loops from transfer bits to needles in even the finest gauge circular knitting machines, and that this is accomplished without the introduction of additional parts near the looping elements, i. e., the needles, sinkers and transfer bits. Many variations which do not depart from the scope of our invention will occur to those skilled in the art.

What is claimed is:

1. A circular knitting machine having a dial and transfer elements therein, a cylinder and independent needles therein, in combination with means for raising the needles on each side of a needle to which a loop is to be transferred, said parts being so spaced that each transfer element, when advanced, is held in registry, by the adjacent raised needles, with the needle to which it is transferring a loop.

2. A circular knitting machine having a dial and transfer elements therein, a cylinder and independent needles therein, in combination with means for raising the needles on each side of a needle to which a loop is to be transferred, said parts being so spaced that each transfer element, when advanced, is wedged between the two adjacent raised needles, thereby holding it in registry with the needle to which it is transferring a loop.

3. A circular knitting machine having a dial and transfer elements therein, in combination with a cylinder and independent needles therein, the needles being so spaced that when a transfer element is pushed between two raised needles that adjoin a non-raised needle the raised needles are bent apart slightly, thereby holding the transfer element in registry with the intervening needle for transfer of a loop to that needle.

4. A circular knitting machine including a needle cylinder and a dial, needles independently mounted in the cylinder and transfer elements independently mounted in the dial, means for so controlling the needles and transfer elements as to cause transfer of loops, there being a needle in registry with each transfer element and there being at least two needles between every two such transfer needles, the dimensions of the transfer elements and the space between the needles on each side of the elements being such as to permit their transfer elements and the loops to pass between said adjacent needles by wedging action, thereby deflecting the said needles in opposite directions, said deflected needles resting against opposite sides of the transfer elements to maintain them centered with respect to their companion needles.

5. A circular knitting machine for knitting an

inturned welt, having a needle cylinder and a dial, needles independently mounted in the cylinder and transfer elements independently mounted in the dial, means for so controlling the needles and transfer elements as to knit an inturned welt, there being a needle corresponding to each transfer element and at least two needles between every two needles corresponding to adjacent transfer elements, the spacing of the needles and the width of the transfer elements being such that the needles adjacent to each transfer needle hold the transfer element in registry with said transfer needle when the latter is advanced.

6. A circular knitting machine for knitting an inturned welt and having a needle cylinder and a dial, transfer elements in the dial and independent needles in the cylinder, there being more needles than there are transfer elements, certain of said needles being transfer needles adapted to receive loops from the elements and there being at least two other needles between each two adjacent transfer needles, in combination with means to raise the needles on each side of each such transfer needle in advance of the transfer point, the dimensions of the transfer elements and the spacing of the needles being such as to permit the transfer elements to pass between adjacent needles by a wedging action, thereby deflecting the raised needles in opposite directions and causing them to center the transfer elements over the transfer needles so that the latter upon being elevated will pass through the loops.

7. A circular knitting machine for knitting an inturned welt, having a needle cylinder and a dial, independent needles mounted in the cylinder and transfer elements mounted in the dial, certain of said needles being positioned to cooperate with the transfer elements for transfer of loops, there being at least two other needles between each two such transfer needles, in combination with means adapted to raise said intermediate needles before the transfer needles are raised, and means to project the transfer elements after said intermediate needles are raised, the spacing of the needles being such that the needles adjacent a transfer needle are bent slightly apart by the transfer element and the loops in it when projected, so that they hold the transfer element in registry with the transfer needle for transfer of the welt loops.

8. A circular knitting machine for knitting an inturned welt and having a needle cylinder and a dial, independent needles mounted in the cylinder and transfer elements mounted in the dial, means for knitting an inturned welt by cooperative movement of the needles and the transfer elements and including the knitting of a transfer course, means for advancing the transfer elements over depressed needles for the knitting of the transfer course and causing elevation of the depressed needles, the spacing of the needles and dimensions of the transfer elements being such that the needles adjacent to depressed needles and prior to the transfer movement, center said transfer elements so that the depressed needles upon being elevated shall pass through one or more loops held by each transfer element.

9. In a method of operating a circular knitting machine having needles and transfer bits, the steps of forming and holding loops on the bits and subsequently centering the bits and loops over the companion needles by raising the adjacent needles and advancing said bits and loops, whereby when the companion needles are raised they will pass through the loops held by the bits.

10. In a method of operating a circular knitting machine having a needle cylinder with independent needles and a dial with transfer elements, the steps of raising the needle on each side of a needle which is to receive yarn from a transfer element and then projecting the transfer element to transfer position and wedging it between the adjacent raised needles, thereby holding the transfer element in registry with its needle, and subsequently raising the transfer needle and withdrawing the transfer element.

11. A circular independent needle knitting machine having a needle cylinder and a dial, needles independently mounted in the cylinder and transfer elements independently mounted in the dial, means for knitting an inturned welt by cooperative movements of the needles and transfer elements and including the forming of a course of transfer loops on recurrent needles spaced apart at least two needles, means to elevate the adjacent needles on each side of the recurrent transfer needles and advance the transfer elements for the transfer course and thereafter raise the recurrent transfer needles to pass through loops on the elements, whereby the adjacent needles engage the sides of the transfer elements and center them.

12. A circular independent needle knitting machine having a rotary needle cylinder and a rotary dial, needles in the cylinder and transfer bits movably mounted in the dial adapted to transfer loops to certain needles, cam means to project the bits for transfer and other cam means including a raising cam and an early lowering cam for the needles adapted to take loops from the bits, said second cam means also including an element adapted to insert both the raising and lowering cams, said lowering cam being adapted to lower needle butts underneath said raising cam, and unitary means controlling said operating element and the transfer bit cam means whereby the lowering cam lowers the needles corresponding to the transfer bits while the transfer bits are inserted, in combination with means raising needles adjacent to the transfer bit needles while the latter are down during bit insertion.

13. A circular independent needle knitting machine having a rotary needle cylinder and a rotary dial, needles in the cylinder and transfer bits movably mounted in the dial adapted to transfer loops to certain needles, cam means to project the bits for transfer and other cam means including a raising cam and an early lowering cam for the needles adapted to take loops from the bits, said second cam means also including an element adapted to insert both the raising and lowering cams, resilient means causing insertion of the raising cam ahead of the lowering cam but limiting its insertion while permitting insertion of the lowering cam, said lowering cam being adapted to lower needle butts to pass under said raising cam, and unitary means controlling said operating element and the transfer bit cam means, whereby the lowering cam lowers the needles corresponding to the transfer bits before the transfer bits are inserted, in combination with means raising needles adjacent to the transfer bit needles.

14. A circular independent needle knitting machine having a rotary needle cylinder and a rotary dial, needles in the cylinder, transfer bits movably mounted in the dial, jacks under the needles which do not receive loops from the transfer bits,

jack cam means adapted to raise such needles at an early point, a lowering cam adapted to lower needles not raised by the action of the jack cam, a stationary cam adapted to raise such lowered needles at a later point for knitting and a cam inserting the transfer bits prior to the raising of the needles by the stationary cam, in combination with a unitary cam control means adapted to cause insertion of said early lowering cam and transfer cam, whereby the needles adjacent a transfer needle and the transfer bits are projected prior to raising of the transfer needles.

15. A circular independent needle knitting machine as in claim 14, in which there is a transfer bit retracting cam active at a point prior to the stationary needle cam and controlled by the unitary control means.

16. A circular independent needle knitting machine having a rotary needle cylinder and a rotary dial, needles in the cylinder and transfer bits movably mounted in the dial, cam means to project the bits for transfer of loops to needles and jacks underneath the needles which do not take loops from the transfer bits, in combination with a clearing cam, a cam adapted to lower needles below the clearing cam, a raising cam adapted to clear needles above said lowering cam, jack cam means adapted to raise the needles having jacks thereunder, an early lowering cam adapted to lower needles so that their butts pass below the needle raising cam, a stationary cam adapted to raise needles thus lowered to be taken by the clearing cam and unitary means adapted to cause insertion of the early lowering cam in unison with the transfer bit cam or insertion of the needle raising cam without insertion of the first lowering cam, whereby all the needles can be made to knit either by raising over the regular clearing cam, on the one hand, or by raising over the raising cam or on the jack cam means, on the other.

17. A circular independent needle knitting machine having a rotary needle cylinder and a rotary dial, needles in the cylinder and transfer bits movably mounted in the dial, cam means to project the bits for transfer of loops to needles and jacks underneath the needles which do not take loops from the transfer bits, in combination with a clearing cam, a cam adapted to lower needles below the clearing cam, a raising cam adapted to clear needles above said lowering cam, jack cam means adapted selectively to raise the needles having jacks thereunder, an early lowering cam adapted to lower needles so that their butts pass below the needle raising cam, a stationary cam adapted to raise needles thus lowered to be taken by the clearing cam and unitary means adapted to cause insertion of the early lowering cam in unison with the transfer bit cam or insertion of the needle raising cam without insertion of the first lowering cam, whereby all the needles can be made to knit either by raising over the regular clearing cam, on the one hand, or by raising over the raising cam or on the jack cam means, on the other hand.

18. A circular knitting machine for knitting an inturned welt, having a rotary needle cylinder and a dial, independent needles in the cylinder and transfer elements in the dial, means for controlling the needles and transfer elements to knit a stocking having an inturned welt including welt loops and a transfer course for connecting the make-up courses to the leg of the stocking, the relative dimensions of the machine being such that during the knitting of the transfer course the transfer elements are centered by the needles on each side thereof so that the needles companion to the transfer bits engage the transfer loops properly.

19. A circular independent needle knitting machine having a rotary needle cylinder and a radial dial, needles in the cylinder and transfer bits movably mounted in the dial adapted to transfer loops to certain needles, jacks underneath the needles which do not take loops from the transfer bits adapted to clear those needles, there being butts of two lengths on said jacks and cam means adapted to cause raising of the long or the long and short butt jacks and their needles, in combination with a lowering cam adapted to lower below the regular clearing cam needles reaching it at normal level, transfer bit cams adapted to cause projection of said bits, and control means adapted to cause insertion of the jack, lowering and transfer bit cams for at least two revolutions and at another time to cause insertion of the jack and transfer bit cams but not the lowering cam when making the transfer.

20. A circular independent needle knitting machine having a rotary needle cylinder and a radial dial, needles in the cylinder and transfer bits movably mounted in the dial adapted to transfer loops to certain needles, jacks underneath the needles which do not take loops from the transfer bits adapted to clear those needles, there being butts of two lengths on said jacks and cam means adapted to cause raising of the long or the long and short butt jacks and their needles, in combination with a lowering cam adapted to lower below the regular clearing cam needles reaching it at normal level, transfer bit cams adapted to cause projection of said bits, and control means adapted to cause insertion of the jack, lowering and transfer bit cams for at least two revolutions and at another time to cause insertion of the jack and transfer bit cams but not the lowering cam when making the transfer, the relative dimensions of the machine being such that at the latter time the transfer bits are centered by the raised needles on each side thereof, for the purpose described.

21. A circular knitting machine having a dial and transfer elements therein, a cylinder and independent needles therein, there being a needle corresponding to each transfer element and at least two needles between every two needles corresponding to adjacent transfer elements, the spacing of the needles and the width of the transfer elements being such that the needles adjacent to each transfer needle hold the transfer element in registry with said transfer needle when the latter is advanced.

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