

Jan. 24, 1956

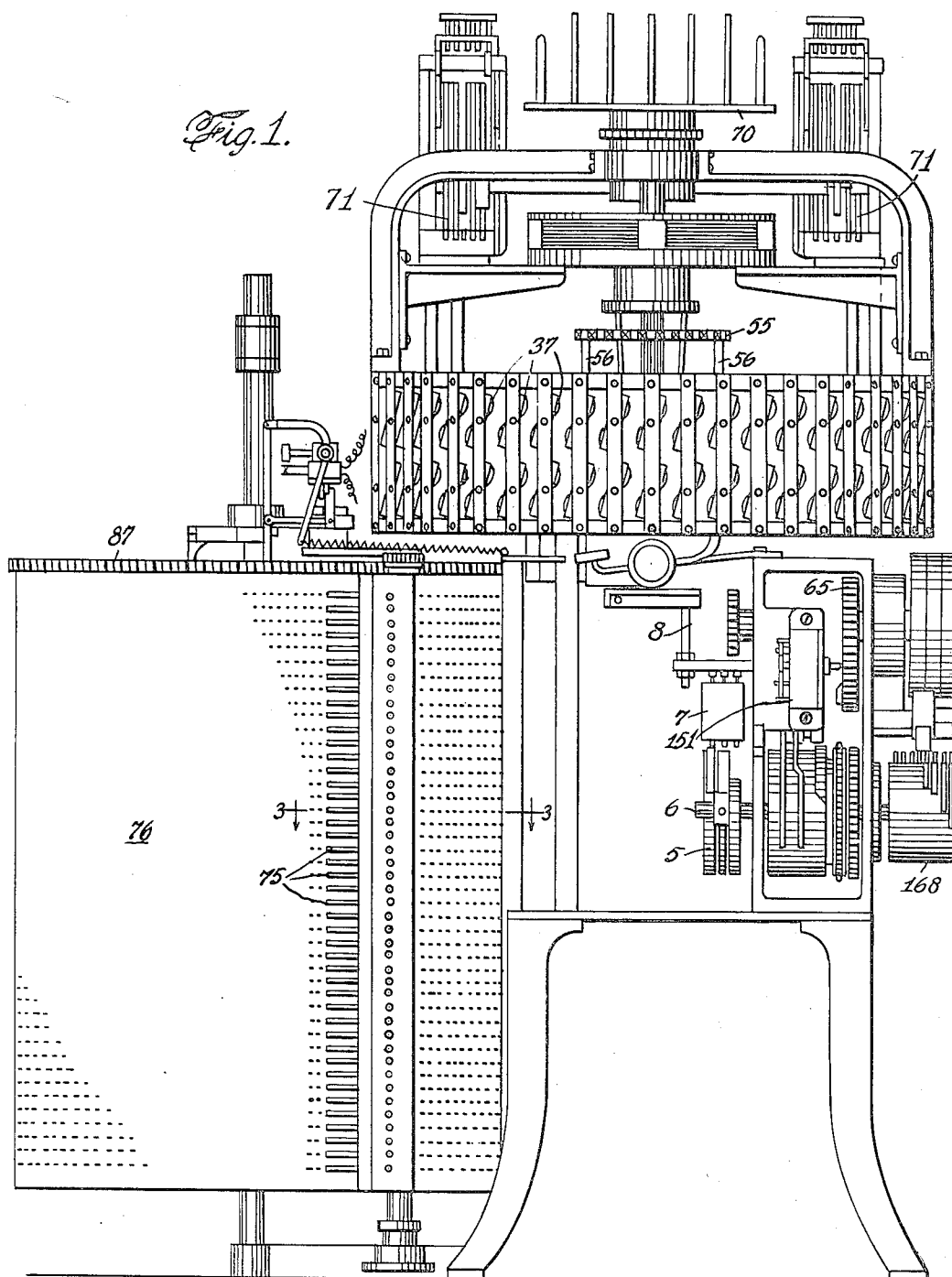
P. L. THURSTON

2,731,817

ELECTRICALLY OPERATED KNITTING MACHINE

Filed Nov. 16, 1953

5 Sheets-Sheet 1



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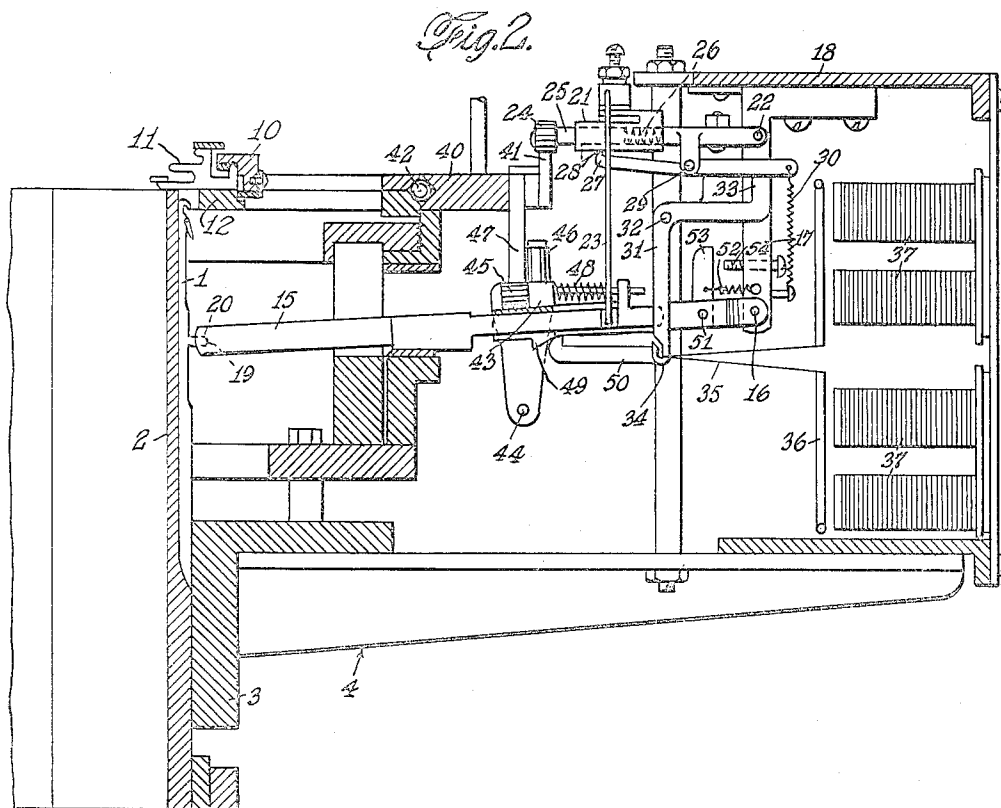
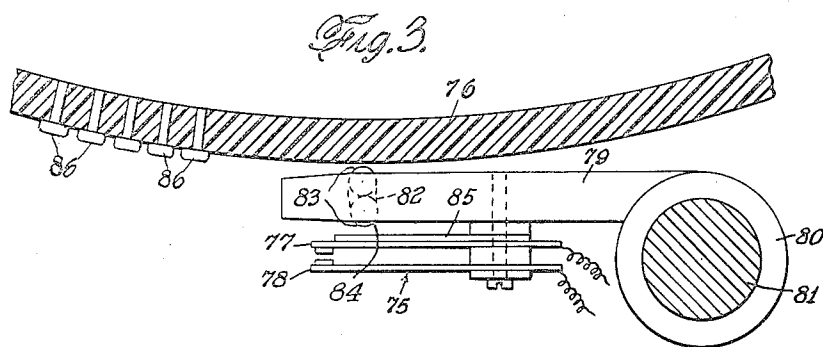
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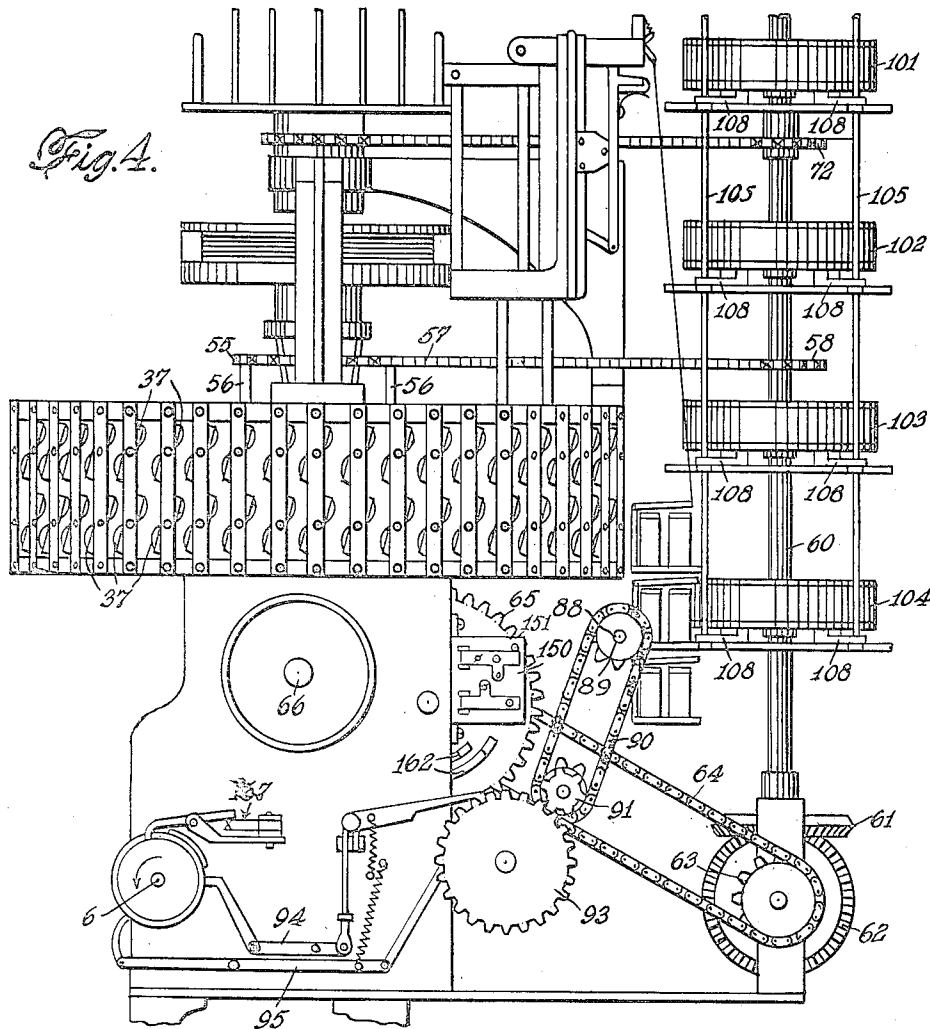
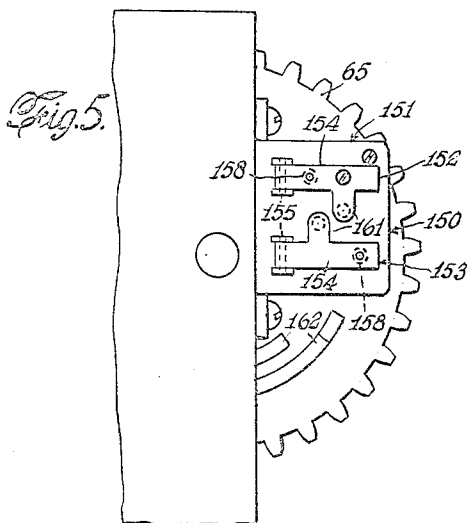
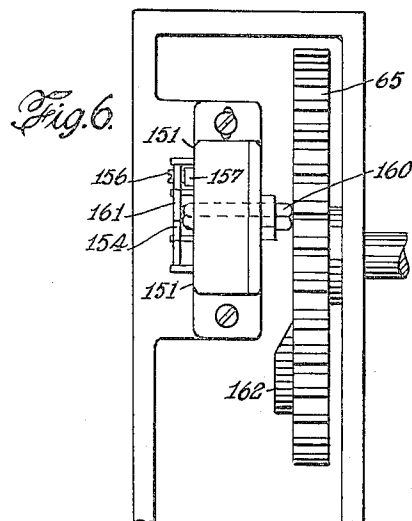
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Fig. 7.

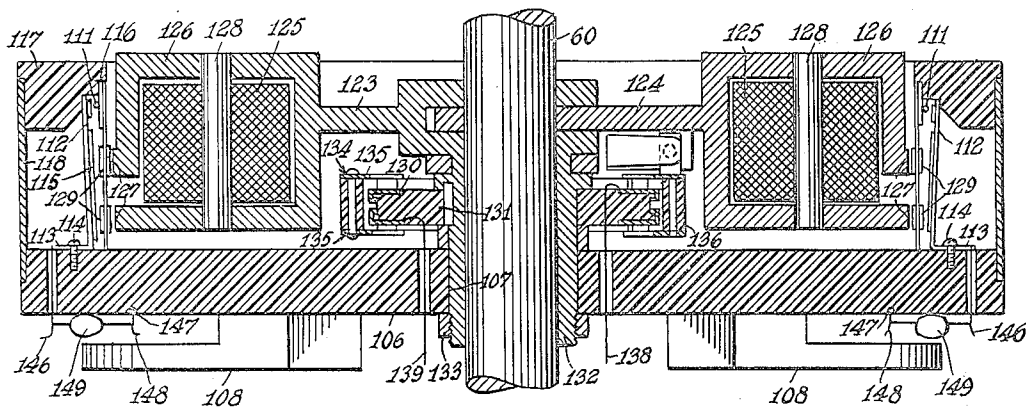
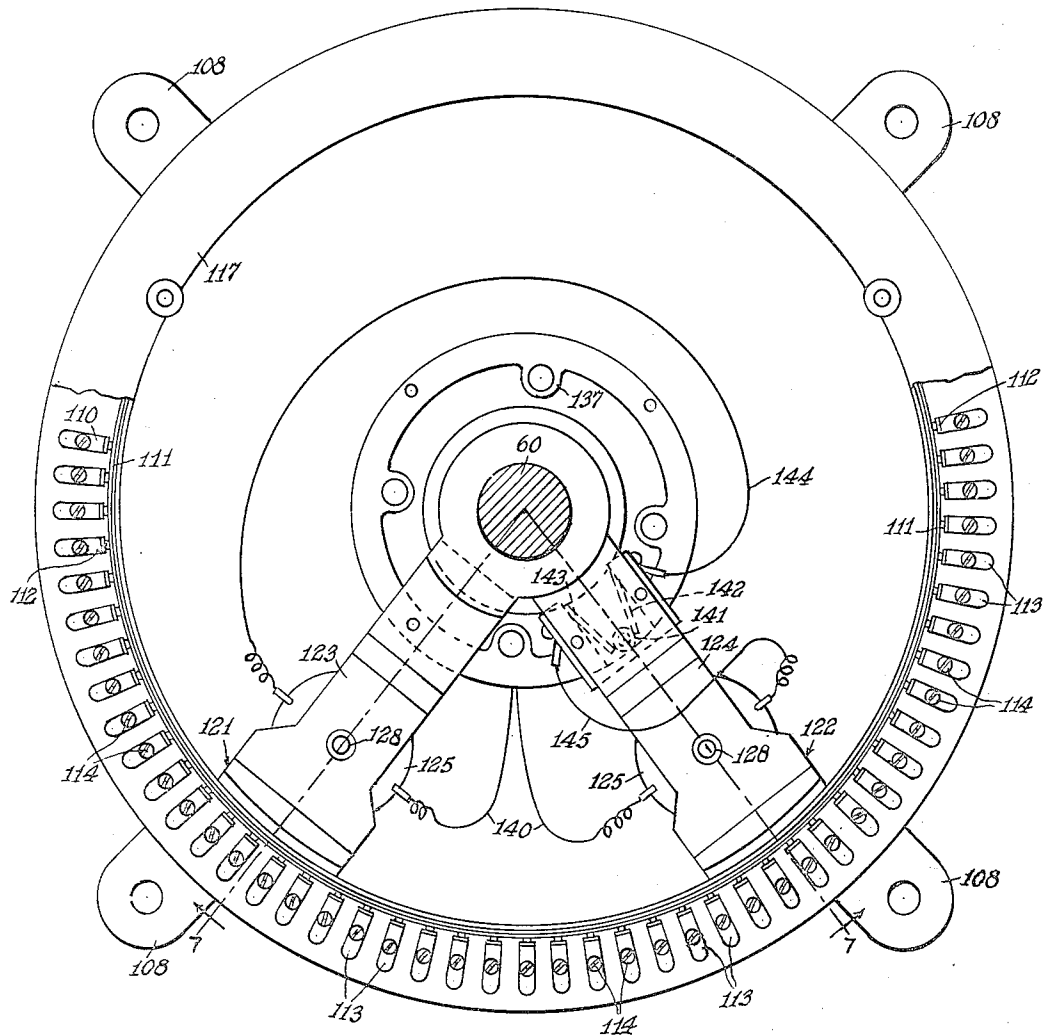


Fig. 8.



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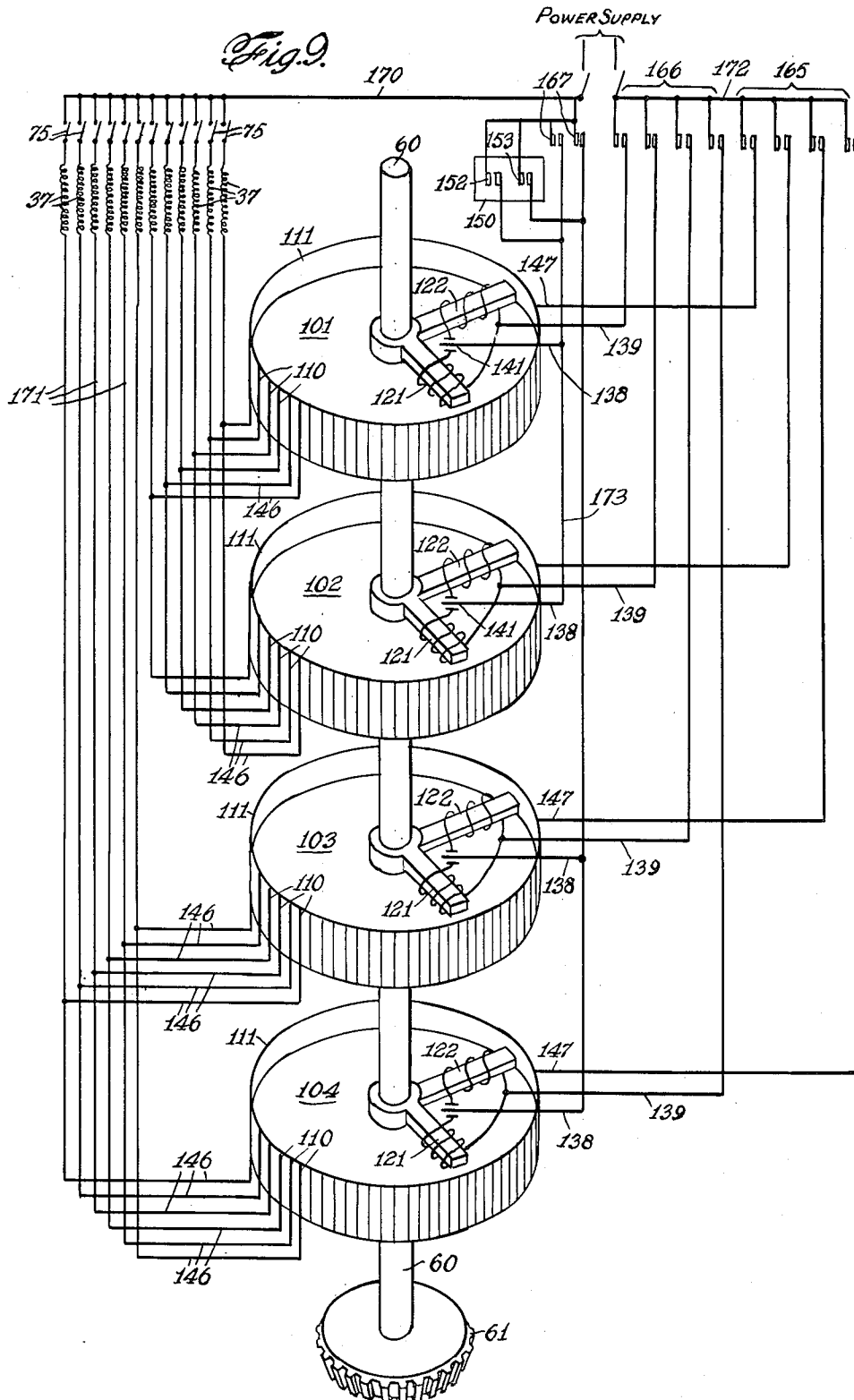
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2,731,817

ELECTRICALLY OPERATED KNITTING MACHINE

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Application November 16, 1953, Serial No. 392,283

11 Claims. (Cl. 66—43)

The present invention relates to knitting machines, and particularly to knitting machines in which the needles or other instrumentalities are activated electrically. The electrical actuation of the needles may, for example, be by means of electromagnets which provide forces for moving the needles or, alternatively, an electric current or pulse may be utilized to trip or initiate the operation of the needles, force for moving the needles being provided, at least in part, by other means, for example mechanical, hydraulic or pneumatic mechanisms. A knitting machine of this kind is shown, for example, in Paul Thurston application Serial No. 183,989 filed September 9, 1950, now Patent No. 2,680,961, of which the present application is a continuation-in-part.

In an electrical knitting machine, a series of needles is electrically actuated or controlled so that the needles of the series are actuated sequentially. The needles may be arranged in a straight row, as, for example, in a flat knitting machine, or in an arc or circle, as in a circular knitting machine. The sequential operation of the needles in a circular knitting machine proceeds continuously in the same direction for continuous circular knitting and alternately in opposite directions when knitting by reciprocation. In a flat knitting machine, the needles are ordinarily actuated sequentially first in one direction and then the other.

The present invention relates to an improved control system for an electrical knitting machine providing greater flexibility of control and assuring that the needles are actuated in accordance with a predetermined pattern of operation at all times.

The objects and advantages of the invention will be more clearly understood from the following description and claims in conjunction with the accompanying drawings which illustrate by way of example a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a front elevation of a knitting machine in accordance with the invention.

Fig. 2 is an enlarged partial radial section showing needle-operating mechanism.

Fig. 3 is an enlarged fragmentary horizontal section taken approximately on the line 3—3 in Fig. 1.

Fig. 4 is a right side elevation of the machine.

Fig. 5 is an enlarged portion of Fig. 4.

Fig. 6 is a rear elevation of the mechanism shown in Fig. 5.

Fig. 7 is a vertical section taken on the line 7—7 in Fig. 8 and showing one of the sequential control relays illustrated in Fig. 4.

Fig. 8 is a plan of one of the sequential control relays.

Fig. 9 is a schematic view and wiring diagram showing the electrical connections for the needle-operating mechanism.

As the machine illustrated in the drawings is basically similar to that shown and described in the above mentioned Thurston application, Serial No. 183,989, certain

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details of the machine are omitted from the drawings and description of the present application and are included by reference to the aforesaid prior application.

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 in the needle bed, electrically energized mechanism for individually operating the needles, an electrical power supply, a series of selecting switches controlling individual needles, a series of activating switches, each needle-operating mechanism being connected to the power supply through one of the selecting switches and through one of the activating switches so that the operating mechanism is energized only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern-controlled means for periodically actuating selected ones of the selecting switches, electrically energized means for sequentially actuating the activating switches and means for controlling the energizing of said switch-actuating means. A feature of the machine in accordance with the invention herein shown and described is that the switch-actuating means for sequentially actuating the activating switches is energized intermittently in timed relation with its operation so that it is energized for a portion of its cycle of operation and is deenergized the remainder of its cycle. A further feature of the machine is that several series of activating switches are preferably provided and the respective switch-actuating means are selectively energized to put selected series of activating switches into, or out of, operation according to which actuating means are energized.

Needle-operating mechanism

The machine illustrated in the drawings has a circular series of independent needles 1 reciprocally supported in a needle bed shown in the form of a slotted cylinder 2 which is stationary in the sense of being non-rotating but is preferably supported for vertical endwise movement by a cylindrical sleeve portion 3 of the machine frame 4. The needle cylinder 2 is vertically adjustable, for example by means of cams 5 on a main pattern drum shaft 6, a cam follower 7 being connected to the cylinder through suitable linkage 8. At the upper end of the needle cylinder, there is a sinker ring 10 carrying a circular series of radially slidable sinkers 11 which are moved in and out by means of suitable cam surfaces in a rotatable and oscillatable sinker cap 12. The main pattern drum shaft 6 is driven in conventional or convenient manner so as to be rotated step-by-step during the knitting operation.

The electrical needle-operating mechanism may assume different physical forms, three embodiments being illustrated in the above mentioned Thurston application. As shown by way of example in Fig. 2, each needle is provided with an operating lever 15 pivotally mounted at its outer end, as indicated at 16, on a bracket 17 carried by a stationary supporting ring 18. The inner end of the operating lever 15 is provided with a socket 19 to receive a butt 20 provided on the needle. An upper arm 21 is pivoted on the bracket 17 at 22 and is connected with the operating lever 15 by an adjustable link 23 so that the lever 15 and arm 21 move up and down together as in a parallelogram linkage.

At its inner end—nearest the needle cylinder—the arm 21 carries a roller 24 rotatably mounted on a plunger 25 that is telescopically slidable in the arm 21 and is pressed inwardly toward the needle cylinder by a spring 26. The plunger 25 is releasably held in an outer position against the pressure of its spring by means of a latch 27 engaging a detent 28 on the shaft. The latch 27 is pivotally mounted on the arm 21 at 29 and is pressed into engagement with the detent 28 by a light spring 30. The latch is releasable by a bell crank 31 pivoted at 32

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on a projecting portion of the bracket 17 and having an upwardly projecting portion 33 adapted to engage the rear end of the latch. A downwardly extending arm 34 is connected by a link 35 with a pivoted armature 36 of a two-pole electromagnet 37. When the magnet 37 is energized, the latch 27 is released to permit the roller 24 to move inwardly toward the needle cylinder and thereby be in a position to be engaged by cams 41 on a cam ring 40 rotatably supported by ball bearings 42.

On the needle-operating lever 15, there is a carrier 43 having a bifurcated portion that slidably embraces the lever and is pivotally connected at 44 to a downwardly projecting arm provided on the lever. A horizontal roller 45 and vertical roller 46 on the carrier 43 are adapted to engage cams 47 provided on the cam ring 40 when the carrier 43 is swung inwardly by a spring 48. The carrier is held in an outer position against the action of its spring by the engagement of a detent 49 on the carrier engaging a bell crank latch 50 that is pivoted on the lever 15 at 51 and is urged into detent-engaging position by a spring 52. An upwardly projecting arm 53 of the latch engages an adjustable screw 54 when the lever 15 is swung upwardly a predetermined distance, thereby releasing the carrier 43 which is moved inwardly into cam-engaging position by its spring 48.

Means is provided for rotating the cam ring 40 for continuous circular knitting and oscillating the cam ring for reciprocatory knitting. As illustrated in Figs. 2 and 4, the cam ring 40 is rotatable and oscillatable by means of a chain sprocket 55 mounted on posts 56 that project upwardly from the cam ring and driven by a chain 57 from a sprocket 58 on a vertical control shaft 60. A bevel gear 61 on the lower end of shaft 60 meshes with a bevel gear 62 on a stub shaft carrying a sprocket 63 driven by a chain 64 from a sprocket on the main shaft of the machine. Through suitable gearing, like that used for driving the cylinder of a conventional rotating cylinder knitting machine including a so-called "104" gear 65 (Fig. 4), the main shaft is driven from a drive shaft 66 so as to be rotated continuously in one direction for continuous circular knitting or alternately in opposite directions for reciprocatory knitting.

Yarn is fed to the needles by a rotatable and oscillatable yarn-feeding head 70 having a plurality of depending feed fingers 71 that are selectively movable into and out of feeding position, for example as described in the above mentioned Thurston application Serial No. 183,989. The yarn-feeding head 70 is driven from the control shaft 60 by means of a chain drive 72 so as to be rotated or oscillated in synchronism with the needle-operating cam ring 40.

In the operation of the needle-operating mechanism, starting with the needle down and the plunger 25 and carrier 43 both in their outer, or retracted, positions, the electromagnet 37 (Fig. 2) is energized, tripping the latch 27 to release the plunger 25. When released, the plunger 25 moves inwardly to a position in which the roller 24 is engaged by a cam on the rotating cam ring 40 which moves the roller, and hence the pivoted arm 21, upwardly. Through the connecting link 23, the needle-operating lever 15 is also swung upwardly, raising the needle 1 to receive a yarn fed by one of the yarn fingers 71. Upward movement of the lever 15 releases the carrier 43 from its latch 50 and the spring 48 moves the carrier inwardly to its inner position. The roller 45 is thereby brought into a position to be engaged by a cam on the cam ring 40 which moves the lever 15, and hence the needle 1, downwardly to draw a stitch. Cam surfaces provided on the cam ring 40 thereupon act radially outwardly on the vertical roller 46 and on the plunger 25 to press the carrier 43 and the plunger to their outer positions where they are held by the respective latches until the magnet 37 is again energized. The activation of the needle-operating mechanism is thus controlled by the electromagnet 37. Each needle is provided with op-

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erating mechanism like that described above. To conserve space, the magnets for successive needles are placed alternately below and above the level of the trip means 35, as illustrated in Figs. 1, 2 and 4. As will be described more fully below, the magnets of the respective needles are energized selectively to provide any desired needle selection and are also energized in predetermined sequence in timed relation with the rotation or oscillation of the cam ring 40 and the yarn-feeding head 70 to provide selective and sequential operation of the needles.

Needle selection

Selective operation of the needles is obtained by a series of "switches" 75 and mechanism for selectively actuating the switches shown in the form of a pattern drum 76. The term "switch" is herein used in a generic sense to include any means for controlling the supply of current to the needle-operating means. Preferably, a switch is provided for each needle so that the selective operation of each needle can be individually controlled.

As illustrated in Figs. 1 and 3, the selecting switches 75 comprise spring contact fingers 77 and 78 mounted with suitable insulation on a plate 79 carried by a sleeve 80 that is angularly and axially adjustable on a vertical supporting shaft 81. A series of holes 82 is provided in the plate 79, with a hole behind the inner leaf spring 77 of each switch 75. Two bearing balls 83 are disposed in each of the holes, being suitably retained, for example by peening the edge of the hole as indicated at 84. The sum of diameters of the balls 83 is greater than the thickness of the plate 79 so that the balls are adapted to project beyond the faces of the plate. The outer ball is adapted to engage an insulating leaf or layer 85 on the back of the spring contact finger 77. The inner ball is adapted to be engaged by pins 86 inserted into holes in the pattern drum 76 and having enlarged heads so that, when pins are inserted in successive holes, their heads provide a substantially continuous surface. When the inner ball 83 is engaged by the head of a pin 86, the balls are moved radially outwardly with respect to the pattern drum and the outer ball presses the inner contact finger 77 into engagement with the outer contact finger 78, thereby closing the switch. Where there is no corresponding pin 86 on the pattern drum 76, the switch is opened by the inherent resilience of the inner spring contact finger 77 which is of sufficient strength to push the balls 83 to their inner position. There is a circumferential row of pin holes in the pattern drum 76 at the level of each of the switches 75. The number of holes in each circumferential row, or, in other words, the number of vertical rows of holes, may vary in accordance with the number of different needle selections desired but should preferably be not less than half the number of needles. In the present embodiment of the invention, there are 300 holes in each horizontal row.

The pattern drum 76 is rotatably mounted and is intermittently rotated or "racked" to bring vertical rows of pins successively into position to actuate the respective switches 75. In the embodiment shown in the drawings, the pattern drum 76 is racked by means of a worm wheel 87 on the drum meshing with a worm on a shaft 88 (Fig. 4) which extends horizontally across the back of the machine and, at its opposite end, has a sprocket 89 driven by a chain 90 from a sprocket 91 on a shaft which also carries a gear meshing with a larger gear 93. Suitable mechanism is provided for intermittently racking the gear 93 and thereby racking the pattern drum 76 in timed relation with the rotation or oscillation of the cam ring 40. The racking mechanism may, for example, be driven from the "104" gear 65, as described in the above mentioned Thurston application, Serial No. 183,989, the racking preferably being controlled by cams on the main pattern drum shaft 6, for example through mechanisms 94 and 95.

Sequential actuation of needles

The actuation of the needle-operating mechanism is controlled not only by the individual selecting switches 75 actuated by the pattern drum 76 but also by one or more series of activating switches which are actuated sequentially in order to produce sequential operation of the needles. The selecting switches determine which needles will be operated. The activating switches determine when the selected needles will be actuated.

As illustrated in the drawings, there are four series of activating switches shown as rotary relays 101, 102, 103 and 104. The relays are mounted one above another coaxially with the control shaft 60, being suitably supported, for example by rods 105. While four relays have been shown in the drawings, it will be understood that more or fewer may be used, depending on the patterning requirements of the particular machine.

The relays 101—104 are illustrated as being of the kind shown and described in Osborne I. Price application Serial No. 386,239, filed October 15, 1953. Each relay (Figs. 7 and 8) has a base portion 106 which is preferably formed of insulating material and has a central hole 107 through which the shaft 60 extends. Four brackets 108 extending downwardly, and then radially outwardly, form the base 106 to provide convenient means for mounting the relay on the supporting rods 105. On the base 106, there is mounted an arcuate series of switches 110 arranged on a circle concentric with the hole 107. Each of the switches comprises relatively movable contacts shown in the drawings as a stationary contact 111 and a spring contact finger 112 that is L-shaped, having a base portion 113 secured to the base 106, for example by a screw 114. The spring contact finger 112 is formed wholly or in part of magnetic material, or, as illustrated in the drawing, carries a strip 115 of magnetic material which, as will be explained below, serves as an armature of an electromagnet for moving the contact finger 112 into engagement with the stationary contact 111. The switches 110 may, if desired, have individual stationary contacts but, in the embodiment shown, the stationary contact 111 comprises an arcuate or circular wire or ring that provides a common contact for all of the switches 110 of the relay. The contact ring 111 is supported by a thin circular collar 116 that is mounted on the base 106 concentric with the central hole 107 and formed of non-conductive, non-magnetic material.

The spring contact fingers 112 are resiliently urged outwardly away from the stationary contact ring 111, outward movement being limited by an insulating ring 117 supported by a band 118 that projects upwardly from the outer periphery of the base 106 and is preferably removable so as to form a removable cover for the switches 110. The contact fingers 112 are adapted to be swung inwardly into engagement with the contact ring 111 by one or more magnets movable in an arcuate or circular path concentric with the central hole 107 of the base plate 106 and passing in close proximity to the armature portions 115 of the contact fingers. As shown in Figs. 7 and 8, there are two electromagnets 121 and 122 carried respectively by arms 123 and 124 that are secured on the shaft 60 so as to be angularly adjustable relative to the shaft and each other. The two electromagnets are preferable alike, each comprising a coil 125 and a C-shaped core 126 that surrounds the coil on four sides except for a gap providing spaced pole faces 127. The core also has a central portion 128 that passes axially through the coil 125. The pole faces of the electromagnets are preferably arcuate and move along a circular path just inside the collar 116 as the shaft 60 turns. As the electromagnets sweep past the switches 110, they attract the armature portions 115 of the spring fingers 112 and thereby pull the fingers inwardly one after another into contact with the ring 111. After the magnets have passed, the fingers 112 spring to their outer position, thereby breaking the contact. Preferably strips

or buttons 129 of high permeability magnetic material are inserted in the collar 116 so as to provide a magnetic path of higher permeability between the electromagnets and the armatures 115.

Means is provided for supplying electric current to the electromagnets 121 and 122 so as to energize these magnets selectively. In the embodiment shown in the drawings, provision is made for energizing the magnet 121 when the shaft 60 turns in one direction and energizing the magnet 122 when the shaft turns in the opposite direction. Current is supplied to the electro-magnet by means of two slip rings 130 mounted on the upper and lower faces, respectively, of a stationary disc 131 of insulating material supported by a bushing 132 that surrounds the shaft 60 and is removably secured in the central hole 107 of the base 106, for example by a nut 133. A rotatable cage 134 surrounds the disc 131 and comprises upper and lower rings 135 secured to the upper and lower faces, respectively, of an insulating spacing ring 136. Each of the rings 135 carries a plurality of inwardly projecting brush portions 137 (Fig. 8) adapted to engage the slip rings 130. Suitable leads 138 and 139 extend from the slip rings down through the base plate 106 for connection to the external circuit, as described below. The lower contact ring of the cage 134 is connected by leads 140 with one terminal of each of the electromagnets 121, 122. A contact pin 141 projects upwardly from the upper contact ring of the cage 134 and is disposed between two spaced resilient contacts 142 and 143 that are carried by, but insulated from, the magnet arm 124 and are electrically connected by leads 144 and 145, respectively, to the remaining terminals of the electromagnets 121 and 122. When the shaft 60, and hence the magnets 121 and 122, rotate in a clockwise direction as viewed in Fig. 8, the contact 142 engages the pin 141 and thereby carries the cage 134 around with the magnet. Electric current is thereby supplied to the coil of the electromagnet 121 through the lead 138, the upper slip ring 130, the upper contact ring 135, pin 141, contact 142 and lead 144 with a return through lead 140, the lower contact and slip rings and lead 139. When the shaft 60 is rotated in a counterclockwise direction, the electromagnet 122 is energized in like manner by engagement of the contact 143 with the contact pin 141. The spacing and resiliency of the contacts 142 and 143 is such that, when one of said contacts is in driving engagement with the pin 141, the other contact does not engage the pin. Hence, the electromagnet 121 is energized when the shaft 60 turns in a clockwise direction and the electromagnet 122 is energized when the shaft turns counterclockwise. By thus energizing the "leading" magnet in each direction of rotation, the proper angular relationship is provided between the actuation of the needle-activating switches 110 and the needle-operating cams carried by the cam ring 40.

A lead 146 (Fig. 7) extends from the spring contact finger of each of the switches 110 down through a hole in the base plate 106 for connection to the external circuit. A ring 147 on the lower face of the base 106 is electrically connected to the contact ring 111 by a suitable conductor (not shown) and is provided with a lead 148 for connection to the external circuit. A wafer-type condenser 149 is shown connected between each lead 146 and the ring 147 in order to minimize sparking when the switch contacts are opened.

When the machine is knitting by reciprocation, for example in making an ingrain solid color pattern by knitting each of several yarns back and forth across individual areas, the control shaft 60 is rotated first in one direction and then the other, thereby rotating the cam ring 40, yarn-feeding head 70 and the magnets 121 and 122 of the relays 101—104 alternately in opposite directions. To assure proper operation of the needles and of the yarn-feeding mechanism, the cam ring 40 and yarn-feeding head 70 are turned more than 360°, for

example $1\frac{1}{4}$ turns. This raises a problem in the operation of the relays 101—104 controlling the sequence of operation of the needles. If the magnets 121, 122 make more than one complete revolution, the needle-activating switches 110, actuated at the beginning of the movement of the magnets in one direction, are again actuated when the magnets swing past one full turn. The present invention solves this problem by providing an "overthrow cutout" actuated in timed relation to the movement of the magnets so as to deenergize the magnets when they swing past a complete revolution. Hence, even though the magnets pass certain switches twice, they are deenergized the second time so that the switches are actuated only once in each "swing."

As illustrated in Figs. 4, 5 and 6, the overthrow cutout 150 comprises a base 151 mounted on the frame of the machine adjacent, and parallel to, a face of the "104" gear 65 and one or more switches mounted on the base, two switches 152 and 153 being shown. Each switch comprises a swingable lever 154 pivotally mounted on the base at 155 and carrying a contact 156 adapted to engage a fixed contact 157 on the base, it being understood that the contacts are suitably insulated. A tension spring 158 tends to swing the lever toward the base to bring the contacts of the switch into engagement with one another. A plunger 160 extends through a hole in the base beneath a laterally projecting arm 161 of the lever 154, being disposed approximately normal to the plane of the lever. The plunger 160 is axially slidable and its inner end is adapted to be engaged by a cam 162 on the face of the gear 65. When the plunger slides up the inclined leading end of the cam 162, it is moved axially to the left, as viewed in Fig. 6, and thereby swings the lever 154 away from the base 151 so as to open the switch contacts. When the plunger 160 rides off the cam, the lever 154 is swung toward the base by the spring 158 and brings the contacts 156 and 157 into engagement with one another.

The magnets 121, 122 actuating the switches of the rotary relays 101—104 are connected to a power supply through the contacts 156, 157 of one or more of the switches of the overthrow cutout 150 so that the magnets are energized when the cutout contacts are closed and deenergized when said contacts are open. In the normal gearing of the machine, the "104" gear 65 turns one revolution for each complete swing of the magnet-carrying arms of relays 101—104 around in one direction and back in the opposite direction. With this arrangement, two cams 162 are provided at approximately diametrically opposite positions on the gear 65 so that the respective magnet is energized for a portion of its swing in each direction and deenergized during another portion of its swing. The magnets of certain of the relays 101—104 may be connected through different ones of the switches 152, 153 so that one or more relays are controlled by each of said switches. The cam or cams 162 for operating the respective switches 152, 153 may be differently positioned according to the desired points at which the relays are to be cut out.

Fig. 9 is a simplified schematic wiring diagram showing circuits for controlling the operation of the needles. A power supply is indicated as being direct current since unidirectional current is usually considered preferable for energizing magnets but alternate current may be employed if desired. In addition to the elements already described, the circuit is shown as including a series of individual switches 165 controlling the supply of power to the common contact rings 111 of the relays 101—104, a series of individual switches 166 controlling the supply of power to the electromagnets 121 and 122 of the relays 101—104 and switches 167 bypassing the overthrow cutout switches 152, 153. The switches 165, 166 and 167 are preferably controlled automatically, for example by cams on a pattern drum 168 (Fig. 1) on the main pattern drum shaft 6 or by cams or rows of pins on the pattern drum 76. For example, the switches 165,

166 and 167 may comprise switches like switches 75. While only one switch 165 and one switch 166 is shown for each of the relays 101—104, there may be two or more, for example one controlled by cams on the main pattern drum shaft and one controlled by the pattern drum 76, the switches being connected in parallel.

The magnet 37 of each needle-operating mechanism is connected to the power supply through a selecting switch 75 controlled by the pattern drum 76 and an activating switch 110 actuated by the magnet 121 or 122 of at least one of the relays 101—104. Tracing the circuit of one needle magnet 37, beginning at the positive terminal of the power supply, current is led to the magnet through a trunk 170 and one of the selecting switches 75 with return through a line 171, lead 146, one of the activating switches 110, contact ring 111, lead 147, one of the switches 165 and a return trunk 172 to the negative terminal of the power supply. To avoid complication of the drawing, the circuits of only a few of the magnets 37 are shown. Preferably, some of the magnets 37 are controlled by one of the relays 101—104 and some by another. For some patterns, it is desirable to have each, or at least some of the magnets 37 controlled through the activating switches of two or more of the relays 101—104 connected in parallel. Each of the relays 101—104 is shown as having only half a circle of switches 110 corresponding to approximately half the total complement of needles. With this arrangement, one of the relays controls approximately half of the needles, for example the needles in 180 degrees of the needle circle, and another relay controls the remaining needles. This arrangement is particularly suitable for reciprocatory knitting as well as continuous circular knitting. However, one or more of the relays 101—104 may be provided with a full circle of switches 110, if desired. For convenience and clarity of illustration, the magnets 121, 122 of all of the relays 101—104 are shown in the same position, but it will be understood that they may be displaced angularly relative to one another to provide the particular sequence of actuation of the needles desired.

The supply of power to the actuating magnets 121, 122 of each of the relays 101—104 is controlled by the overthrow cutout 150, one of the bypassing switches 167 and one of the selecting switches 166. As described above, the contact pin 141 engages one or the other of the co-operating contacts 142, 143 (Fig. 8) so that one of the magnets is energized in one direction of rotation and the other is energized in the opposite direction of rotation. When it is desired to have the cutout 150 in operation, the switches 167 are open. The circuit is then from the positive terminal of the power supply through one or another of the switches 152, 153 of the overthrow cutout 150, one of the lines 173, lead 138, one or the other of the magnets 121, 122 depending on the position of the contact pin 141, lead 139, one of the selecting switches 166 and the return trunk 172 to the negative terminal of the power supply. If it is desired to render the overthrow cutout 150 ineffective, for example in continuous circular knitting, the switches 167 are closed so that the current bypasses the overthrow cutout. The circuit is otherwise the same.

It will be seen that, although the magnets 121, 122 of all of the relays 101—104 move with the control shaft 60 at all times during operation of the machine, the relays can be put into or out of operation selectively, merely by closing one or another of the selecting switches 166. Even though the magnets 121, 122 continue to move past the switches 110 of a relay, the relay is inactive if the magnets are not energized.

The operation of the control circuits will be apparent from the foregoing description. The desired pattern is set up on the pattern drum 76 which controls the needle-selecting switches 75 and on the main pattern drum controlling switches 165, 166 and 167. With each move of the pattern drum 76, predetermined ones of the needle-

selecting switches 75 are opened or closed to determine which needles will be operated. The selected needles are thereupon actuated sequentially one after another under control of the activating switches 110 of one of the relays 101—104, the activating switches being closed sequentially by movement of the magnet 121 or 122, as described above. In predetermined portions of its rotation or swing, the magnet 121 or 122 is deenergized by operation of the overthrow cutout 150, for example to avoid an unintended second operation of the selected needles which might result in shedding stitches since no yarn is fed to the needles the second time. The selecting switches 165, 166, under control of suitable patterning mechanism, determine which of the relays 101—104 are activated.

With the control system in accordance with the invention, the operation of the machine can be predetermined so as to knit even a complicated article fully automatically. For example, the machine will produce automatically an article of hosiery having an elastic top, a diamond or other involved pattern in the leg and an integral foot with heel and toe pockets knit by reciprocation. The individual control of the needles and the large number of moves available by the pattern drum 76 make it possible to produce a wide variety of different patterns.

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

1. In a knitting machine, a series of independent needles, electrically controlled means for individually operating the needles, an electrical power supply, a first series of individual switches for controlling individual needles, a second series of individual switches for controlling individual needles, means connecting the operating means of each needle to the power supply through a switch of said first series and a switch of said second series so that said operating means is energized only when said switch of the first series and said switch of the second series are actuated, selecting means for periodically actuating selected ones of the switches of said first series, means for sequentially actuating switches of the second series comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving the electromagnet along a defined path in proximity to said armatures to attract said armatures successively and thereby actuate the respective switches and means for connecting said electromagnet to the power supply including means for periodically disconnecting said electromagnet from the power supply to deenergize said magnet so that it does not actuate said switches of the second series.

2. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electrical power supply, a first series of individual switches for controlling individual needles, a second series of individual switches for controlling individual needles, means connecting the operating means of each needle to the power supply through a switch of said first series and a switch of said second series so that said operating means is actuated only when said switch of the first series and said switch of the second series are both actuated, means for periodically actuating selected ones of the switches of said first series, means for sequentially actuating switches of said second series comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving the electromagnet along a defined path in proximity to said armatures to attract said armatures successively and thereby actuate the respective switches and means for intermittently connecting said electromagnet to the power supply in timed relation to the movement of said magnet to energize said magnet during a portion only of its travel along said path.

3. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electric power supply, a

first series of switches for controlling individual needles, a second series of switches for controlling individual needles, said second series of switches being arranged on the arc of a circle, means connecting the operating means of each needle to the power supply through a switch of the first series and a switch of the second series so that said operating means is operated only when said switch of the first series and said switch of the second series are both actuated, pattern controlled means for periodically actuating selected ones of the switches of said first series, means for sequentially actuating switches of said second series comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving said electromagnet in an arcuate path concentric with said arcuate series of switches and in proximity to said armatures to attract said armatures successively and thereby actuate the respective switches and means for intermittently connecting said electromagnet to the power supply in timed relation to the movement of said magnet to energize said magnet during a portion only of its travel along said arcuate path.

4. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electric power supply, a first series of switches for controlling individual needles, a second series of switches for controlling individual needles, said second series of switches being arranged on the arc of a circle, means connecting the operating means of each needle to the power supply through a switch of the first series and a switch of the second series so that said operating means is operated only when said switch of the first series and said switch of the second series are both actuated, pattern controlled means for periodically actuating selected ones of the switches of said first series, means for sequentially actuating switches of said second series comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving said electromagnet back and forth along an arcuate path concentric with said arcuate series of switches and in proximity to said armatures to attract said armatures successively and thereby actuate the respective switches and means for intermittently connecting said electromagnet to the power supply in timed relation to the movement of the magnet to energize said magnet during a predetermined portion only of its travel along said arcuate path.

5. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electric power supply, a first series of switches for controlling individual needles, a second series of switches for controlling individual needles, said second series of switches being arranged on the arc of a circle, means connecting the operating means of each needle to the power supply through a switch of the first series and a switch of the second series so that said operating means is operated only when said switch of the first series and said switch of the second series are both actuated, pattern controlled means for periodically actuating selected ones of the switches of said first series, means for sequentially actuating switches of said second series comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, driving mechanism for moving said electromagnet back and forth along an arcuate path concentric with said arcuate series of switches and in proximity to said armatures to attract said armatures successively and thereby actuate the respective switches, means including a cam-operated switch for connecting said electromagnet to the power supply and a cam on a portion of said driving mechanism actuating said cam operated switch to energize said magnet during a predetermined portion only of its travel along said arcuate path.

6. In a knitting machine, a series of individually op-

erable needles, electrically controlled means for individually operating the needles, an electric power supply, a series of selecting switches controlling individual needles, a plurality of series of activating switches controlling individual needles, means connecting the operating means of each needle to the power supply through one of said selecting switches and through an activating switch of at least one of said series, so that said operating means is activated only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern controlled means for periodically actuating selected ones of said selecting switches, means for sequentially actuating said activating switches, the actuating means for each series of said activating switches comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving said electromagnet along a defined path in proximity to a series of armatures to attract said armatures successively and thereby actuate the respective switches, and means for intermittently connecting said electromagnet to the power supply in timed relation to the movement of said magnet to energize said magnet during a portion only of its travel along said path.

7. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electrical power supply, a series of selecting switches controlling individual needles, a plurality of series of activating switches controlling individual needles, means connecting the operating means of each needle to the power supply through one of said selecting switches and through an activating switch of at least one of said series, so that said operating means is activated only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern controlled means for periodically actuating selected ones of said selecting switches, means for sequentially actuating said activating switches, the actuating means for each series of activating switches comprising an armature associated with each of said switches and movable to actuate the switch, an electromagnet, means for moving said electromagnet along a defined path in proximity to said armatures of a series to attract said armatures successively and thereby actuate the respective switches, means for selectively connecting said electromagnet to the power supply to put into operation a series of activating switches the electromagnet of which is connected to said power supply and thereby energized and to put out of operation any series of activating switches the electromagnet of which is not energized, and means for intermittently disconnecting a selected electromagnet from the power supply in timed relation to the movement of said magnet to deenergize said magnet during a portion only of its travel along said path.

8. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electrical power supply, a series of selecting switches controlling individual needles, a plurality of series of activating switches controlling individual needles, means connecting the operating means of each needle to the power supply through one of said selecting switches and through an activating switch of at least one of said series, so that said operating means is activated only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern controlled means for periodically actuating selected ones of said selecting switches, means for sequentially actuating said activating switches comprising an armature associated with each of said switches and movable to actuate the switch, an electro-magnet, means for moving said electromagnet along a defined path in proximity to said armatures of a series to attract said armatures successively and thereby actuate the respective switches, and means for selectively connecting said electromagnet to the power supply to put into operation a series of activating switches the electromagnet of which is connected to said power

supply and thereby energized and to put out of operation any series of activating switches the electromagnet of which is not energized.

9. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electrical power supply, a series of selecting switches controlling individual needles, a plurality of series of activating switches controlling individual needles, means connecting the operating means of each needle to the power supply through one of said selecting switches and through an activating switch of at least one of said series, so that said operating means is activated only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern controlled means for periodically actuating selected ones of said selecting switches, individual means for sequentially actuating each series of activating switches, means for selectively energizing said actuating means to put into operation a series of activating switches the actuating means of which is energized and to put out of operation any series of activating switches the actuating means of which is deenergized, and means for intermittently deenergizing a selected actuating means during a portion of each cycle of operation.

10. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electrical power supply, a series of selecting switches controlling individual needles, a plurality of series of activating switches controlling individual needles, means connecting the operating means of each needle to the power supply through one of said selecting switches and through an activating switch of at least one of said series, so that said operating means is activated only when a selecting switch and an activating switch corresponding to said needle are both actuated, pattern controlled means for periodically actuating selected ones of said selecting switches, electrically energized means for sequentially actuating each series of activating switches, means for selectively connecting said actuating means to a power supply to put into operation a series of activating switches the actuating means of which is connected to said power supply and thereby energized and to put out of operation any series of activating switches the actuating means of which is not energized, and means for intermittently disconnecting a selected actuating means from said power supply to deenergize said actuating means during a portion of its cycle of operation.

11. In a knitting machine, a series of individually operable needles, electrically controlled means for individually operating the needles, an electric power supply, a first series of switches for controlling individual needles, a second series of switches for controlling individual needles, said second series of switches being arranged on the arc of a circle, means connecting the operating means of each needle to the power supply through a switch of the first series and a switch of the second series so that said operating means is operated only when said switch of the first series and said switch of the second series are both actuated, pattern controlled means for periodically actuating selected ones of the switches of said first series, electrically energized means for sequentially actuating the switches of said second series and means for intermittently connecting said actuating means with a power supply to energize said actuating means with a power supply to energize said actuating means during a portion only of each cycle of its operation.

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