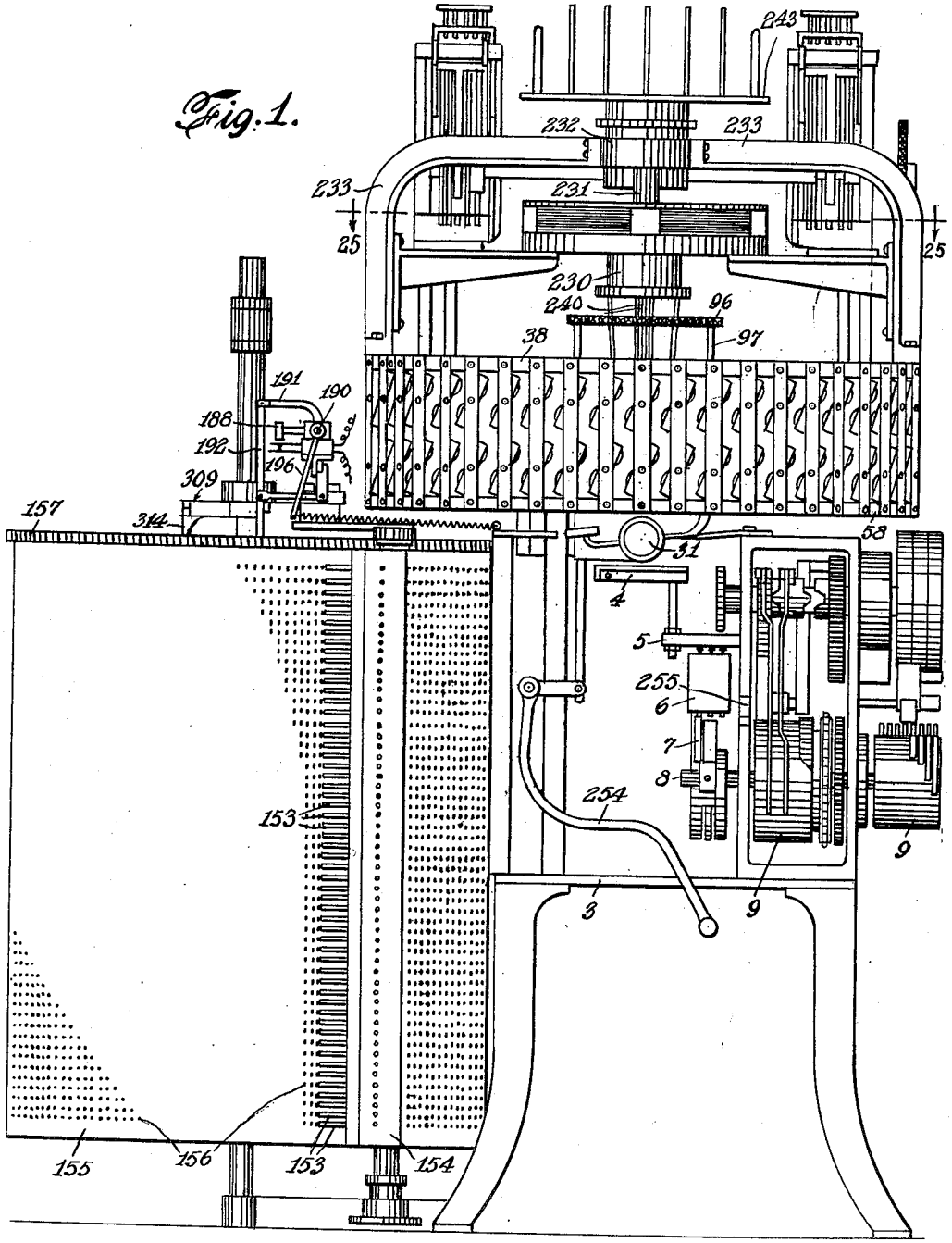
June 15, 1954 P. L. THURSTON 2,680,961

KNITTED ARTICLE OF HOSIERY AND FABRIC

Filed Sept. 9, 1950

15 Sheets-Sheet 1

Fig. 1.



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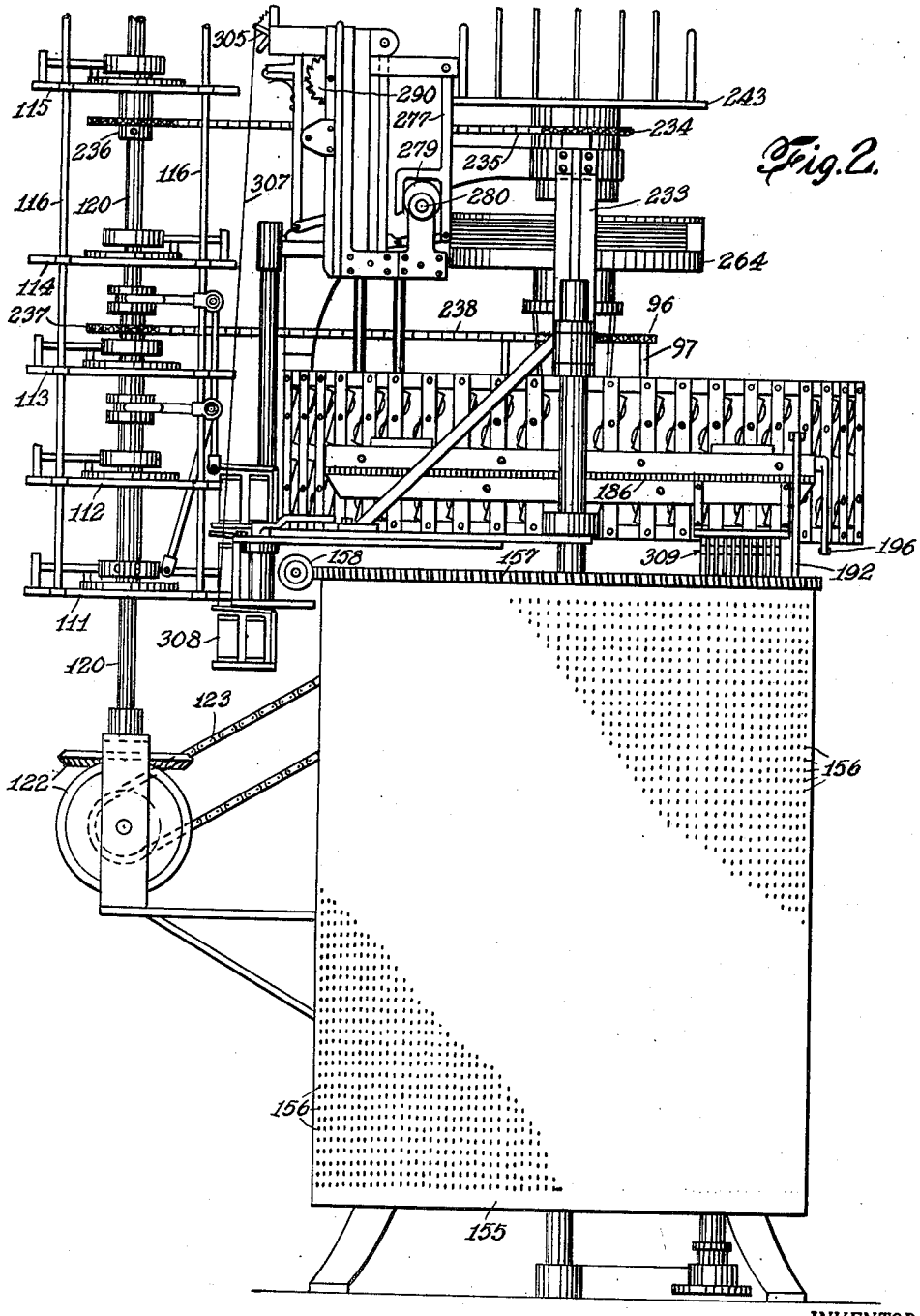


Fig. 2.

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KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 3.

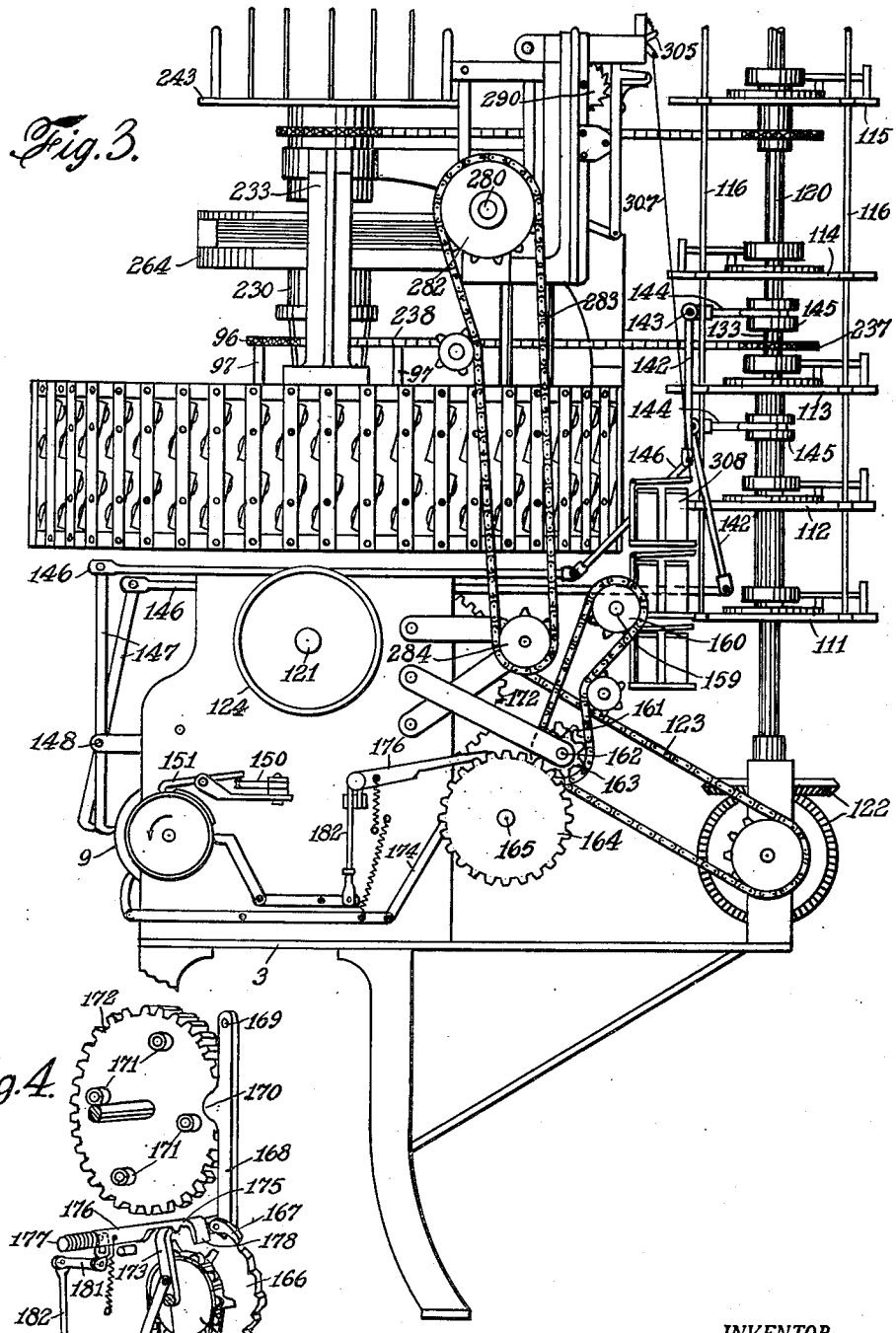


Fig. 4.

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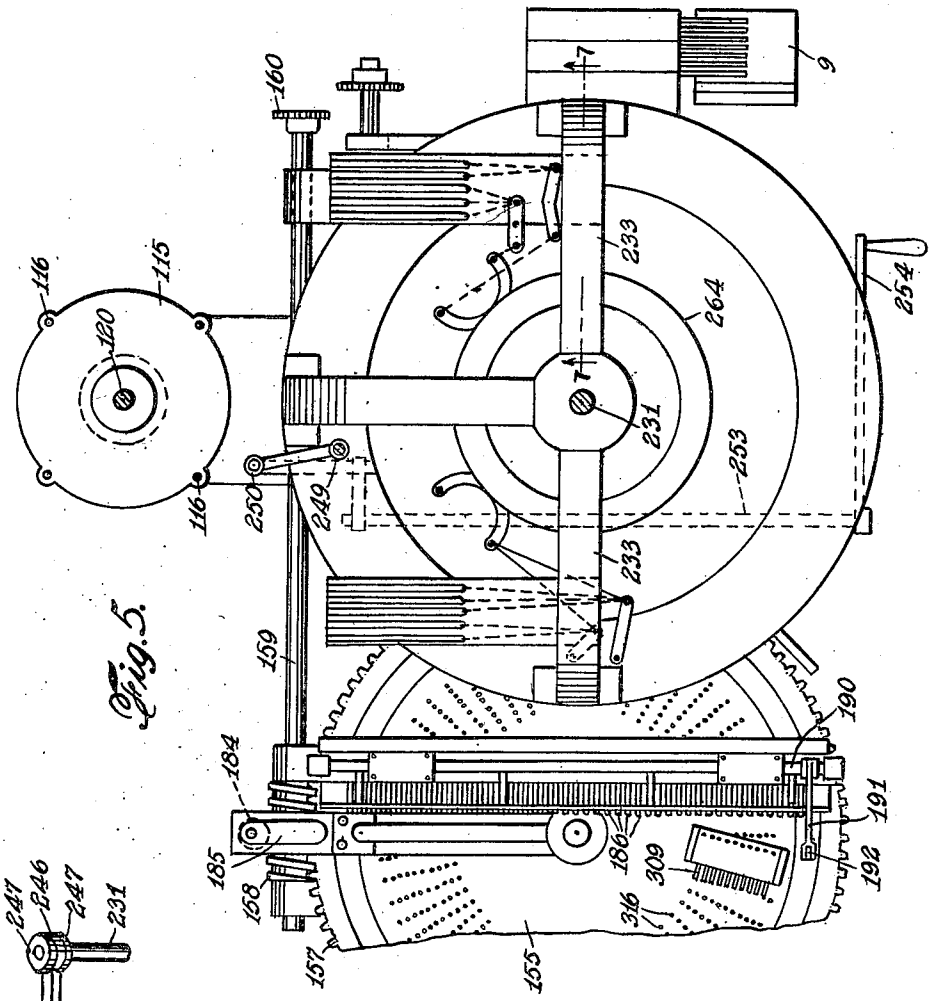


Fig. 5.

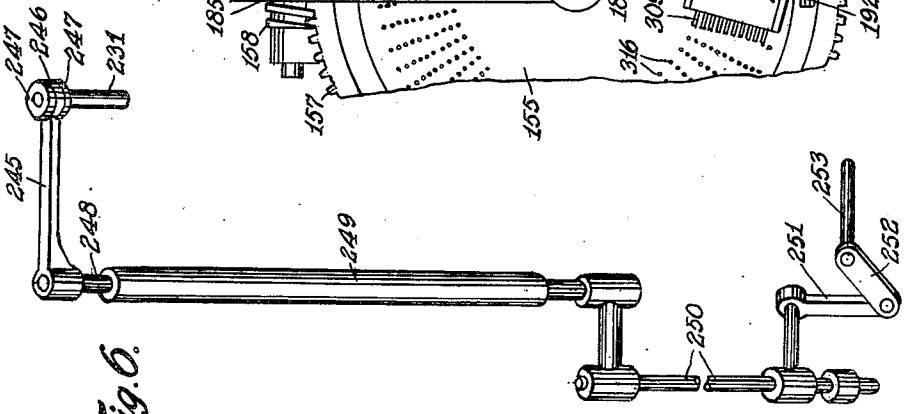


Fig. 6.

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KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 7.

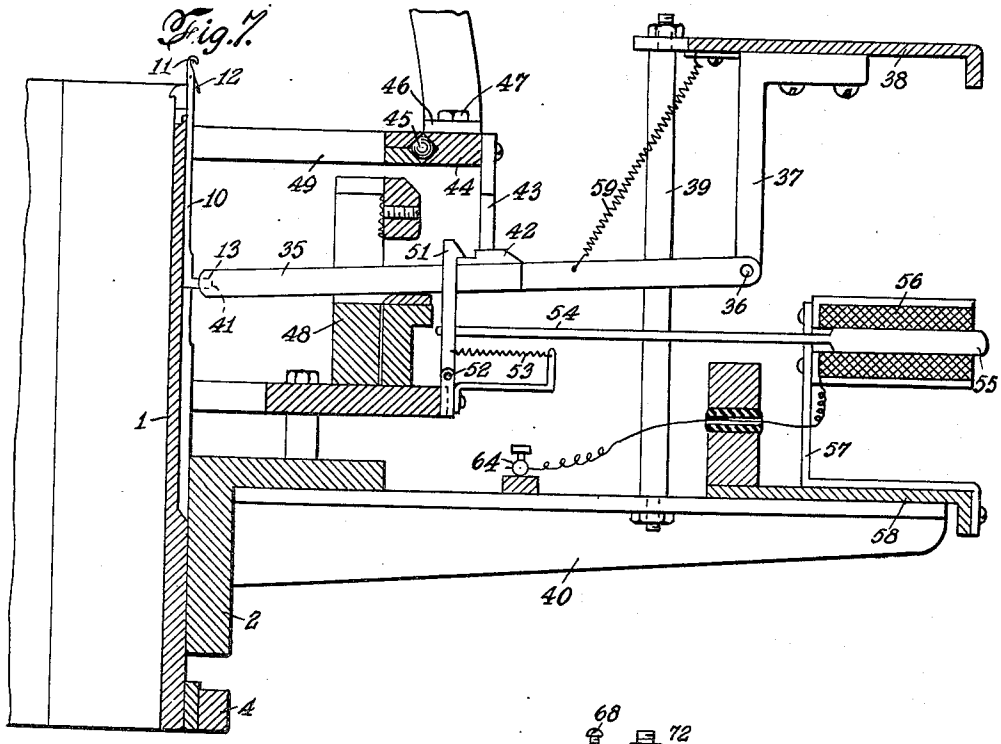
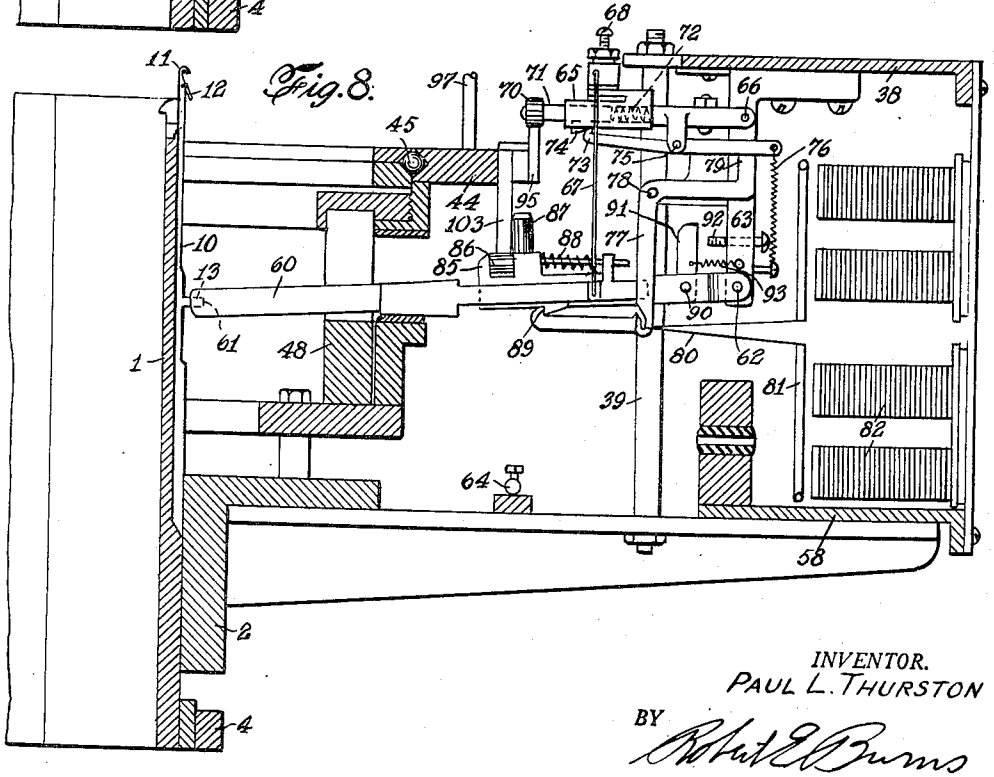


Fig. 8.



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KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 9.

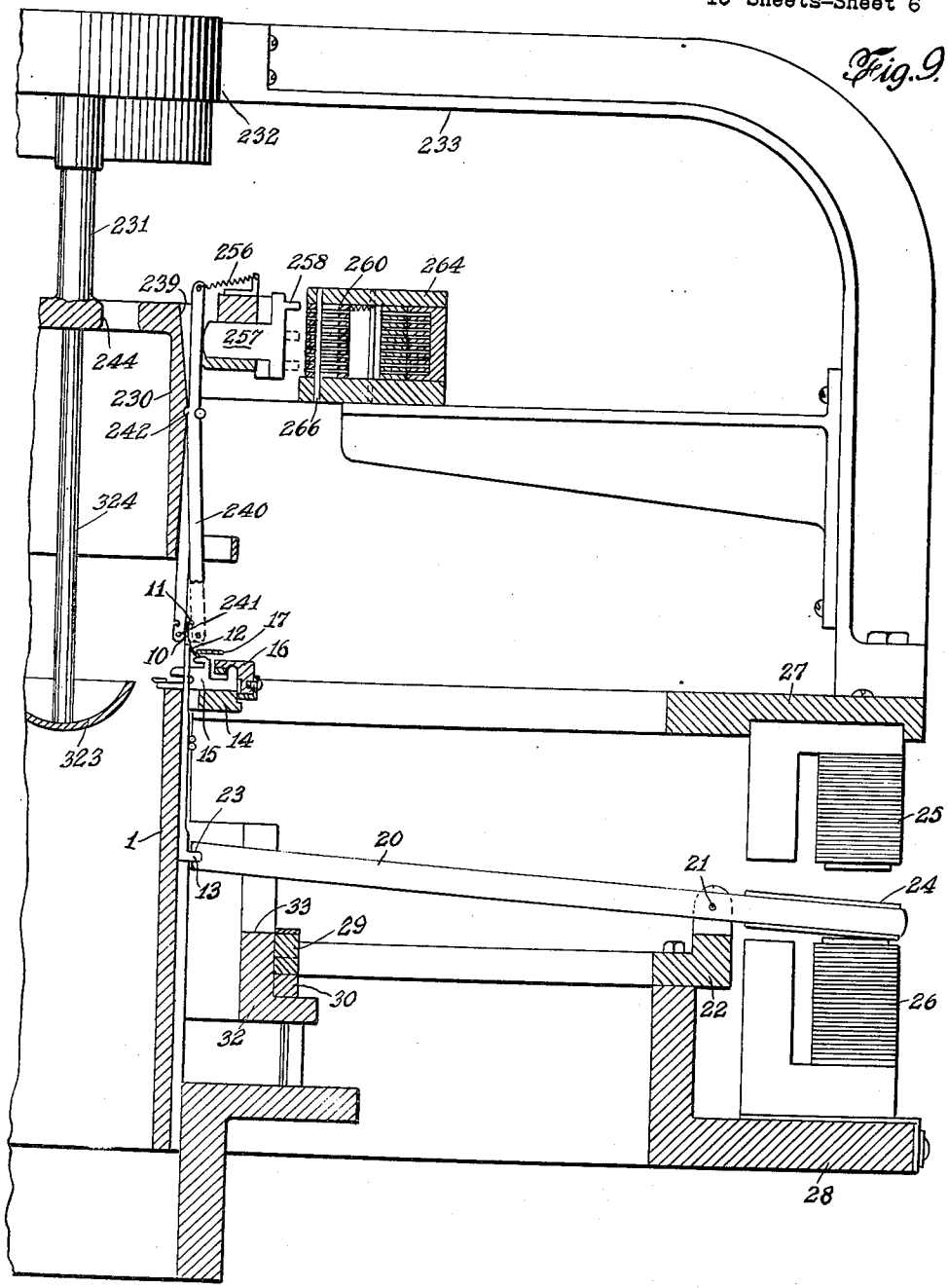
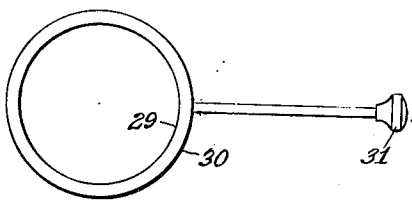


Fig. 10.



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KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 11

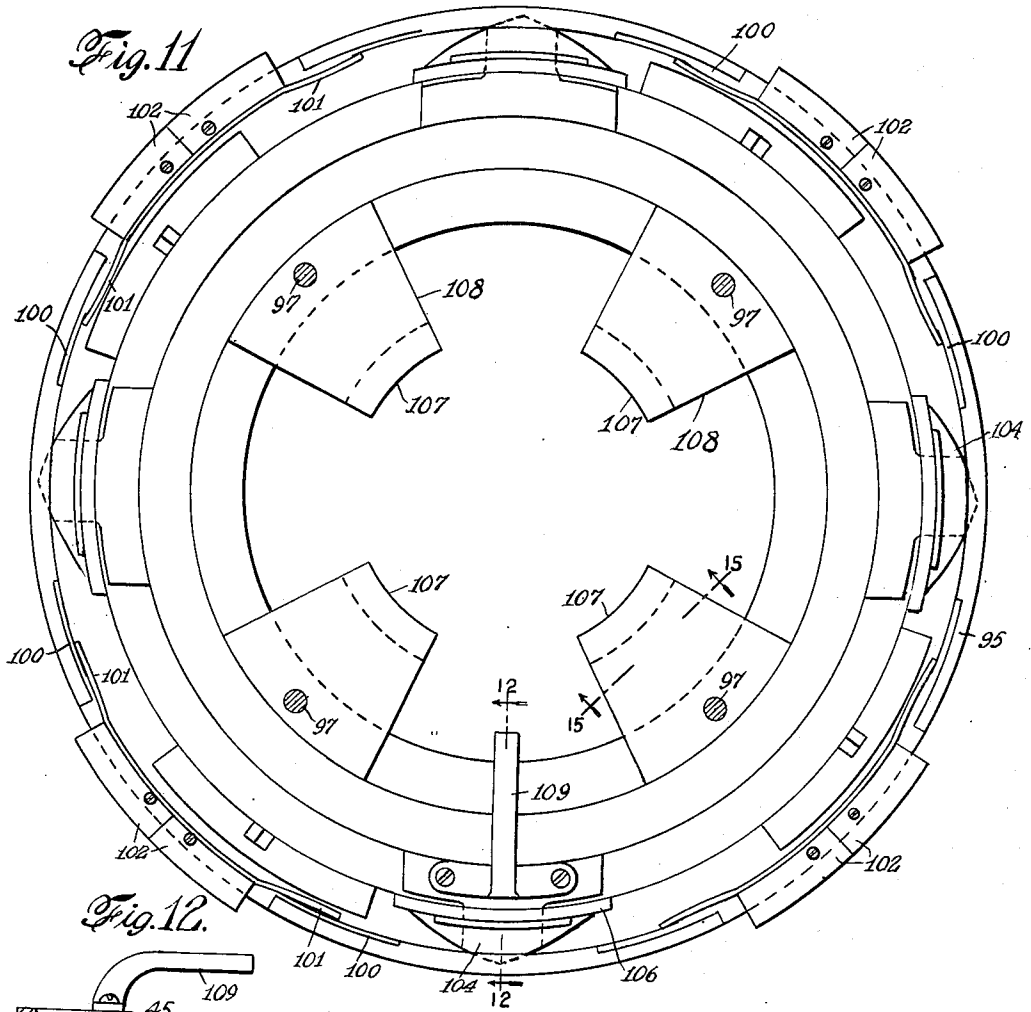


Fig. 12.

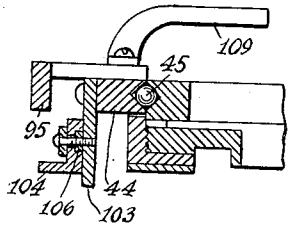


Fig. 13.

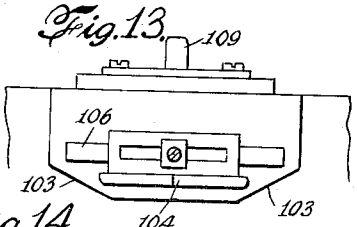


Fig. 15.

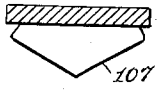
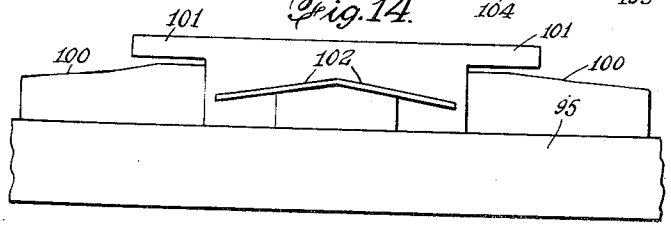


Fig. 14.



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KNITTED ARTICLE OF HOSIERY AND FABRIC

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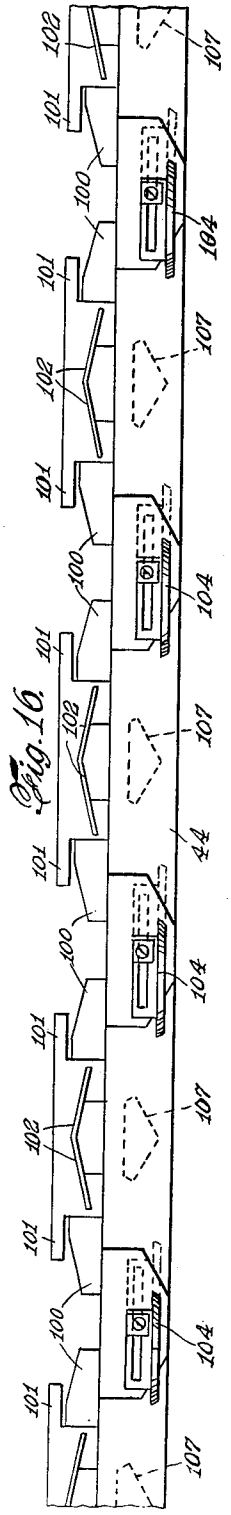


Fig. 16.

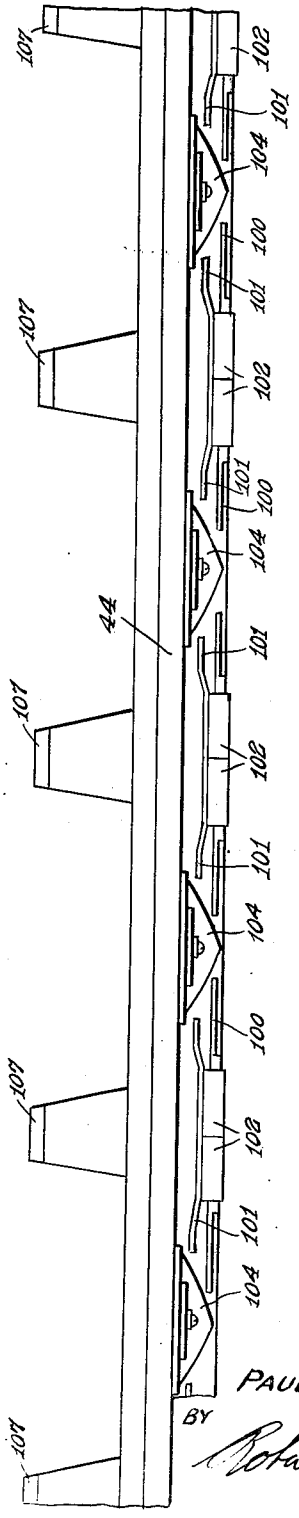


Fig. 17.

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June 15, 1954 P. L. THURSTON 2,680,961

KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 18.

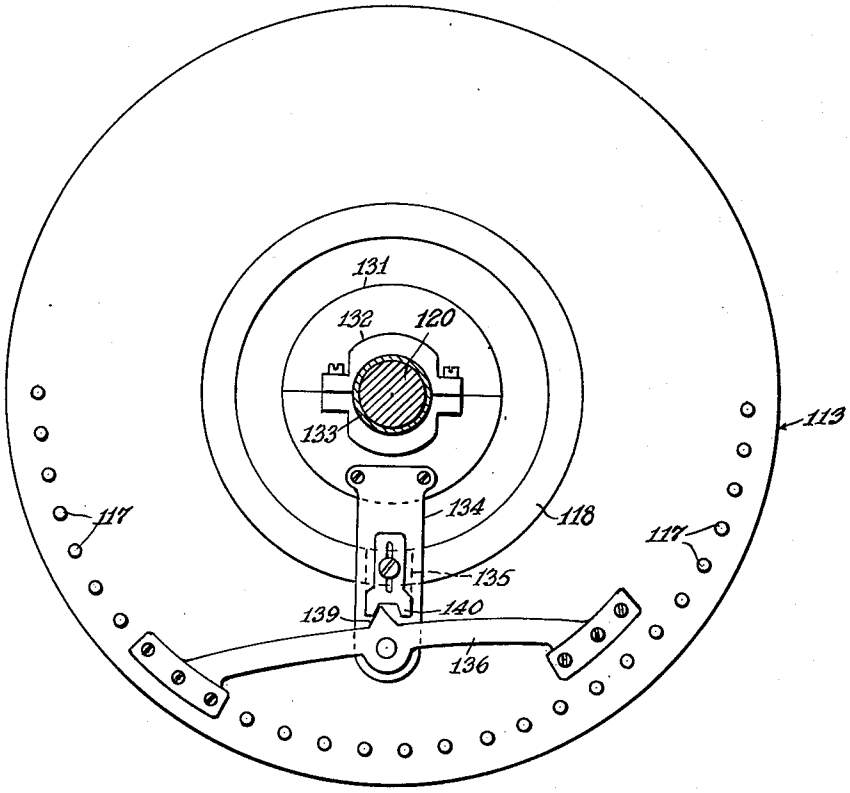
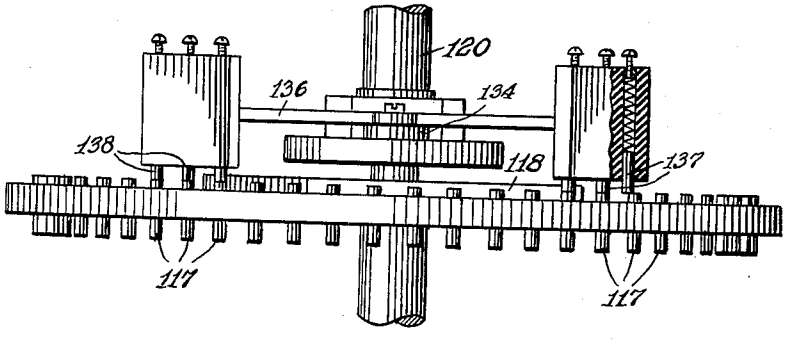


Fig. 19.



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KNITTED ARTICLE OF HOSIERY AND FABRIC

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Fig. 20.

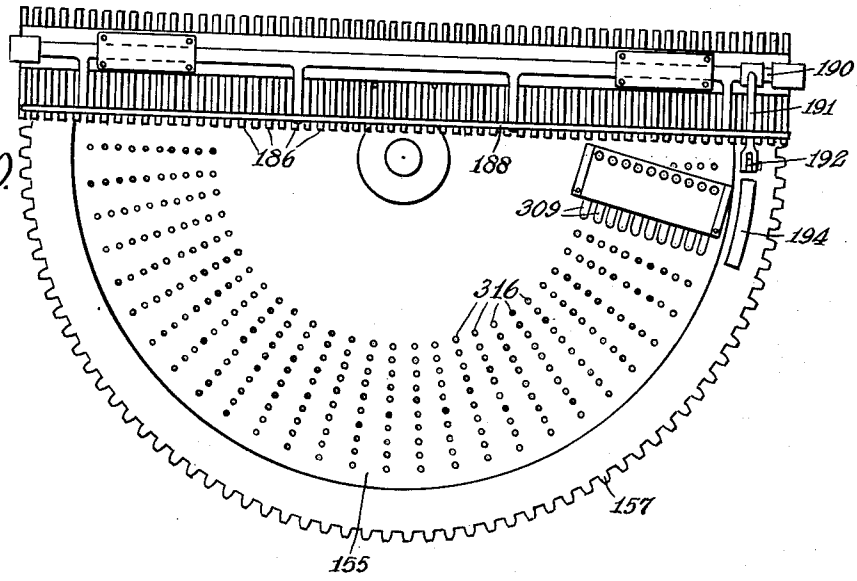
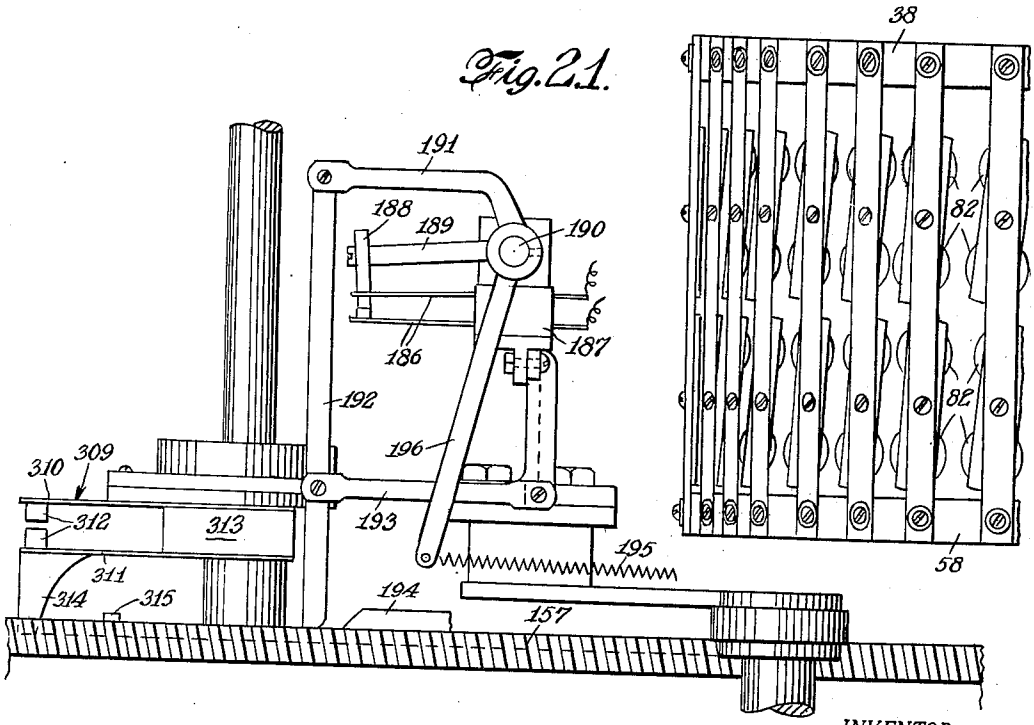


Fig. 21.



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Fig. 23.

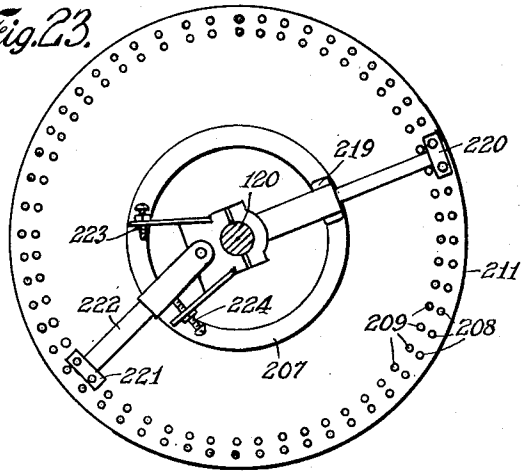


Fig. 22.

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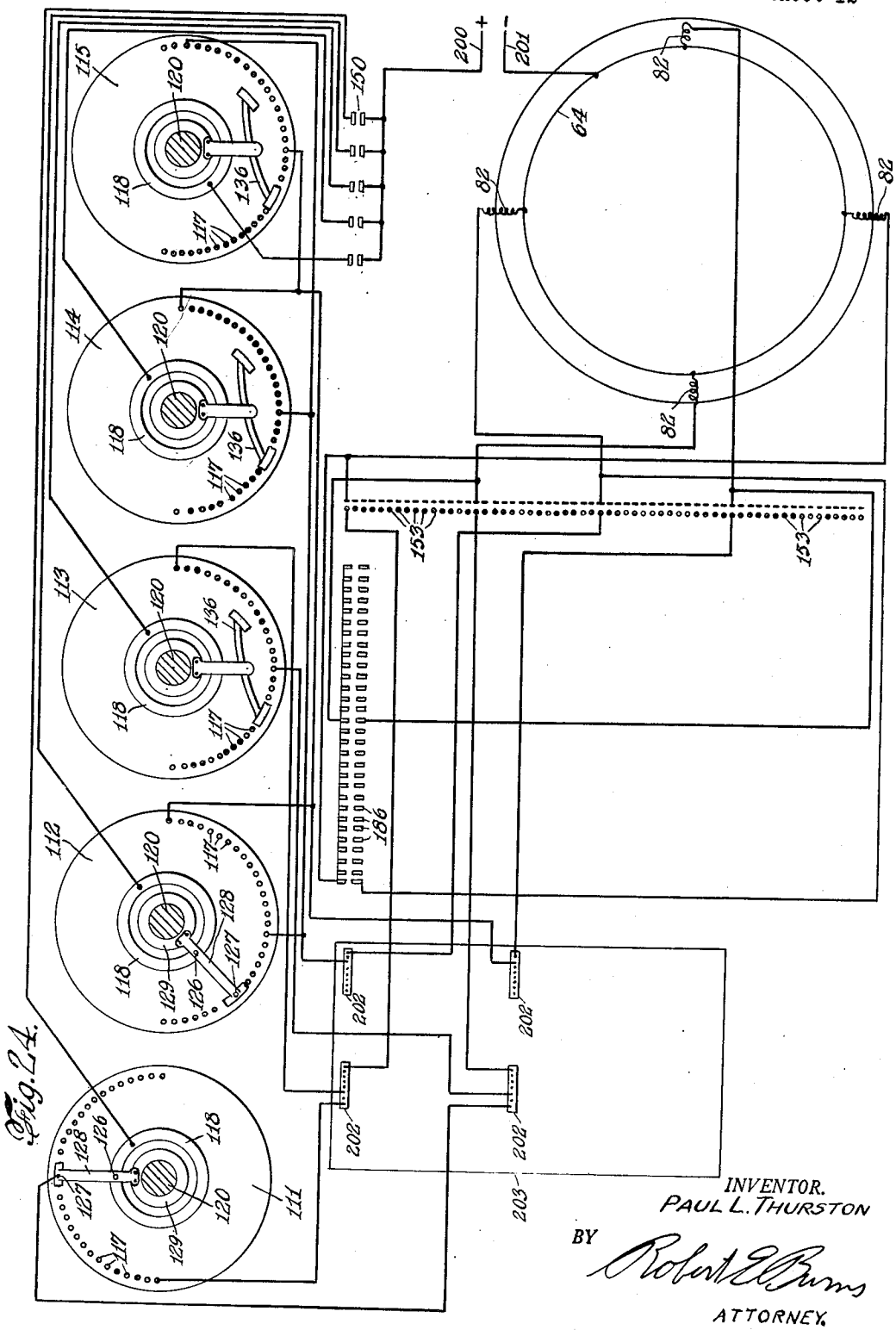


Fig. 24.

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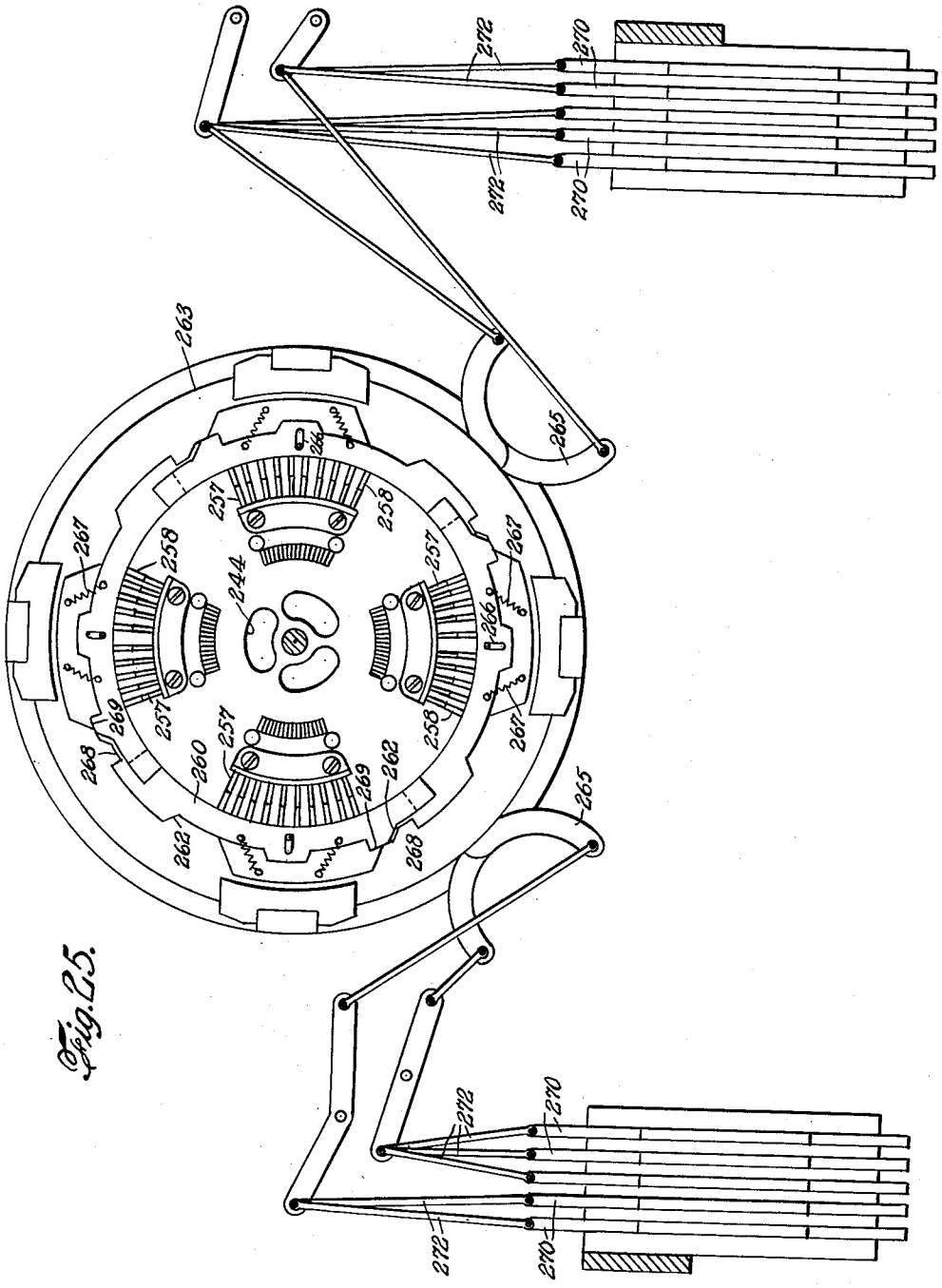


Fig. 25.

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KNITTED ARTICLE OF HOSIERY AND FABRIC

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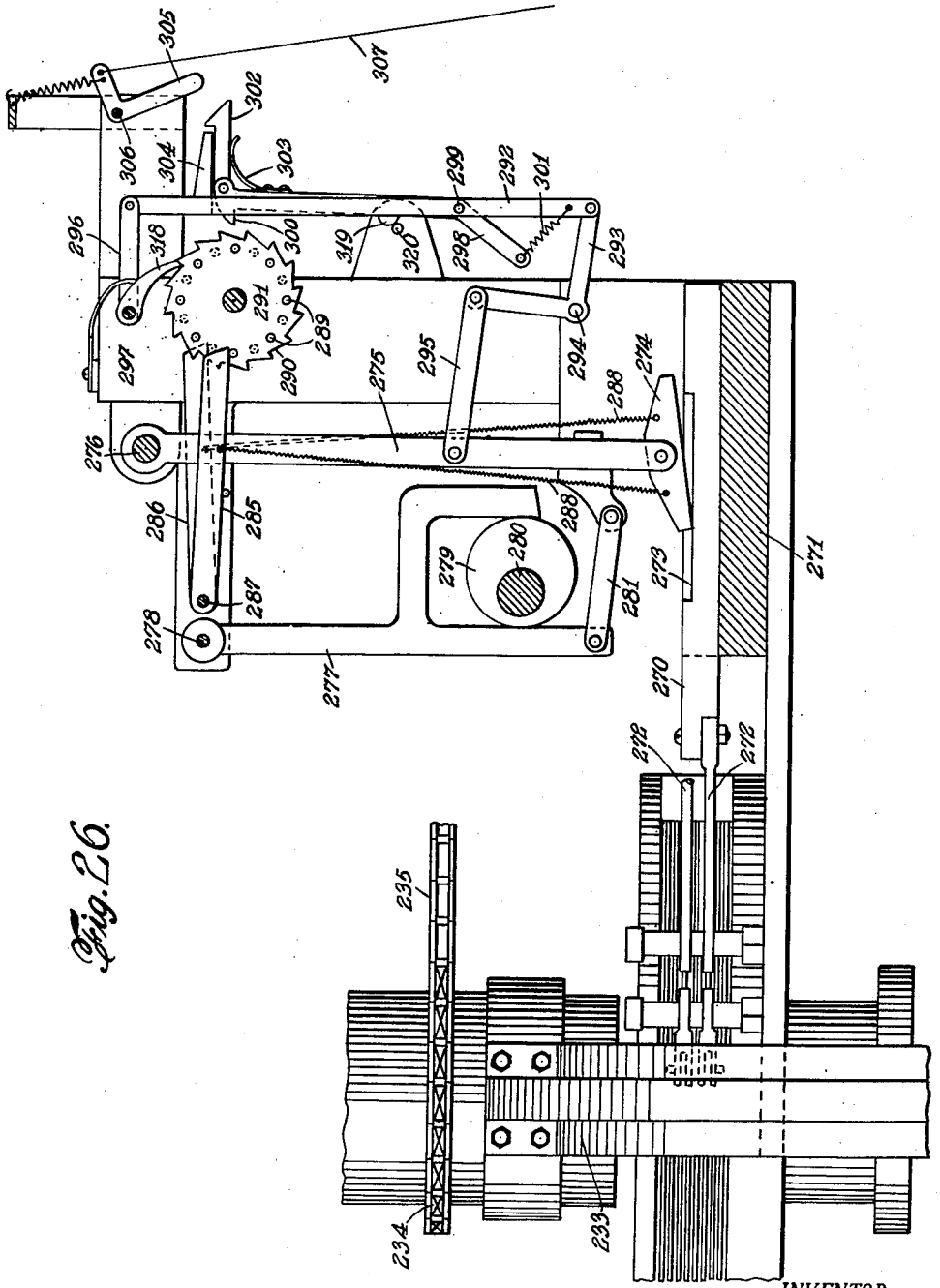


Fig. 26.

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KNITTED ARTICLE OF HOSIERY AND FABRIC

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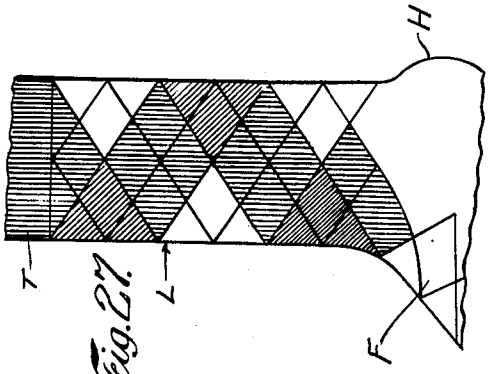


Fig. 27.

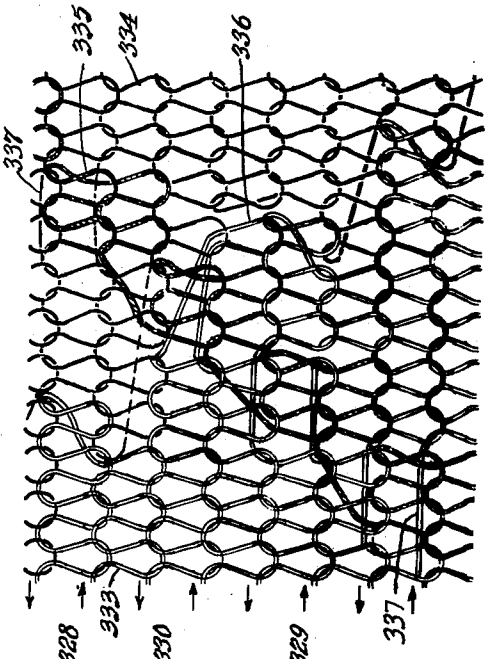


Fig. 29.

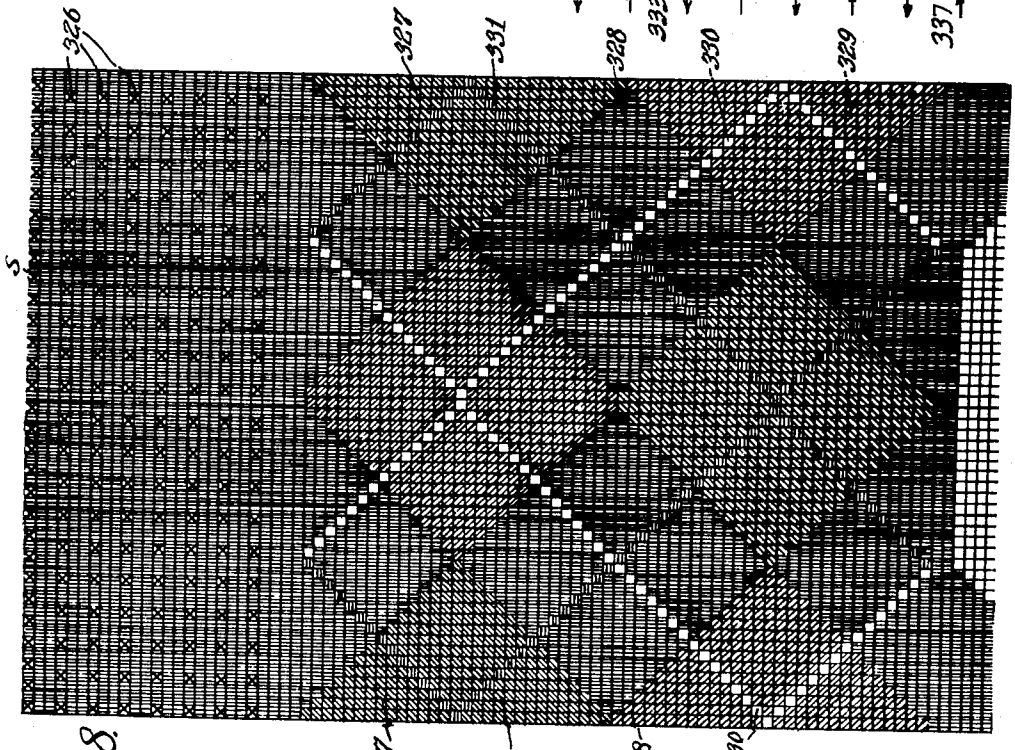


Fig. 28.

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Patented June 15, 1954

2,680,961

UNITED STATES PATENT OFFICE

2,680,961

KNITTED ARTICLE OF HOSIERY AND FABRIC

Paul L. Thurston, Martinsburg, W. Va., assignor to Interwoven Stocking Company, New Brunswick, N. J., a corporation of New Jersey

Application September 9, 1950, Serial No. 183,989

8 Claims. (Cl. 66—179)

1

The present invention relates to knitting machines and, particularly, to circular knitting machines. It is especially applicable to machines for knitting circular seamless hosiery.

While many mechanisms have been proposed for producing different patterns in knitted fabrics, the patterning potentialities of such mechanisms have been limited. This is especially true with respect to solid color patterns, as distinguished from plating where the back yarn tends to show through. Moreover, with present machines, attempts to make more difficult patterns result in decrease of the production of the machines to a point where they are uneconomical to operate. In some instances, hand operations are necessary. The problem of patterning is still more difficult in small diameter machines such as those used for producing hosiery by reason of space limitations. In automatic hosiery machines, the difficulty is increased by the necessity of operating by reciprocation and widening and narrowing to produce heel and toe pockets.

It is an object of the present invention to provide a knitting machine with far greater patterning capabilities than the knitting machines presently available. These patterning capabilities can be used either to produce decorative designs or to produce different fabric structures. A further object of the invention is to provide a machine that is wholly automatic in its operation and produces difficult patterns while maintaining a high rate of production. While the invention is applicable to knitting machines for many different types of fabric, it is especially advantageous in small diameter circular knitting machines for automatically producing seamless hosiery and, for this reason, a machine of this type is illustrated in the drawings. It will be understood, however, that this machine is shown and described merely by way of example and that the invention is in no way limited to it. As will be seen from the description and drawings, the machine in accordance with the invention is basically different from knitting machines heretofore available and embodies many novel features. While it is preferable to use all of these features to gain full advantage of the invention, it will be understood that certain features can be used without using others.

In accordance with the invention, the neeedles of the knitting machine are individually operated and their operation is electrically controlled, needle selection being effected by means of electrical control circuits rather than by conventional cams, jacks, etc. The control circuits

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provide both patterning selection and sequence selection. Patterning selection determines which needles operate and how they operate. Sequence selection determines the timing and sequence of operation of the selected needles. In the preferred embodiment of the invention, each needle is individually controlled in each course. The electrical operation of the needles offers many possibilities, such as cross-connecting or interconnecting certain needles electrically by means of switching, and also the possibility of switching from one selection or sequence control to another. Preferably, the yarn selection is also controlled electrically to provide wide selection and extremely flexible control. Many other novel features and advantages of the invention will appear from the following description in conjunction with the accompanying drawings, in which:

Fig. 1 is a front elevation of a machine embodying the present invention.

Fig. 2 is a left side elevation of the machine.

Fig. 3 is a right side elevation.

Fig. 4 is a fragmentary view corresponding to a portion of Fig. 3 but with certain parts removed in order to show other parts behind them.

Fig. 5 is a plan view of the machine with certain of the superstructure cut away.

Fig. 6 is a schematic perspective view showing connections for raising the yarn-feeding head of the machine.

Fig. 7 is a radial section taken in a vertical plane indicated approximately by the line 7—7 in Fig. 5.

Figs. 8 and 9 are similar sections showing respectively different forms of needle-operating mechanism.

Fig. 10 is a small scale schematic plan showing means for raising and levelling the needles, for example to receive a transferred top.

Fig. 11 is a plan of the needle-operating cam ring shown in Fig. 8.

Fig. 12 is a partial section on the line 12—12 in Fig. 11.

Fig. 13 is an outside elevation of one of the cam assemblies shown in Fig. 11.

Fig. 14 is an outside elevation of another of the cam assemblies.

Fig. 15 is a section on line 15—15 in Fig. 11.

Fig. 16 is a developed elevation showing cams on the cam ring of Fig. 11.

Fig. 17 is a developed plan view of the cams.

Fig. 18 is a plan of a control plate for sequence control.

Fig. 19 is an elevation of the control plate and associated parts shown in Fig. 18.

Fig. 20 is a plan of the upper end of a pattern drum controlling needle selection and yarn selection and also shows an arrangement for cross-connecting certain needles.

Fig. 21 is a partial right side elevation of the parts shown in Fig. 20.

Fig. 22 is a wiring diagram showing control circuits for the needle-operating mechanism shown in Fig. 9.

Fig. 23 is a plan of a sequence control plate for use in this embodiment.

Fig. 24 is a wiring diagram showing circuits for controlling the needle-operating mechanism illustrated in Figs. 7 and 8.

Fig. 25 is a view, partially in plan and partially in horizontal section, taken approximately on the line 25—25 in Fig. 1 illustrating yarn selection mechanism.

Fig. 26 is an elevation and partial section of the yarn selection mechanism, as viewed from the left of Fig. 25.

Fig. 27 is a side view of an article of hosiery made in accordance with the present invention.

Fig. 28 is a schematic developed view showing the pattern of the fabric illustrated in Fig. 27.

Fig. 29 is a stitch diagram of a small portion of the fabric.

In the drawings, the lines on which sections are taken are located as accurately as possible but should be considered as approximate. In order to simplify the drawings, certain parts of the machine are omitted in the various figures.

GENERAL CONSTRUCTION

The machine in accordance with the invention has a frame on which the moving parts are supported, a needle bed, a series of independent needles reciprocally mounted on the needle bed, mechanism for individually operating the needles, including an electromagnet for each needle, electric circuits controlling both the sequence of operation and the selection of the needles, yarn-feeding mechanism and preferably means for changing yarns during the operation of the machine.

The needle bed is shown in the form of a slotted cylinder 1 (Fig. 8) which is stationary in the sense of being non-rotating but preferably is supported for vertical endwise movement by a cylindrical sleeve portion 2 of the machine frame 3 (Figs. 1 and 8). The needle cylinder 1 is movable vertically by means of a collar 4 and suitable connecting members 5 and a cam follower 6 (Fig. 1) which cooperates with cams 7 carried by the shaft 8 of the main pattern drum 9 of the machine. The vertical movement of the cylinder adjusts the length of the knitted stitch and also provides for lowering the cylinder relative to the needles when it is desired to transfer fabric on to the machine, as for example the rib knit top of a stocking.

A circular series of needles is provided on the needle bed, each needle 10 having a hook 11 and latch 12 at its upper end and one or more butts 13 at its lower end (Fig. 9). At the upper end of the cylinder, there is a sinker ring 14 carrying a circular series of radially slidable sinkers 15 which are moved in and out by means of suitable cam surfaces in a rotating and oscillating sinker cap 16. The latches of the needles are controlled by one or more latch rings 17 (Fig. 9).

Needle-operating mechanism

The needle-operating mechanism may assume different physical forms, three embodiments being illustrated in Figs. 7, 8 and 9, respectively. In the form shown in Fig. 9, each needle is provided with an operating lever 20 which extends radially outwardly from the needle cylinder 1 and is pivoted at 21 on a stationary frame member 22. At its inner end, the lever 20 has a socket 23 that fits over the butt 13 of the needle. At its outer end, the lever has an armature 24 disposed between two electromagnets 25 and 26 carried, respectively, by stationary rings 27 and 28. When the magnet 25 is energized, it lifts the armature 24 to pull the needle down. The energizing of magnet 26 pulls downwardly on the armature 24 to raise the needle. Hence, by energizing selected magnets in predetermined sequence, selected needles can be raised to receive a yarn and then drawn down to knit it.

In order to raise and level all of the needles simultaneously, for example to transfer a rib knit stocking top on to the needles, a buffer ring 29 is raised beneath the inner end portions of levers 20 by means of interengaging cam portions on ring 29 and a cooperating ring 30 which is rotatable by means of a handle 31 (Figs. 1 and 10). The inner ends of the levers 20 are guided in their vertical movement by means of a stationary ring 32 having a series of vertical radial slots 33 in which the levers are received.

In the form as shown in Fig. 7, the needle-operating mechanism comprises an operating lever 35 for each needle. Each of the levers is pivoted at 36 on a bracket 37 carried by an upper ring 38 supported by means of posts 39 which project upwardly from radial ribs 40 projecting outwardly from the cylinder-supporting sleeve 2. At its inner end, the lever 35 has a socket portion 41 engaging the butt 13 of the corresponding needle. Intermediate its ends, each lever is provided with a rider 42 which is preferably formed of hardened material. A portion of the upper surface of each rider 42 is preferably rounded for smooth engagement by one or more cams 43 carried by a cam ring 44 which is rotatably supported by means of ball bearings 45. The cam ring 44 is driven in synchronism with a rotating yarn feed head (described below) and the number and position of cams 43 provided on the ring correspond to the yarn feeds. In the present embodiment, there are four yarn feeds which are equally spaced in a circumferential direction and four cams 43 likewise equally spaced. The cams 43 are substantially V-shaped with flattened bottoms and are adapted to engage the riders 42 on the needle-operating levers 35 in either direction of rotation of the cam ring 44 to draw the needles down and thereby draw stitches of the yarn fed to the needles. The phase relation in such that the cams 43 follow the respective yarn feeds. The cam ring 44 is driven in any suitable manner, for example by means of a separate sprocket as described below in conjunction with Fig. 7 or by an arm 46 that projects downwardly from the yarn-feeding head and acts on one or the other of spaced buffer screws 47 on the ring 44, the spacing being such as to provide proper phase relationship between the cam ring and the yarn feed head in both directions of rotation. These screws provide suitable adjustment. The levers 35 are guided adjacent the riders 42 by means of a vertically slotted cylinder 48 which also supports a bearing ring 49 for the rotating cam ring 44.

When the needle-operating levers 35 are pressed down by a cam 43, each lever is held in

its "down" position by means of a spring latch 51 which has a bifurcated upper end straddling the lever 35 and engaging the rider 42. The latch 51 is pivoted at 52 and a spring 53 tends to swing it in a clockwise direction (as viewed in Fig. 7) about its pivot. The latch 51 is swung in the opposite direction to release the needle-operating lever 35 by means of a rod 54 connected with the plunger-type armature 55 of a cylindrical electromagnet 56 supported by a bracket 57 on a stationary ring 58. A tension spring 59 acts between the lever 35 and the upper ring 38 to raise the lever when it is unlatched.

In this embodiment, the needles and operating levers are normally locked down in their lower position. By energizing selected ones of the magnets 56 in predetermined sequence, the corresponding levers are unlatched and the needles are raised by springs 59. After receiving yarn for that particular feed, the needles are pressed down by one of the cams 43 acting on the operating levers which are again latched. If a magnet 56 is not energized, the corresponding needle holds its stitch and does not knit a new stitch in that course.

If it is desired to raise and level the needles for transferring, this can be done by mechanism like that described in conjunction with Figs. 9 and 10. In this event, provision is made for disengaging the cams 43 from the riders 42, for example by making the riders slidable on the levers or by providing for the lifting or radial movement of the cams 43. Otherwise, certain needles would be held down by the cams. One end of the winding of each electromagnet 56 may, for convenience, be connected to a bus bar 64.

In the embodiment of Fig. 8, the needles are operated by radially projecting levers 60, each of which has a socket 61 at its inner end to receive the needle butt 13 and is pivotally mounted at its outer end 62 on a bracket 63 carried by the supporting ring 38. Upper arm 65 is pivoted on the bracket 63 at 66 and is connected with the lever 60 by a pair of rods 67 so that the lever 60 and arm 65 form a parallelogram linkage. A screw adjustment device 68 provides adjustment of the relative positions of the lever 60 and arm 65.

At its inner end—nearest the needle cylinder—the arm 65 carries a roller 70 mounted on a shaft 71 that is telescopically slidable in the arm 65 and is pressed inwardly towards the needle cylinder by a spring 72. In its outer position, the shaft 71 is held against the spring pressure by means of a latch 73 engaging a detent 74 on the shaft. The latch 73 is pivotally mounted on the arm 65 at 75 and is pressed into engagement with the detent 74 by a light spring 76. The latch is released by means of a bell crank lever 77 pivoted at 78 on an extension of the bracket 63 and having an upwardly projecting portion 79 adapted to engage the rear end of latch 73 at a point adjacent the pivot 66 of arm 65. The other arm of the bell crank 77 extends downwardly and is connected by a wire or link 80 with the pivoted armature 81 of a two-pole electromagnet 82. When the magnet is energized, the latch 73 is released to permit the roller 70 to move in towards the cylinder and thereby be in a position to be engaged by cams carried by a cam ring described below. The roller 70 is subsequently cammed back to its outer position and held there by the latch 73 until the magnet 82 is again energized.

On the needle-operating lever 60, there is a slider 85 carrying a horizontal roller 86 and a vertical roller 87. A spring 88 tends to move the slider in towards the needle cylinder. The slider is held in its outer position against the pressure of the spring by a latch 89 which is pivoted on the lever 60 at 90 and has an upstanding portion 91 adapted to engage an adjustable screw 92 carried by the bracket 63. A spring 93 tends to hold the latch in engagement with a detent on the slider 85 when the lever is in its lower position. When the lever is moved upwardly a predetermined distance determined by the adjustment of screw 92, the engagement of upstanding portion 91 of the latch with the screw 92 causes the latch to release the slider 85, allowing it to move inwardly to a position in which roller 86 is engaged by cams described below. Cam surfaces are also provided to engage with vertical roller 87 to move the slider to its outer position, whereupon it is again held by the latch 89.

The cams that act on the lever 60 and arm 65 are carried by the rotating and oscillating cam ring 44 (cf. Fig. 8) and an associated outer cam ring 95 which is spaced from, and carried by, ring 44 by means of suitable brackets. These cam rings are rotated and oscillated in synchronism with the yarn-feeding head, for example by means of an arm 46, as in Fig. 7, or preferably by means of a chain sprocket 96 (Fig. 3) which is mounted on posts 97 projecting upwardly from the cam ring 44 and driven by a chain from a sprocket on the control shaft 120 described below.

In the embodiment illustrated in the drawings, there are four complete sets of cams on the cam rings 44 and 95, the sets being equally spaced and corresponding to the four feeds of the yarn-feeding head. Moreover, since the machine is designed to work in reciprocation as well as in straight rotary movement, each of the cams is double-faced or there are two corresponding cams. Referring to Figs. 8 and 11 to 17, the cams adapted to act on the roller 70 of arm 65 are carried by the outer cam ring 95 and comprise clearing cams 100, resetting cams 101 and levelling cams 102. The clearing cams are so positioned that they act on the rollers 70 only when the rollers have been "fired" by release of the latches 73 and are hence in their inner position. The clearing cams are of such height that, acting through the roller 70, arm 65, links 67 and lever 60, they raise the corresponding needles to latch-clearing position. The resetting cams 101 engage the ends of rollers 70 and push them back out to their outer positions where they are held by latches 73 until they are again "fired" by energizing the magnets 82. The levelling cams 102 extend out farther than clearing cams 100 in a radial direction so as to engage the rollers 70, even when the latter are retracted. These cams are of such height as to raise the unselected needles so that their hooks are approximately level with the sinkers. This prevents the formation of undesirably large loops at the gore during widening and narrowing, for example in making the heel and toe pockets and in knitting diamond patterns.

The cams acting on the rollers 86 and 87 on the lever 60 are carried by the inner cam ring 44 and comprise stitch cams 103 and a V-shaped resetting cam 104. The cams 103 are in such position radially that they do not engage the rollers 86 when the sliders are latched in their outer position. When the rollers are in their

inner position, they are engaged by the stitch cams 103 to draw the needles down and thereby draw stitches of the yarn fed to the needles. Resetting cam 104 acts radially on the vertical rollers 87 to move the sliders 85 to their outer position. As the needles and operating levers 69 have at this time been drawn down by the stitch cam 103, the sliders 85 are held in their outer position by the latches 89. The resetting cam 104 is slidable relative to the stitch cams 103, for example by being slidably mounted on a rib 105 that projects from the outer face of the stitch cams. It thereby assumes the position shown in solid lines in Figs. 16 and 17 during rotation of the cam rings in one direction and the position shown in dotted lines during the other direction of rotation so that resetting cam at all times trails the active stitch cam.

There are also provided V-shaped feeding cams 107 (Figs. 11, 15, 16 and 17) which are carried by inwardly projecting portions 108 of the inner cam ring 44 and are adapted to engage either the inner ends of the levers 69 or additional butts on the needles just below these levers so as to to lower all of the needles to a predetermined level to receive the yarn fed by the yarn-feeding means. It has been found that the needles should be lowered to a point where their latches are protected by the sinkers so that the yarn cannot accidentally get below the latches.

It has been found that with a four-feed machine such as that shown in the drawings it is not necessary to provide any shogging between the cam rings and the yarn-feeding head during reciprocation. As the yarn-feeding points are disposed between two stitch cams, the needles are operated to draw stitches of the yarn by one stitch cam during rotation in one direction and by the stitch cam on the other side of the feeding point during rotation in the opposite direction.

The rotatable sinker cap 16 (Fig. 9) is driven from the cam ring 44 by means of an upwardly projecting arm 109 (Figs. 11 to 13) which engages opposed bumper screws that are adjustable to control the angular relation of the cam ring and the sinker cap in both directions of rotation.

The operation of the needle-actuating mechanism shown in Fig. 8 is as follows: When the electromagnet 82 is energized, the corresponding roller 70 is "fired" to its inner position where it is engaged by one of the clearing cams 100 (Figs. 11 to 17) to raise the needle to clearing position. The raising of the needle-operating lever 69 releases latch 89 (Fig. 8), allowing the slider 85 to move to its inner position so as to be engaged by a stitch cam 103 which draws the needle down to form a stitch. The roller 70 and slider 85 are reset by their corresponding resetting cams 101 and 104. When a needle is not selected, i. e. when the corresponding magnet 82 is not energized, the roller 70 is raised slightly by the levelling cam 102 but not enough to release the latch 89 and not enough to clear the latch of the needle. The unselected needles hence hold their stitches.

Needle selection

The selection of needles at each of the four feeds is effected by a combination of sequence selection, which determines the sequence and timing of the needle operation, and pattern selection, which determines whether or not a particular needle is to take the yarn and draw a new stitch at that feed.

Sequence selection

Sequence selection is provided by means of a series of devices for opening and closing the circuits that supply electric energy to the individual electromagnets in predetermined sequence one after the other. For convenience of terminology, these devices are referred to as "circuit breakers" although they may assume any suitable form, for example mechanical contacts, mercury switches or equivalent devices for stopping and starting the flow of current to energize the magnets or for varying the flow of current above and below a critical value required for energizing the magnets. By means of this sequence control, the magnets that control the needles are energized in predetermined timed relation to the rotation of the yarn feed. When knitting by reciprocation, the sequence control is automatically reversed each time the yarn feed reverses its direction.

In the embodiment of the invention illustrated by way of example in the drawings, sequence selection is obtained by the use of a plurality of control plates. The number of control plates may be varied as desired, depending upon the type of patterns it is desired to produce with the machine. In Figs. 2 and 3, five control plates numbered 111, 112, 113, 114 and 115, respectively, are mounted one above the other at the back of the machine. The plates are supported by suitable frame structure including a plurality of rods 116 which extend between the peripheries of the plates. The plates are formed of insulating material and each carries an arcuate series of electrical contact buttons 117 (Figs. 18 and 19) which are connected by the circuits described below with the respective magnets for the individual needles. Preferably, each contact controls a particular magnet although in some instances a contact may control two or more magnets as desired by suitable cross-connection. In some instances, there may be a complete circular series of contacts, the number of contacts corresponding, for example, to the number of needles in the machine. In the embodiment illustrated in the drawings, the control plates are shown with approximately semi-circular series of contacts, the number of contacts on each plate being equal to, or slightly greater than, half the number of needles. In order to operate all of the needles, two of the control plates may be used simultaneously, one controlling half of the needles and the other the remaining half. Alternatively, the needles may be cross-connected so that each contact controls two needles, for example pairs of needles that are diametrically opposite one another. In some instances, as illustrated on control plate 115 (Fig. 24), there may be somewhat more than a semi-circle of contacts. Such a control plate may, for example, be used in reciprocating knitting, as in knitting heel and toe pockets of a stocking when it is desired to use more than half of the needles. Other arrangements of the contacts may be used to obtain the particular results desired. In addition to the contact buttons provided near the periphery of the control plates, each plate has a concentric inner slip ring 118. A rotatable shaft 120 extends up through aligned holes in the control plates and carries brushes adapted to engage the slip rings 118 and contacts 117, the brushes being electrically connected with one another. The

shaft 120 is driven from the main shaft 121 of the machine by means of bevel gears 122, a chain 123 and suitable chain sprocket so that the shaft 120 is always rotated and reciprocated in exact synchronism with the main shaft 121. The latter is driven in any suitable manner, for example by means of pulleys 124 (Fig. 3). The shaft 120 rotates in a clockwise direction, as viewed from the top, during operation of the machine in continuous circular motion.

Each of the control plates 111 and 112 (Fig. 24) is shown with a single set of brushes, i. e. a brush 126 contacting the slip ring 118 and a brush 127 engaging the contact buttons 117. The brushes are resiliently carried by an arm 128 which projects radially from an insulating collar 129 that is mounted on, and rotates with, the shaft 120. Provision is preferably made for adjusting the brush arms angularly with respect to the shaft so as to vary the phase relation of the arms to one another and to the shaft.

Control plates 113, 114 and 115 (Fig. 24) each have a brush engaging the slip ring 118 and a pair of brushes adapted to engage the contact buttons 117. The two latter brushes are spaced a predetermined distance apart, for example a distance of twelve contact buttons, and are so arranged that in reciprocating motion the leading brush is in contact with the buttons while the trailing brush does not engage them. In the construction illustrated in the drawings (Figs. 18 and 19) a split fiber collar 131 having a bushing 132 clamps on to a sleeve 133 that surrounds and rotates with the shaft 120. The collar carries a radially projecting arm 134 on the lower side of which is resiliently mounted a brush 135 adapted to engage the inner slip ring 118. A cross arm 136 is pivotally mounted at the outer end of the radial arm 134 and carries spring-pressed brushes 137 and 138 at its opposite ends. The extent of oscillation of the cross arm 136 is limited by engagement of a point 139 provided on the arm with an adjustable stop 140 on the radial arm 134. With this arrangement, the frictional engagement of the brushes with the control plate and contact buttons automatically rocks the cross arm 136 upon reversal of the direction of rotation so that the leading brushes only contact the buttons. This assures that the needles are properly raised to receive the yarn in both directions of rotation.

Provision is made for lifting the brushes of at least certain of the control plates when the respective plates are not in use. While the drawings illustrate mechanism for raising the brushes of control plates 112 and 113 (Fig. 3), it will be understood that similar or other mechanism may be provided for raising any desired ones or all of the brushes. The brush-lifting mechanism shown in the drawings comprises a bell crank 142 pivoted on a suitable support at 143 and having a forked arm 144 engaging a collar 145 on the sleeve 133 (Fig. 18) that carries the brushes, the sleeve being rotatable with, but axially slidable on, the shaft 120. The other arm of the bell crank is connected by a link 146 with a rocker 147 which is pivoted at 148 and has a nose portion adapted to be engaged by suitable cams on the main pattern drum 9. When the nose of the rocker 147 rides up on a cam, the brush assembly is lifted by the bell crank 142.

Means is provided for switching any desired ones of the control plates into the needle-operating circuits so that the sequence of operation of the needles may be controlled by one or another of the control plates or by two or more plates in combination. This makes it possible readily to vary the sequence of operation of the needles, for example when knitting different parts of an article or when knitting different articles. As illustrated in the drawings (Figs. 3, 5 and 24), the machine is provided with a series of switches 150, each consisting of a pair of contacts adapted to be pressed together by means of a pivoted rocker arm 151 adapted to be engaged by suitable cams on an extension of the main pattern drum 9. Each of said switches is connected in series between a source of electromotive force and the inner slip ring 118 of one of thec ontrol plates. When the rocker arm 151 is engaged by a cam, the corresponding switch is closed so that electrical energy is supplied through the slip ring to the brushes of the corresponding control plate. As the shaft 120 rotates, the brushes supply current sequentially to the contacts 117 since the brush that engages the slip ring 118 and the brush that engages the contacts are electrically connected. Where provision is made for lifting the brushes, as described above, it is not necessary to have a disconnecting switch 150 since the lifting of the brushes automatically opens the circuit. However, for greater flexibility of control, each control plate is preferably provided with a corresponding switch 150.

Pattern selection

Pattern selection is obtained by means of "circuit breakers" provided in the electrical operating circuits of the individual needles and opened and closed in accordance with a predetermined pattern or plan. The connections between the circuit breakers controlling needle selection and the circuit breakers which control the sequence of needle operation are such that a needle is operated only by the cooperation of both circuit breakers, i. e. when both circuit breakers are in proper position. In the machine illustrated in the drawings, the two circuit breakers are in series with one another so that current is supplied for operating a particular needle only when both circuit breakers are closed. Suitable patterning mechanism is provided for opening and closing the circuit breakers that control needle selection during the knitting of an article. Preferably, the arrangement is such that the needle selection can be changed for each course of the fabric. The patterning mechanism may assume different forms as, for example, a moving strip or sheet which may be perforated or may have magnetized and unmagnetized areas acting through suitable responsive media to open and close the circuit breakers controlling pattern selection. Alternatively, a strip or sheet may have areas of different opacity acting through light-responsive media to control the circuit breakers. However, the machine illustrated in the drawings has pattern selection circuit breakers controlled by a rotatable drum having removable pins for actuating the circuit breakers.

As shown in Fig. 1, the circuit breakers controlling pattern selection comprise a series of switches 153 mounted on a vertical supporting strip 154 which is preferably formed of insulating material. The switches may be of any suitable form, as, for example, contacts carried by spaced resilient leaves mounted on a suitable insulating strip or block. Switches of this type—but for a different purpose—are illustrated in Fig. 21. Suitable terminals are provided for the wiring connections described below. The contacts are

normally open, the circuit being closed by pressing the spaced contacts together. There is preferably a pattern selection circuit breaker for each needle so that each needle can be individually controlled although in some instances it may be desirable or permissible to control two or more needles by a single circuit breaker. Conversely, a needle may be controlled by more than one circuit breaker, as, for example, in a multi-feed machine where it is desired to have one needle selection for one feed and a different needle selection for another feed.

The pattern selection circuit breakers are closed by means of a pattern-selecting drum 155 which is rotatable about an axis parallel to the strip 154 and has in its peripheral surface a multiplicity of holes into which pins can be inserted. The pins 156 are adapted to press on the adjacent leaves of the switches 153 so as to bring the contacts together and close the circuit. The pins are formed of insulating material or, alternatively, the pin-engaging portions of the switches are insulated so as to maintain electrical insulation between the switches and the drum. The number and spacing of the horizontal rows of holes in the drum 155 correspond with the number and spacing of the switches 153. In the illustrated embodiment, the number of switches 153 is equal to the number of needles in the machine. The number of holes in each row may vary in accordance with the patterning desired but should preferably not be less than half the number of needles. To provide still greater patterning range, the number of holes in each horizontal row is increased and may, for example, be equal to the number of needles or even greater. In the present embodiment of the invention, there are three hundred holes in each row. By having the number of horizontal rows of holes and corresponding number of switches equal to the number of needles and by having the number of holes in each row equal to the number of courses in the patterned portion of the fabric being knit, it is possible to control each needle individually in the knitting of each course.

The pattern selection drum 155 is rotated intermittently by means of a worm wheel in the form of a toothed ring 157 secured to the upper end of the drum and rotated by means of a meshing worm 158 on a horizontal shaft 159 rotatably supported by suitable bearings (Figs. 1, 2 and 5). The shaft 159 extends across the back of the machine and, at its opposite end, has a sprocket 160 driven by a chain from a sprocket 161 (Fig. 3) on a shaft 162 which also carries a gear 163 meshing with a larger gear 164 on a shaft 165. The shaft 165 is rotated intermittently by means of a ratchet 166 which is mounted on the shaft and is racked by a pawl 167 carried on a swinging lever 168 pivotally supported at 169 and having a cam portion 170 adapted to be engaged by one or more rollers 171 carried by a gear wheel 172 driven by an intermeshing gear on the main shaft of the machine. The frequency of racking of the ratchet is determined by the gear ratio between gear 172 and the main shaft and by the number of rollers 171. Preferably, the sprocket is racked once each revolution of the main shaft. The racking of the ratchet 166 may be interrupted by means of an L-shaped blocking arm 173 which is swingable about the shaft 165 by linkage 174 actuated from the main pattern drum to a position in which it holds the swinging lever 168 out away from the rollers 171. The blocking lever 173 is held in this position by a detent 175 on a lever 176 which is swingable about a pivot shaft 177. The lever 176 has a nose portion 178 adapted to be engaged by spaced projections on an auxiliary pattern chain 179 which runs on a sprocket 180 mounted on the shaft 165; the engagement of a projection on the chain with the nose portion 178 lifts the lever 176 so as to release the blocking lever 173 from the detent 175 and thereby free the swinging arm 168. A bell crank 181 actuated from the main pattern drum by suitable linkage 182 has a yoke portion adapted to engage the lever 176 adjacent its pivot so as to shift the lever laterally, i. e. axially of the pivot shaft 177, so that the nose portion 178 is out of line with the chain 179 so as not to be engaged by the projections on the chain. When the lever 176 is shifted in this manner, it will continue to hold the arm 173 in a position to block the racking of the ratchet 166. Suitable springs or other means are provided for returning the various parts to their normal positions. When the ratchet 166 is racked, the shaft 159 is rotated and the worm 158 acts on the worm wheel 157 to move the drum 155 forward a distance equal to the space between successive holes in the peripheral surface of the drum. The worm locks the drum in the position to which it is moved and prevents any over-shooting. In order to release the drum so that it can be moved independently of the worm 158, for example to time the machine, means is provided for engaging and disengaging the worm with the worm wheel 157. In the illustrated embodiment, the bearing at the end of shaft 159 adjacent the selecting pattern drum is movable toward and away from the drum by means of an eccentric 184 rotatable by means of a lever or handle 185.

The patterning potentialities of the machine are still further increased by the provision of a series of cross-connecting switches so that two or more needles, for example diametrically opposite needles, can be operated together. Since the pattern designs on the opposite sides of a tubular fabric are ordinarily alike, diametrically opposite needles may be controlled by the same row of pins on the selecting pattern drum. For example, if the machine has 108 needles, they can be controlled by using only 54 rows of pins on the drum. Hence, if there are the same number of rows of pins as there are needles, half of the rows can be used for selection at one feed or in one portion of the fabric while the other half is used at a different feed or in a different portion of the fabric. However, in some instances, as when knitting the heel and toe pockets of a stocking, it is undesirable to operate opposite needles together. Hence, means is provided for disconnecting the needles so that they may be operated separately.

As shown in the drawings (Figs. 1, 5, 20 and 21), the cross-connecting switches are in the form of leaf switches 186, each comprising contacts on resilient spaced leaves mounted on an insulating bar 187 which extends fore and aft of the machine above the selecting pattern drum 155. There are half as many switches as needles, the two contacts of each switch being connected with the circuit of diametrically opposite needles. Hence, when the switches are closed, the opposite needles will be operated together. The resiliency of the leaves tends to hold the contacts apart so that the switches are open. All of the switches are closed simultaneously by means of a bar 188 of insulating material carried by spaced arms 189 on a rock shaft 190. Another arm 191 on the rock shaft is connected

with a cam follower 192 which is guided by a pivoted arm 193 so that it moves with a parallel motion so that each position of the arm is parallel to each other position. The cam follower is adapted to be engaged by one or more cam segments 194 provided on the upper end of the selecting pattern drum 155. A spring 195 acting on a further arm 196 on the rock shaft 190 tends to rotate the shaft in a counter-clockwise direction, as viewed in Fig. 21, with sufficient force to close all of the switches. When the cam follower 192 rides up on a cam segment 194, the rock shaft is oscillated in a clockwise direction to raise the bar 188 and thereby open the switches 186. Instead of controlling all of the cross-connecting switches 186 by a single bar 188, the bar, together with the rock shaft 190, may be divided into two or more segments which are individually controlled so that the switches may be operated separately or in groups of any desired size.

The electrical connections between the circuit components described above are illustrated in the wiring diagram shown in Fig. 24. A suitable source of electrical energy is indicated by the mains 200 and 201. While direct current is preferred, alternating current may be used if the various circuit components are designed for use with alternating current. One of the mains 200 is connected with one side of each of the switches 150 that are operated from the main pattern drum and determine which sequence control plate or plates are to be used to control the sequence of operation of the needles. The other terminals of the switches 150 are connected respectively with the slip rings 118 of the sequence control plates 111, 112, 113, 114 and 115. The contact buttons 117 of the control plates are connected respectively with bus bars 202 on a panel 203. There is preferably a bus bar 202 for each of the needles. Each of the contacts on the several control plates that is intended to operate the first needle of the needle series is connected with the first bus bar while each of the contacts that is to operate the second needle of the series is connected to the second bus bar, etc. To simplify the wiring diagram, connections are shown for only four of the needles disposed respectively at 90° to one another around the needle circle. The bus bars 202 are preferably provided with holes into which conductors leading from the contact buttons 117 can be plugged so that the arrangement of the connections can be easily made and easily changed. To simplify the wiring diagram, junctions have in some instances been shown in the wires leading from the contact buttons 117 to the bus bars 202. Preferably, however, the conductors lead directly from the contact buttons to the bus bars.

Each of the bus bars 202 is connected respectively with one side of one of the switches 153 actuated by the selecting pattern drum 155. The other side of each of the switches 153 is connected respectively with a terminal of one of the needle-operating magnets 82. The other terminal of each magnet is connected with a bus bar 64 which in turn is connected with the other main 201. The opposite sides of each of the cross-connecting switches 186 are connected respectively with the operating magnets of diametrically opposite needles. Hence, when current is supplied to one needle, it is also supplied to the diametrically opposite needle if the cross-connecting switch 186 is closed.

From the wiring diagram (Fig. 24) it will be seen that a needle is operated only when the corresponding selecting switch 153 is closed. Moreover, the selected needles are actuated in predetermined sequence according to the engagement of the contact buttons 117 on the sequence control plates by the rotating brushes 127 and 137 or 138. The opening and closing of the switches 150 under control of the main pattern drum determines which sequence control plate or plates are to control the sequence of operation of the needles. When the machine is operated in reciprocation, the sequence of operation of the needles is alternately reversed. While the various circuit-closing elements have been shown arranged and connected in a particular way in Fig. 24, it will be understood that this is only by way of example. Moreover, the designation of the magnets by the reference numeral 82 in the wiring diagram of Fig. 24 is not intended to limit the circuits shown to the particular needle-operating mechanism shown in Fig. 8 where the magnets are designated by the same numeral. The control circuits are equally applicable, with or without modification, to other forms of needle-operating means, as, for example, that shown in Fig. 7 where the magnets are designated by the reference numeral 56.

An alternative wiring diagram is shown in Fig. 22 while a representative control plate for use in this circuit is shown in Fig. 23. This circuit is particularly applicable to the needle-operating arrangement shown in Fig. 9 but is not limited to that arrangement. An electrical source 205 is connected to one side each of a series of switches 206, the other sides of which are connected respectively with slip rings 207 on corresponding sequence control plates 211, 212, 213, 214, 215, 216, 217 and 218 formed of insulating material. The control plate 211 shown in Fig. 23 has an outer circle of contacts 208 and an inner circle of contacts 209. A brush assembly carried by a rotatable shaft 120 comprises a brush 219 engaging the slip ring 207, a brush 220 engaging the outer circle of contacts 208 and a brush 221 engaging the inner row of contacts 209. The latter brush 221 is carried by a pivoted arm 222 which is swingable between opposed adjustable abutments 223 and 224 so that when the shaft 120 is oscillated the brush 221 trails the brush 220 by more than 180° in both directions of rotation. Sequence control plates 212 and 218 are shown similar to plate 211. Plate 213 has only an inner circle of contacts while plate 214 has only an outer circle. Plates 215, 216 and 217 have a semi-circle of outer contacts and an oppositely disposed semi-circle of inner contacts.

Each of the outer contacts 208 is connected with one side of a corresponding switch 225 actuated by pins 226 on a pattern drum 227. The other side of each of the switches 225 is connected with a terminal of a corresponding needle-lifting magnet 25 (Fig. 9), the other terminal of the magnet being connected with the opposite pole of the current source 205. Each of the inner contacts 209 is connected with a terminal of a corresponding needle-lowering magnet 26, the other terminal of which is connected back to the current source 205. The outer contact 208 and inner contact 209 connected respectively with the magnets 25 and 26 for a particular needle are disposed diametrically opposite to one another on the control plate. As the brush assembly is rotated by the shaft 120, the brush 220 successively engages the outer contacts 208, thereby energizing sequentially the needle-lifting magnets 25 of those needles, the selecting switch 225 of

which is closed by a pin 226 on the pattern drum 227. The brush 221 successively engages the inner contacts 209 to energize magnets 26 and thereby lower the needles sequentially. The switches 206 determine which control plates control the operation of the needles. The plates may be used individually or two or more plates may be used simultaneously, as, for example, plates 213 and 214.

Yarn-feeding mechanism

The machine is provided with means for feeding yarn to the needles simultaneously at spaced points on the needle circle, four feeds being shown in the drawings. At each of the feeds, provision is made for changing the yarn so that any one or more of a plurality of yarns can be fed to the needles.

In the embodiment illustrated in the drawings, an inverted cup-shaped yarn-feeding head 230 (Figs. 1 and 9) is carried on the lower end of a shaft 231 rotatably supported by suitable bearings so that the head is coaxial with the needle cylinder 1 and, when in operative position, is disposed just above the upper end of the needle cylinder. One of the bearings is shown at 232 supported by a bracket 233. The shaft 231 is driven by a sprocket 234 and chain 235 (Fig. 2) from a sprocket 236 on the shaft 120 that carries the brush assemblies for the sequence control plates. The shaft 120 also carries a sprocket 237 for a chain 238 that drives the sprocket 96 carried by the cam ring 44. Hence, the brush assemblies of the sequence control plates, the yarn-feeding head 230 and the cam ring 44 are all driven in unison with one another, whether in reciprocation or continuous rotation. The sprocket 234 is splined on the shaft 231 to permit axial movement of the shaft.

The yarn-feeding head 230 is provided with circumferentially spaced groups of radial slots 239 to receive yarn-feeding fingers 240 which project down below the head 230 and have yarn-feeding eyes 241 at their lower end. In the present embodiment, there are four equally spaced groups of fingers with ten fingers in each group. The fingers are adapted to swing about fulcrum points 242 (Fig. 9) from an inner position (shown in solid lines) in which the lower ends of the fingers are inside the needle circle to an outer position (shown in dotted lines) in which the lower ends of the fingers are just outside the needle circle so that yarn passing through the eye 141 is fed to needles that are in proper position to receive it. Yarn is supplied to the fingers 240 from cones on a suitable yarn rack 243 carried by, or rotating with, the shaft 231. However, when the machine is operating by reciprocation, the yarn rack may remain stationary. This is accomplished either by uncoupling them from the shaft 231 or by providing play in a rotational sense between the shaft and the yarn rack. The upper end of the yarn-feeding head 230 is provided with one or more holes 244 through which the yarn may pass and similar holes are provided in a bushing on the shaft inside of the bearing 232.

Provision is made for moving the shaft 231 axially to lift the head 230 away from the needle cylinder, for example to permit freer access to associated parts or to transfer fabric on to the needles of the machine. The lifting mechanism is shown in the form of an arm 245 (Fig. 6) having a yoke 246 engaging suitable collars 247 on the shaft 231 and carried by a column 248 which is slidable in a guiding sleeve 249. The column has an offset portion 250 that is connected by a link 251 with an arm 252 on a rotatably supported shaft 253 which extends to the front of the machine (Fig. 5) and has on its front end a crank handle 254. When the shaft 253 is turned in a counterclockwise direction by the handle 254 (Fig. 1), the yarn-feeding head 230 is raised. A latch 255 (Fig. 1) releasably holds the head in raised position.

The yarn fingers 240 (Fig. 9) are normally held in their inner non-feeding position by small springs 256. They are swung out to feeding position by means of radially slidable T-shaped jacks 257 having outwardly projecting butts 258. Depending on the thread changes desired, each jack may have one or more butts and the butts of the different jacks are arranged at different levels so as to be engaged by one or another of a plurality of contractible rings 260 that surround the head 230. The rings 260 are disposed above one another at levels corresponding to the levels of the butts 258 on jacks 257. Each of the rings 260 is composed of a plurality of overlapping arcuate segments, the inner peripheries of which are circular arcs while the outer peripheries are provided with inclined cam surfaces 262 adapted to coact with corresponding cam surfaces provided on the inner periphery of a ring 263 that surrounds the segmental ring 260. The rings 260 and 263 are assembled in a suitable housing 264 (Fig. 9) with spaces between the superposed rings. The outer rings 263 are capable of limited rotation about the axis of the yarn-feeding head 230 by means of arms 265 which project outwardly (Fig. 25). The arms 265 are divided into two groups and are staggered alternately left and right in each group to provide greater spacing between the arms. The segments of the inner rings 260 are capable of limited radial movement but are held against rotational movement by pins 266 which pass through elongated holes in the segments and extend into the opposite sides of the housing 264. When one of the outer rings 263 is rotated, the segments of the corresponding inner ring 260 are forced inwardly by the cam surfaces 262 so that the inner ring is contracted and thereby presses inwardly on any of the jacks 257 (Fig. 9) that have butts located at the level of the ring. This swings the corresponding yarn finger outwardly to feeding position. Since the contractible rings 260 are concentric with the yarn-feeding head 230, the rings act simultaneously on jacks at all four feeds, having butts at the corresponding level, and hold the yarn fingers 240 in feeding position continuously as long as the rings are contracted. Small springs 267 (Fig. 25) move the segments of the inner ring 260 outwardly to expand the ring when the corresponding outer ring 263 is rotated in the opposite direction. In the illustrated embodiment, there are as many contractible rings 260 as there are jacks 257 in each group so that each of the yarn-feeding fingers can be controlled independently. When the inner ring segments 260 are cammed inwardly to contracted position, inwardly projecting portions 268 of the outer ring slide over outwardly projecting portions 269 of the inner ring so that the inner ring is held accurately in predetermined contracted position without any reaction on the actuating arms 265 of the outer ring by reason of the springs 267.

Electrically controlled operating mechanism is provided for turning selected ones of the outer

rings 263 in accordance with a predetermined pattern so as to control the yarn feeds to produce the fabric desired. The mechanism includes means for pre-selecting the yarn or yarns desired for a particular course and means for thereafter effecting a yarn change to initiate the feeding of the pre-selected yarn or yarns at a precise point in the operation of the machine. The operating mechanism is divided into two parts, each operating approximately half of the yarn selection control rings. As the two operating units are essentially the same, only one will be described.

A plurality of bars 270 (Figs. 25 and 26) are slidably mounted for reciprocation in an endwise direction in a bed 271 supported by the framework of the machine. The number of bars corresponds to the number of yarn selection rings. Each of the bars is connected to the operating arm 265 of one of the outer rings 263 by suitable linkage 272 so that endwise movement of the bar from one position to another rotates the outer ring 263 to contract and expand the inner ring 260. On the upper side of each of the bars 270, there is an elongated recess 273, the opposite ends of which are adapted to be engaged by the corresponding ends of a tiltable shoe 274 pivotally mounted on the lower end of a swinging arm 275 which is pivotally supported at its upper end by a shaft 276. All of the arms 275 are continually oscillated in unison during operation of the machine by a yoke 277 which is pivotally supported at 278 and embraces an eccentric 279 on a rotating shaft 280, the lower end of the yoke being connected with the arms 275 by suitable linkage 281. The shaft 280 is rotated by means of a sprocket 282 (Fig. 3) which is driven by a chain 283 from a sprocket 284 on a shaft which also carries a gear meshing with gear 172 which in turn is driven from the main shaft of the machine, as described above, and rotates continually in the same direction. When the shoe 274 on the lower end of each of the swinging arms 275 is tilted so that its left hand end is down, it engages the left hand end of the recess 273 in the corresponding sliding bar 270 and moves the bar to the left. When the shoe 274 is tilted so that its right hand end is down, it engages the right hand end of the recess 273 so as to move the sliding bar 270 to the right. Through the linkage connecting the sliding bars with the yarn-selecting control rings, the rings are contracted or expanded in accordance with the position of the sliding bars.

The tilting of each of the shoes 274 is controlled by of pair of levers 285 and 286 which are disposed on opposite sides of the swinging arm 275 near its upper end and are swingable about a pivot shaft 287 which is parallel, but spaced from, the pivot shaft 276. The two levers 285 and 286 are connected to the shoe 274 on opposite sides of the pivot of the latter by means of small diameter tight springs 288. The free ends of the levers 285 and 286 are adapted to be engaged by pins 289 on opposite sides of a disc 290 rotatable on a shaft 291. The pins on opposite sides of the disc are staggered relative to one another so that when the free end of one of the levers is raised by a pin on the disc 290 the other lever is down. The lever that is raised acts through its spring 288 to tilt the shoe 274. Hence, the tilting of the shoe 274 depends on which lever is raised by engagement with a pin 289 on the disc 290.

Each of the discs 290 is individually rotated step by step by means of racking mechanism controlled by an electric circuit. This mechanism comprises a pawl carrier 292 (Fig. 26), the lower end of which is pivotally connected with an arm of a bell crank 293 which is pivoted on a suitable support at 294. The other end of the bell crank 293 extends upwardly and is connected by a link 295 with the swinging arm 275. The upper end of the carrier 292 is guided against lateral movement and is connected to a pivoted arm 296 swingable about a pivot axis 297 that is approximately in vertical alignment with the pivot 294 of the bell crank 293 so that the carrier 292 moves up and down with a parallelogram motion, being continually actuated by the swinging arm 275 acting through the link 295 and bell crank 293.

The carrier 292 is made up of two sleeves which are spaced apart to receive a swingable pawl member 298 which is pivotally connected to the spaced sleeves of the carrier by a pin 299. The upper end of the pawl carries a tooth 300 adapted to engage ratchet teeth on the periphery of the disc 290 when the pawl is swung in toward the disc by a spring 301 acting on an angularly projecting lower end portion of the pawl. The pawl is normally held out of engagement with the ratchet teeth of the disc 290 by means of a latch 302 which is pivotally mounted on the upper end of the pawl and is pressed upwardly by a leaf spring 303 into engagement with an arm or abutment 304 that projects out from the carrier 292. The latch 302 is releasable by means of a bell crank 305 which is swingable about a shaft 306. The lower arm of the bell crank projects downwardly and has a rounded end adapted to engage the nose of the latch 302 to press it out of engagement with the abutment 304 and thereby release the pawl when the bell crank is turned in a clockwise direction. The upper end of the bell crank 305 is connected by a wire 307 to the armature of an electromagnet 308 (Fig. 3).

The electromagnets 308 are controlled by a bank of switches 309 mounted just above the upper end of the needle-selecting pattern drum 155 (Figs. 5, 20 and 21). Each switch comprises spaced resilient leaves 310 and 311 carrying contacts 312 and mounted on an insulating block 313. The leaves are provided with suitable terminals for attachment to the magnets 308 and a source of electrical energy respectively. A wedge-shaped block of insulating material 314 projects downwardly from the lower leaf 311 and is adapted to be engaged by pins 315 placed in selected ones of suitable holes 316 in the upper end surface of the selecting pattern drum. Engagement of the block 314 by a pin 315 closes the corresponding switch 309 and thereby energizes the corresponding magnet 308.

When a magnet 308 is energized, it pulls down on the connecting wire 307 and rotates the bell crank 305 so as to press on the latch 302 and thereby release the pawl 298 so that the tooth of the pawl engages one of the ratchet teeth on the disc 290, thereby causing the disc to be rotated forward one step as the pawl carrier 292 moves downwardly in its reciprocatory movement. A spring-pressed holding pawl 318 prevents reverse movement of the ratchet. As the pawl carrier approaches the downward limit of its movement, a protuberance 319 on the pawl engages a bar 320 which presses the pawl out to its retracted position where it is again held by the latch 302. The racking of the disc 290 causes the relative positions of the levers 285 and 286 to be reversed since the lower lever is raised by a pin 289 on the disc while the upper lever drops

off of the pin which has previously held it in raised position. This results in the shoe 274 being tilted in the opposite direction so that the corresponding sliding bar 270 is moved from one of its positions to the other upon oscillation of the arm 275 by the yoke 277. The sliding bar 270 acts through the connecting linkage to turn the corresponding outer ring 263 and thereby contract or expand the inner ring 260 which acts on the jack butts 258 to produce a yarn change. Although the closing of a control switch 309 (Fig. 21) initiates or pre-selects a yarn change, the actual change is effected through the movement of the yoke 277 by the eccentric 279 which is driven in fixed time relation with the rotation of the yarn-feeding head 230 and the operation of the needles. Moreover, movement of the slide bars 270 in one direction precedes the movement of slide bars in the opposite direction, owing to the manner in which these bars are moved by the oscillating yoke 277 acting through the swinging arms 275 and the tilting shoes 274. This feature can be utilized to introduce a new yarn before the previous yarn is withdrawn to provide an overlap. Since the yarn fingers are inside the needle circle when in non-feeding position, it is unnecessary to cut and bind the yarns. They merely extend down inside the fabric from one point of introduction to the next. To prevent undesirable twisting or tangling of the threads, a guiding cup 323 is positioned below the feeding head 230 on a downwardly extending shaft 324. Suitable tensioning and take-up mechanism for the yarns is provided on the yarn-supporting structure.

Figs. 27 to 29 illustrate fabric that can be made in accordance with the invention. In Fig. 27, there is shown a sock having a top portion T, a leg portion L and a foot F including a heel H. Fig. 28 represents the fabric of the sock cut down the back and flattened out to illustrate the pattern on a larger scale. The top portion T is formed of fabric which is expansible and contractible, for example rib knit fabric or plain knit fabric having elastic thread knit, laid or interlaced in the fabric. As illustrated in Fig. 28, an elastic thread is knit in spaced courses at spaced wales, as indicated by the "x's" 326. The leg portion, and if desired also the instep or upper part of the foot, is formed with a diamond or Argyle pattern and overplaid. Each of the diamonds 327, 328 and 329 is formed of a different body thread, as indicated by the different shading in Fig. 28. At the boundaries of the diamonds, stitches of the thread forming one diamond are interlooped with stitches of the thread forming an adjacent diamond, so that the areas are connected together. Overplaid lines 330 and 331 which extend across the diamonds are of different color from the diamonds and from one another, as indicated by different shading in Fig. 28. These lines are formed of stitches, or groups of stitches, of pattern threads which are knit alone, the body yarn being floated behind the stitches of the pattern threads. However, stitches of the pattern threads interloop with stitches of the body yarns. The relation of the yarns is illustrated in Fig. 29 where 333 designates the thread forming one diamond, 334 designates the thread forming an adjacent diamond and 335 designates a thread forming the overplaid. The direction in which the respective courses are knit is indicated by arrows at the left hand side of the figure. In order to provide a better suture between adjacent diamonds when the fabric is knit by reciprocation, as illustrated in Fig. 29, a yarn from one area may be carried over and knit at selected stitches in an adjacent area, as illustrated at 336. While the overplaid is illustrated in Fig. 29 as being formed of small blocks of four stitches each, it will be understood that fewer or more stitches may be used to form the overplaid or other pattern. The floating of body thread behind the pattern thread forming the overplaid is clearly seen at 337. The structure of the foot will be clearly understood from the following description of the way in which it is made.

The operation of the machine in making a sock such as that shown in Fig. 27 will illustrate the versatility of the machine. If the sock is to have a rib knit top, the yarn-feeding head 230 is raised by means of the handle 254 (Fig. 1) and the needles are raised and levelled by means of the handle 31 to permit the transfer of a rib top onto the needles. If the sock is to have a plain knit elastic top, an elastic thread is fed to alternate needles at one feed and another thread is fed to all of the needles at another feed to form a selvage S. The needle selection is then changed to feed elastic to spaced needles, for example every third or every fourth needle, at one feed while feeding body thread to all of the needles at one or more of the other feeds to make an elastic top in which elastic thread is incorporated at spaced wales in spaced courses. Upon completion of the elastic top, the elastic thread is withdrawn and one or more circular knit courses are produced with body thread alone.

To produce the diamond or Argyle plaid with an over-plaid in the leg portion of the sock, the machine automatically shifts to operation by reciprocation. During one oscillation around and back, a feed finger 240 for feeding overplaid yarn is swung out to feeding position at each of the four feeds and the needles that are to knit overplaid stitches in those courses are raised to take and knit the respective yarns. The other needles remain inactive. During the next oscillation around and back, the overplaid yarn fingers are swung in to inoperative position and a body yarn finger is swung out to feeding position at each of the four feeds. Different colors may be fed at the respective feeds to produce different colored diamonds. The needles that are to form the diamonds are raised to receive and knit the respective body threads while the needles that have produced the overplaid stitches are held inactive so that body yarn is floated behind the previously formed overplaid stitches. This completes a pair of courses. The operation is then repeated to knit a pair of partial courses around and back of the overplaid yarns only and then to fill in with the body yarn of the diamonds on the next reciprocation. The pattern-selecting drum 155 is racked each course to control both the needle selection and yarn selection. The body yarn forming each diamond is knit back and forth across the diamond so that there are no thread ends except at the beginning and the end of the diamond. Stitches of one yarn (333) forming one diamond are interlooped with stitches of a yarn (334) forming an adjacent diamond, as shown, by way of example, in Fig. 29, to provide a suture between the diamonds. Likewise, stitches of the overplaid yarn (335) are interlooped with stitches of the body yarn (Fig. 29). A separate yarn is used for each of the overplaid lines and each yarn is knit only at one line so that there are no long horizontal floats

and no yarn ends except at the beginning and the end of a line.

When the heel is reached, the needles on the instep side of the needle circle are held inactive while knitting is continued on the needles that are to form a heel pocket. Preferably, the heel is formed with somewhat more than one-half of the needles active and the number of active needles is progressively reduced to narrow the heel. During the knitting of the heel, the needles are controlled by the pattern-selecting drum **155** in which the pins are set to effect the desired narrowing. When the heel has been narrowed to the desired number of needles, for example about one-fourth the needles of the needle circle, all of the needles with which the heel was commenced, and, if desired, one or more additional needles at each end, are restored to operation for at least one complete swing around and back. Alternatively, all of the needles in the needle circle may be restored to operation and one or more courses thereupon knit either by reciprocation or continuous rotation. The number of active needles is then reduced back to the above mentioned minimum number and successive courses are knit by reciprocation while progressively restoring needles to operation to widen the fabric until the initial width, or any desired lesser or greater width, is reached. The needles on the instep side of the needle circle are then restored to operation and the sole and instep portions of the foot are knit by reciprocation or circular knitting, as desired. Since the narrowing and widening are controlled by the pattern-selecting drum **155**, they can be varied to produce the exact shape of heel desired. By temporarily restoring all of the needles to operation, after narrowing and before widening the heel, a neater and stronger heel gore is produced.

The toe portion of the foot is produced in the same manner as the heel. Since the needles are controlled by the pattern-selecting drum **155**, the shape of the toe can be varied as desired. After the toe portion is completed, several courses are knit by circular knitting to produce a looper's edge.

While one particular pattern has been illustrated by way of example, it will be understood that the machine is in no way limited to this type of pattern. Since the selecting mechanism described will provide a different needle selection and a different yarn selection at each of the four feeds in each course, the variety of patterns that can be produced is virtually limitless.

It will be understood that the machine parts shown and described by way of example may be replaced by their mechanical or electrical equivalents. For example, the electromagnets may be replaced by motors or other means for converting electrical energy into mechanical movement. The electric circuits may be controlled by any suitable means, such as circuit breakers, contacts, switches, condensers, electronic valves, etc., it being understood that a circuit may be opened and closed, or alternatively, the current in a circuit may be varied above and below a predetermined critical value. The number of control plates and control drums may be increased or decreased, in accordance with the requirements for which a particular machine is designed. If desired, a plurality of machines can be operated in unison from a central control. Still other modifications within the scope of the appended claims will occur to persons skilled in the art. The invention is hence in no way limited to the particular embodiments shown and described by way of example.

The circular knitting machine herein described forms no part of the present invention and is covered by my divisional application, Serial No. 248,339, filed, September 26, 1951.

What I claim and desire to secure by Letters Patent is:

1. Tubular seamless fabric comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body thread knit back and fourth across said area, a second area extending over a plurality of wales and a plurality of courses and formed of a second continuous body thread knit back and forth across said second area, said areas being disposed at least partially in the same courses and stitches of one thread being interlooped with stitches of the other thread at boundaries of said areas, and a continuous pattern thread knit back and forth at selected wales, stitches of the pattern thread being interlooped with stitches of body thread and body thread being floated behind stitches of the pattern thread.

2. Tubular seamless knitted fabric comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body yarn knit back and forth across said area, a second area extending over a plurality of wales and a plurality of courses and formed of a second continuous body yarn knit back and forth across said second area, a third area extending over a plurality of wales and a plurality of courses and formed of a third continuous body yarn knit back and forth across said third area, a fourth area extending over a plurality of wales and a plurality of courses and formed of a fourth continuous body yarn knit back and fourth across said fourth area, all of said areas being disposed at least partially in the same courses and stitches of one yarn forming one area being interlooped with stitches of yarn forming adjacent areas at boundaries of said areas, and a plurality of continuous pattern yarns, each of which is knit back and forth at selected wales, stitches of the pattern yarn being interlooped with stitches of body yarn and body yarn being floated behind stitches of pattern yarn.

3. Tubular seamless knitted fabric comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body yarn knit back and forth across said area, a second area extending over a plurality of wales and and a plurality of courses and formed of a second continuous body yarn knit back and forth across said second area, said areas being disposed at least partially in the same courses and at least partially in the same wales, stitches of one yarn being interlooped with stitches of the other yarn at boundaries of said areas, and a continuous pattern yarn knit back and forth at selected wales, stitches of the pattern yarn being interlooped with stitches of body yarn and body yarn being floated behind stitches of pattern yarn.

4. Tubular seamless fabric according to claim 3, in which said pattern yarn is knit at different wales in different courses.

5. Tubular seamless knitted fabric comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body yarn knit back and forth across said area, a second area extending over a plurality of wales and a plurality of courses and formed of a second continuous body yarn knit back and forth across said second area, a third area extending

over a plurality of wales and a plurality of courses and formed of a third continuous body yarn knit back and forth across said third area, a fourth area extending over a plurality of wales and a plurality of courses and formed of a fourth continuous body yarn knit back and forth across said fourth area, all of said areas being disposed at least partially in the same courses and adjacent ones of said areas being disposed partially in the same wales, stitches of one yarn forming one area being interlooped with stitches of yarn forming adjacent areas at boundaries of said areas, and a plurality of continuous pattern yarns, each of which is knit back and forth at selected wales, stitches of the pattern yarn being interlooped with stitches of body yarn and body yarn being floated behind stitches of patern yarn.

6. Tubular seamless fabric according to claim 5, in which each of said pattern yarns is knit at different wales in different courses.

7. Tubular seamless knitted fabric comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body yarn knit back and forth across said area, a second area extending over a plurality of wales and a plurality of courses and formed of a second continuous body yarn knit back and forth across said second area, said areas being disposed at least partially in the same courses and stitches of one yarn being interlooped with stitches of the other of said yarns at boundaries of said areas, and a continuous pattern yarn knit back and forth at groups of selected wales, said pattern yarn being knit at at least two wales in each of selected courses, stitches of the pattern yarn being interlooped with stitches of body yarn and body yarn being floated behind stitches of pattern yarn.

8. In an article of hosiery having a reciprocatorily knit heel portion, a tubular seamless leg portion comprising an area extending over a plurality of wales and a plurality of courses and formed of a continuous body yarn knit back and forth across said area, a second area extending over a plurality of wales and a plurality of courses and formed of a second continuous body yarn knit back and forth across said second area, said areas being disposed at least partially in the same courses and stitches of one yarn being interlooped with stitches of the other yarn at boundaries of said areas, and a continuous pattern yarn knit back and forth at selected wales, stitches of the pattern yarn being interlooped with stitches of body yarn and body yarn being floated behind stitches of the pattern yarn.

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