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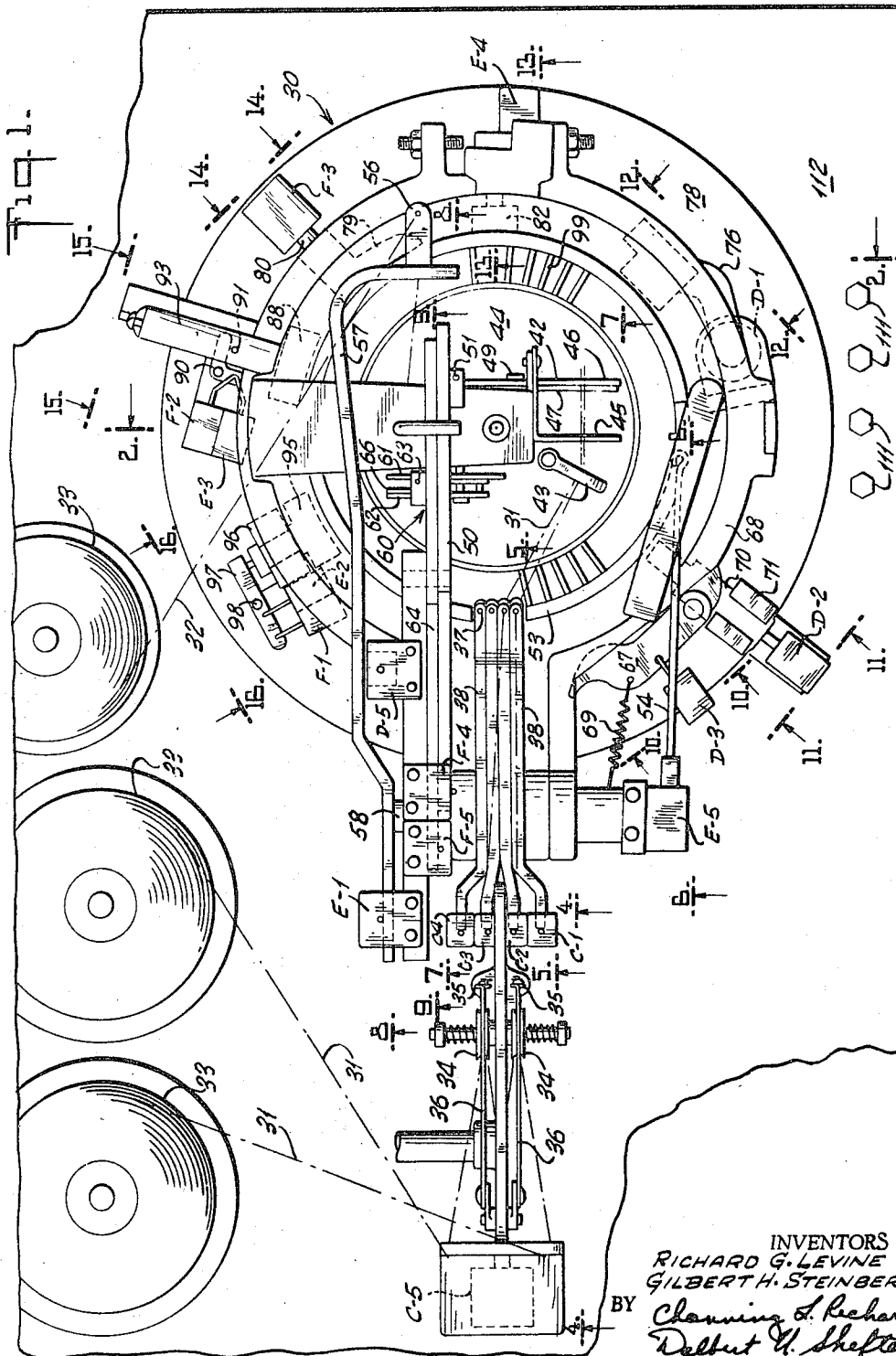
R. G. LEVINE ETAL

3,232,079

CIRCULAR KNITTING MACHINE

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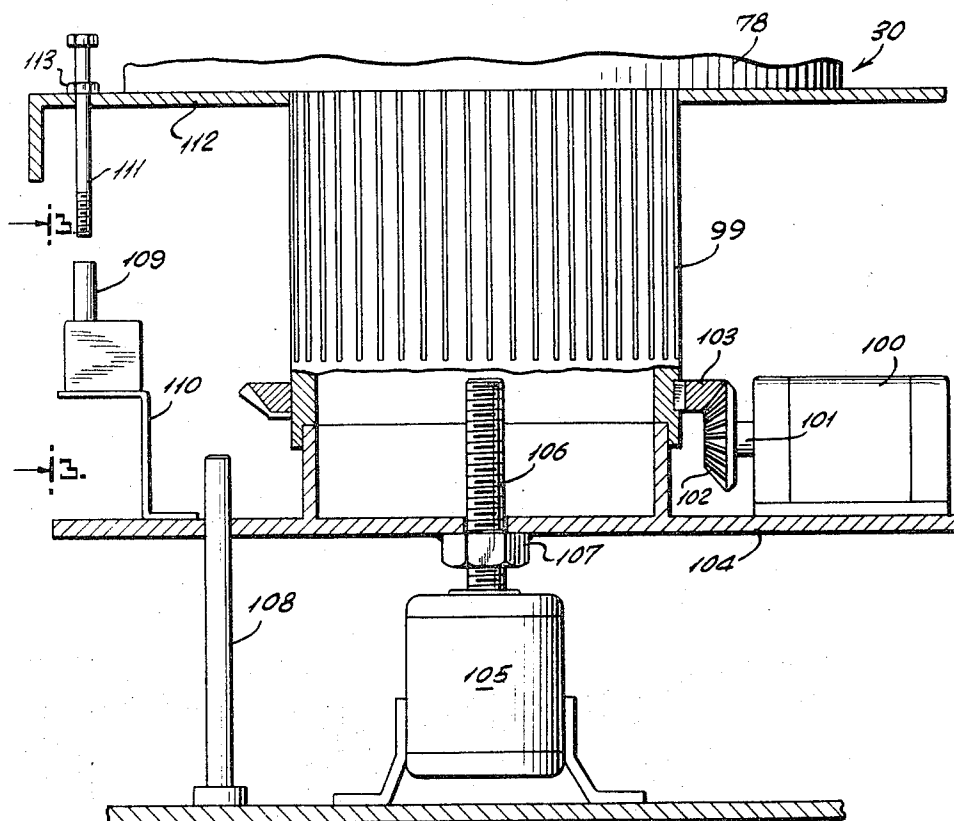
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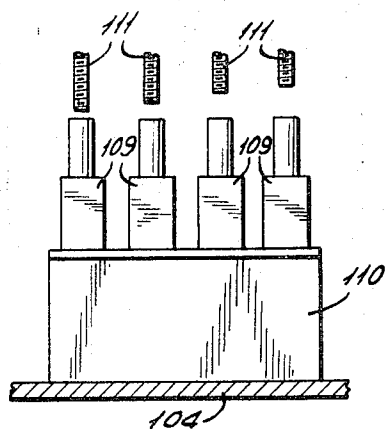
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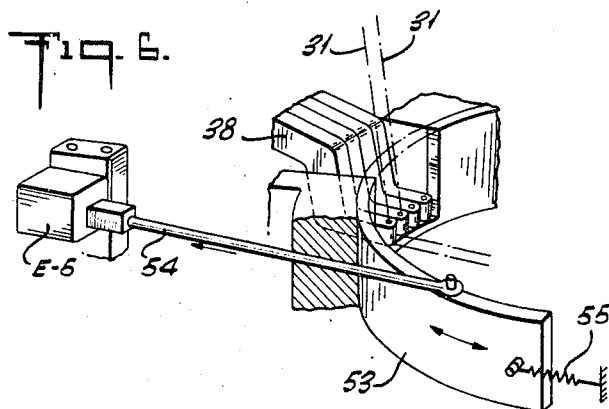
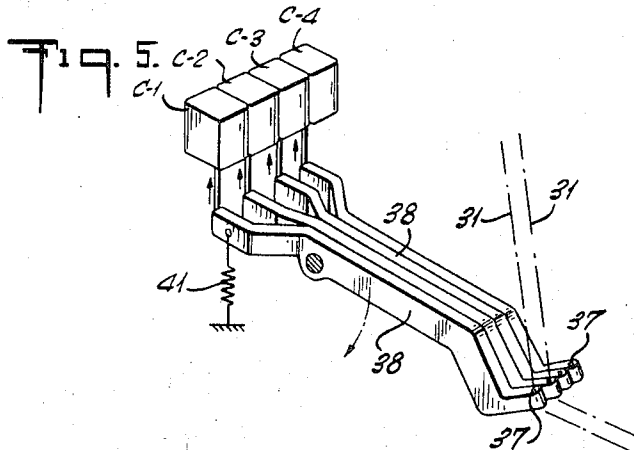
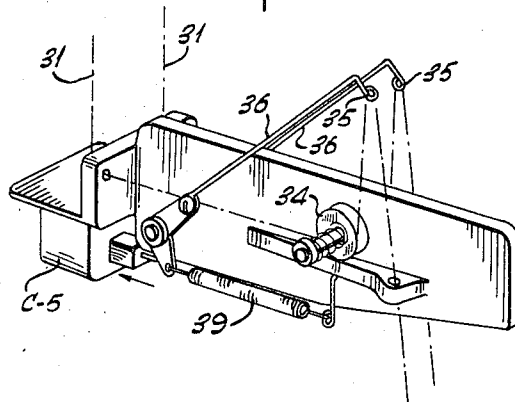
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Fig. 4.



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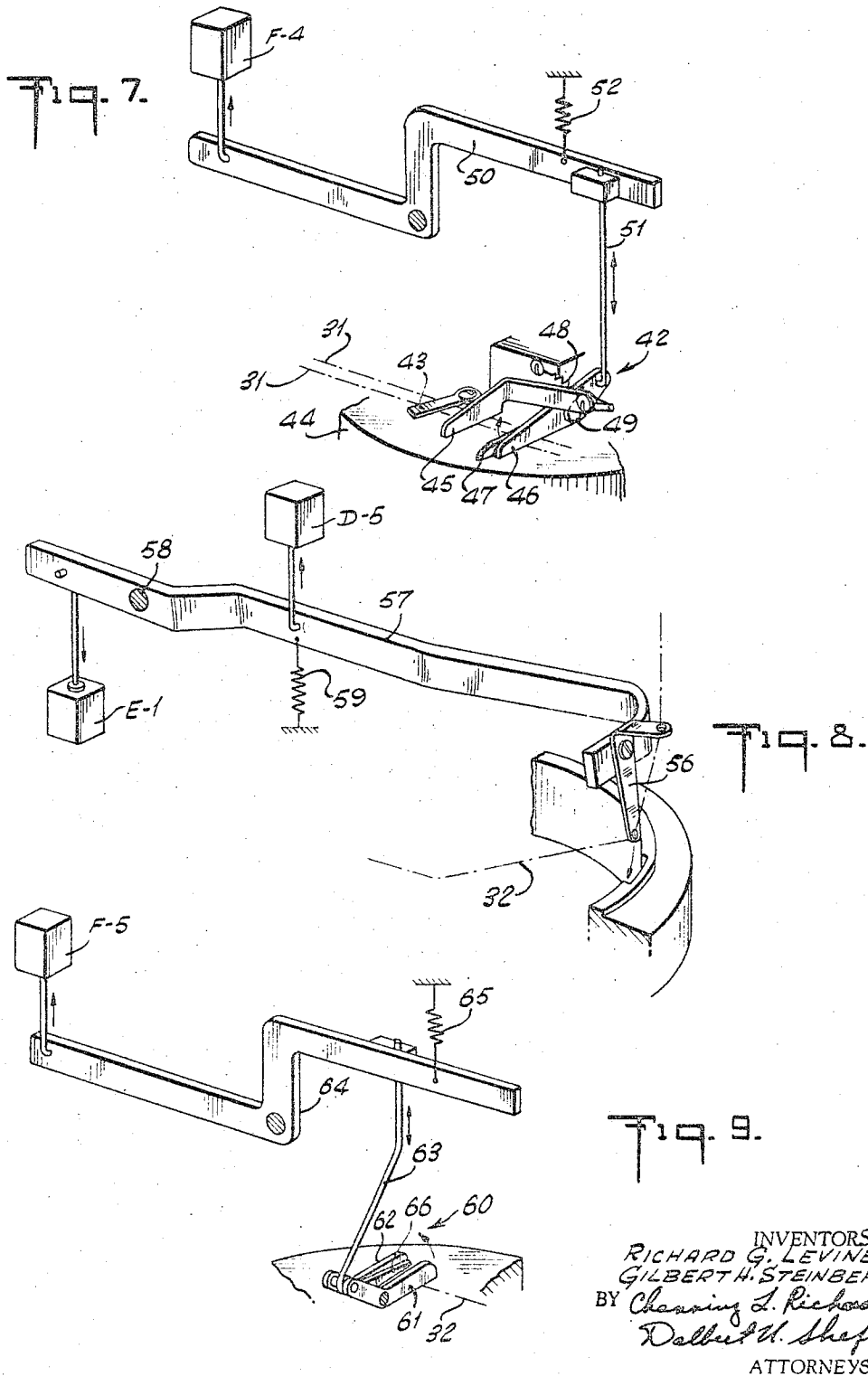
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Fig. 10.

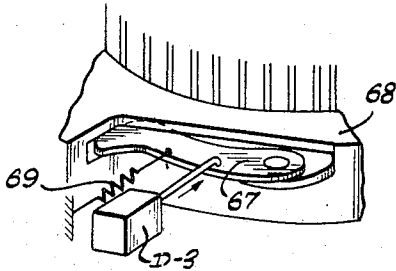


Fig. 11.

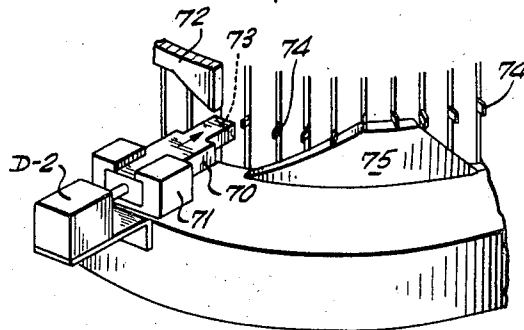


Fig. 12.

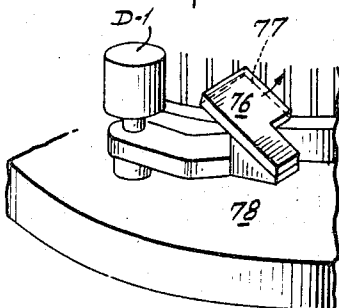


Fig. 13.

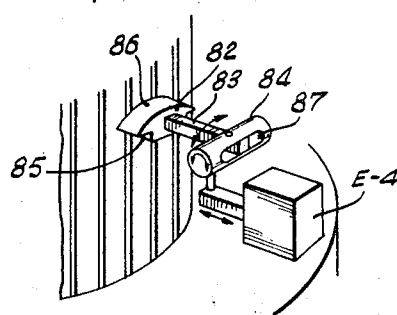
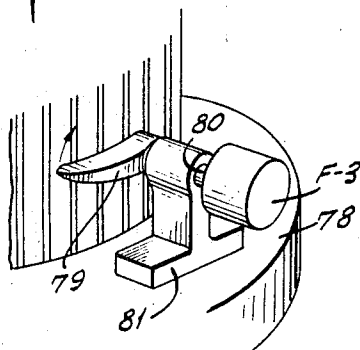


Fig. 14.



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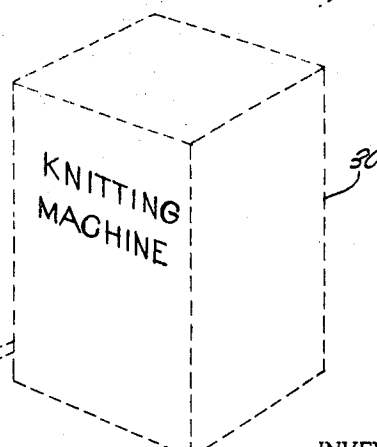
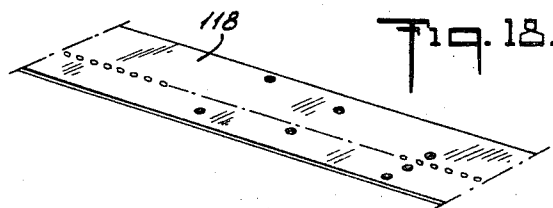
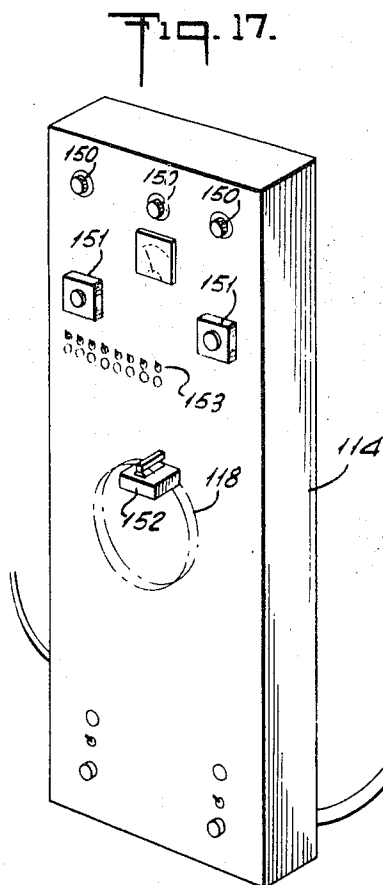
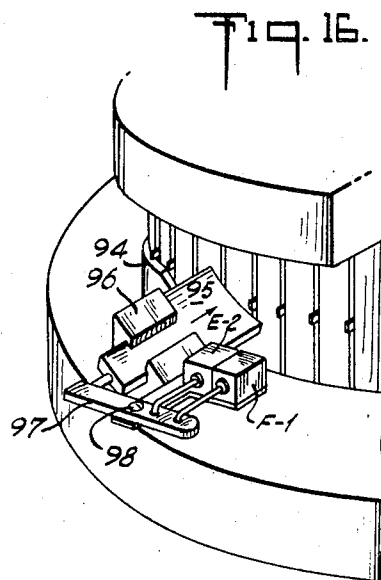
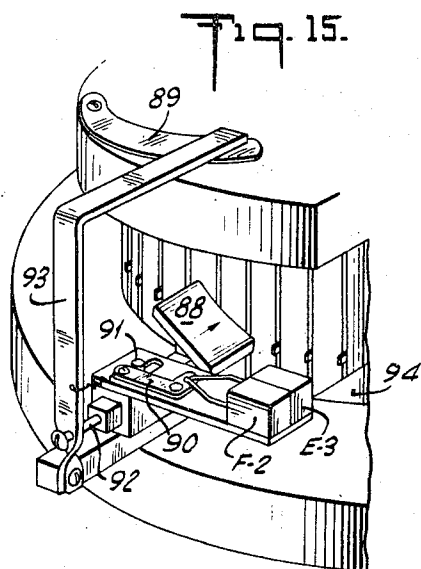
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CIRCULAR KNITTING MACHINE

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Fig. 19.

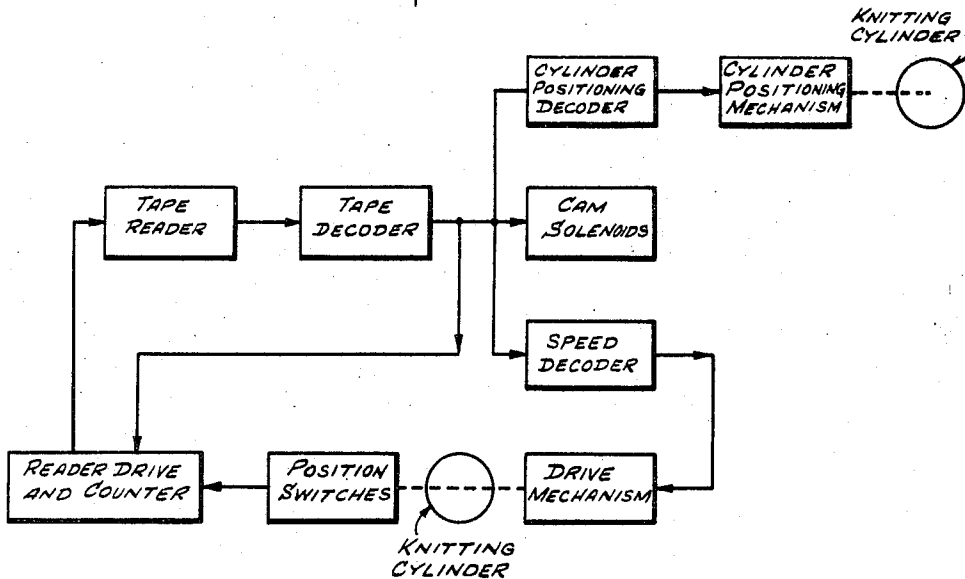
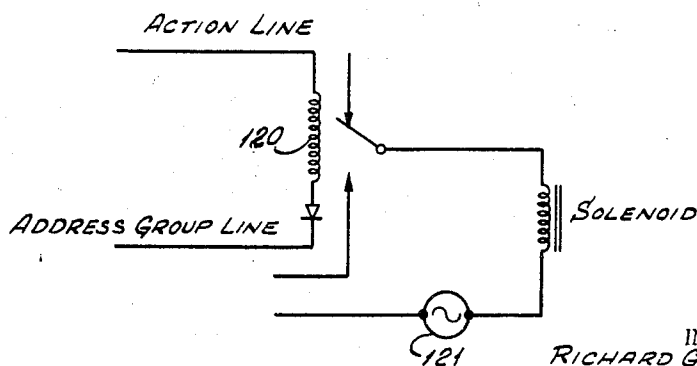


Fig. 20.



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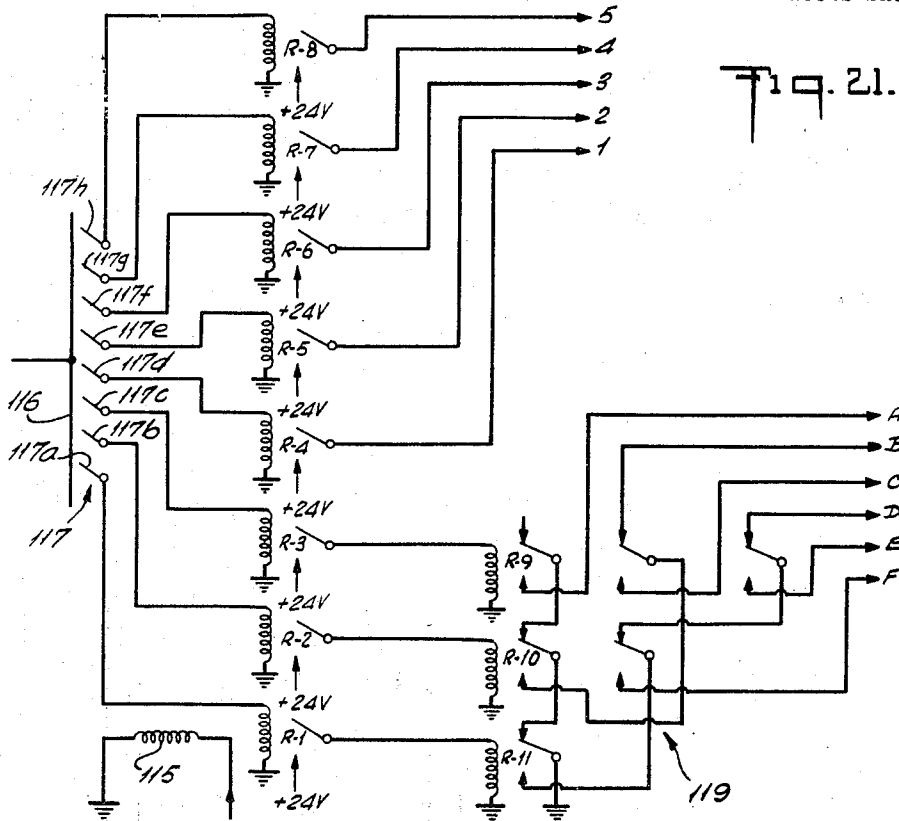


Fig. 21.

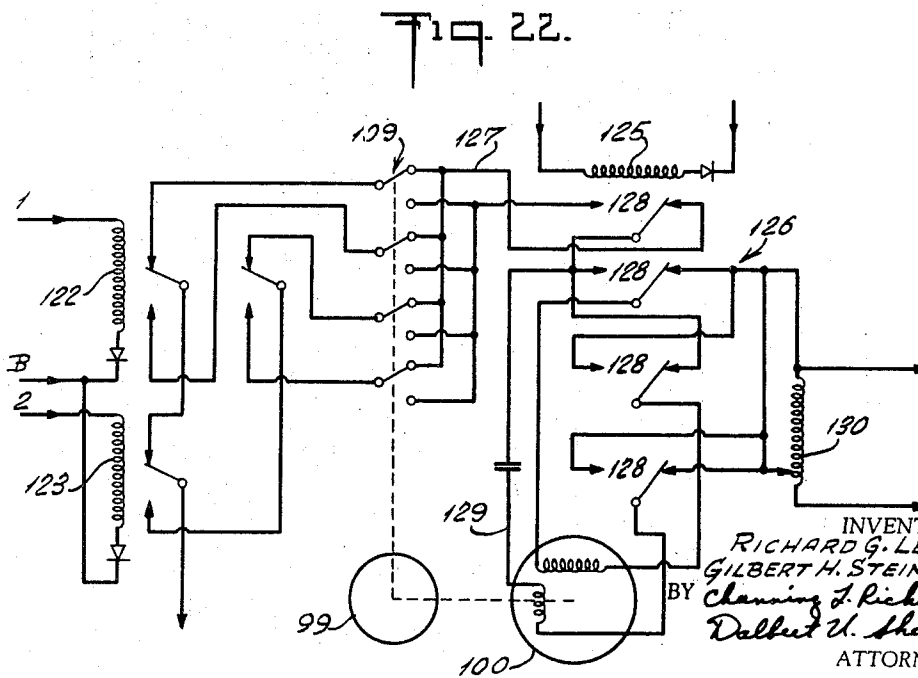


Fig. 22.

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Fig. 23.

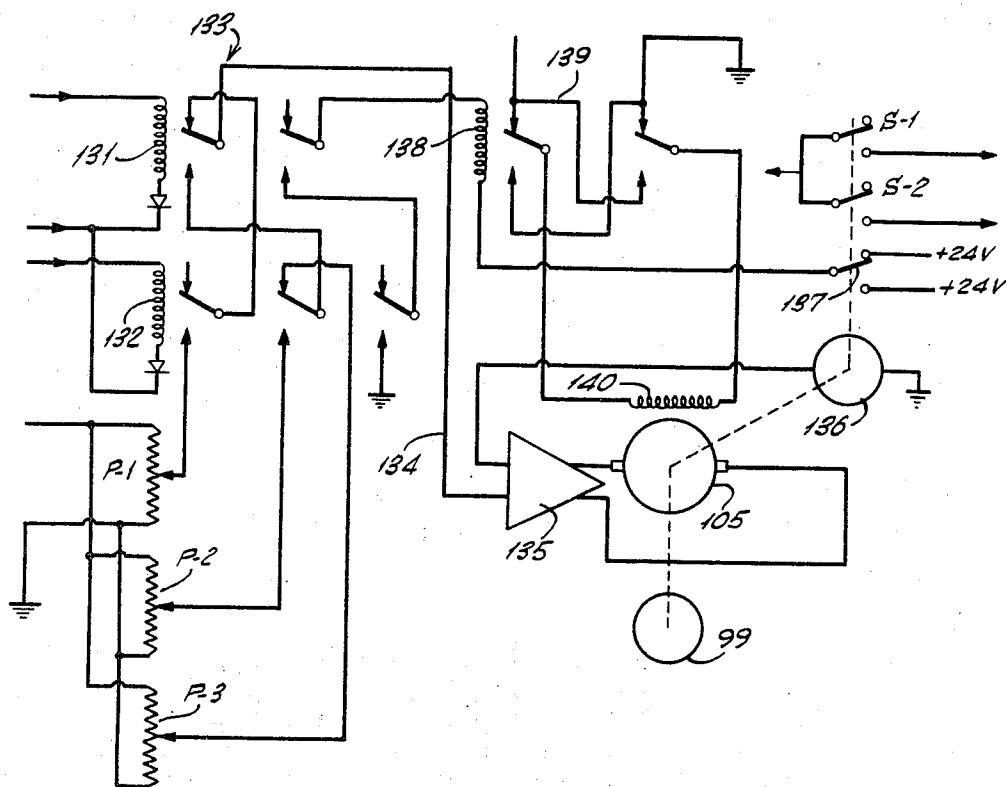
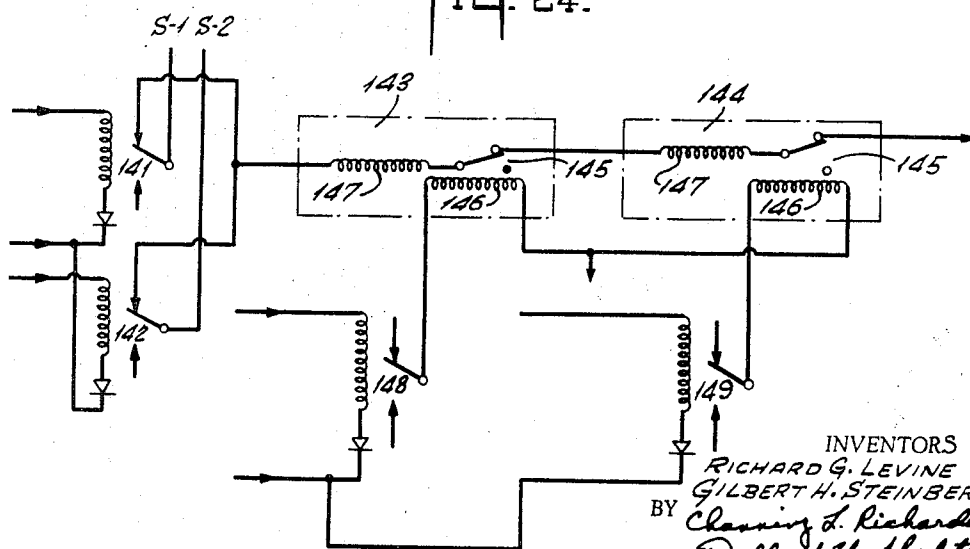


Fig. 24.



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3,232,079

CIRCULAR KNITTING MACHINE

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Filed Dec. 24, 1962, Ser. No. 246,756
11 Claims. (Cl. 66—154)

The present invention relates to circular knitting machines, and more particularly to a circular knitting machine wherein the knitting elements are controlled by remote program responsive means that provide a high degree of selectivity in controlling the functioning of the various knitting elements and provide a highly simplified and compact knitting machine construction without the complex and cumbersome pattern drums and associated mechanical linkages inherent in conventional knitting machines.

In addition to the selectivity, simplification, compactness and remote control features, the elimination of complex linkages, particularly when combined with independent actuation of elements possible by the present invention, provides an important operating speed advantage as compared with conventional knitting machines wherein the mechanical linkages and interconnections have inherent limitations that restrict knitting speeds. The high knitting speeds obtainable by the present invention may be even further developed by handling the yarn in a manner to reduce strain, as by measuring prior to drawing as disclosed in Haddad U.S. Patent No. 3,054,278, issued September 8, 1962, for Knitting Method and Means and Product Formed Thereby.

By the present invention independent operating components for actuating the knitting elements can be compactly and simply arranged for efficient operation at the individual locations at which the components are to act on the knitting elements, with the components being separately actuated by program responsive means in any desired pattern.

The operating components may be electrically controlled by the program responsive means, further simplifying the machine construction itself and facilitating remote control of the operating components. Electrical operation also facilitates the use of a single program responsive control system to control operation of the individual elements of a plurality of knitting machines simultaneously.

A further feature of the present invention is the incorporation of means responsive to the progression of the knitting elements for advancing the program that is read by the program responsive means, thus synchronizing the control with the knitting element progression so that actuations of the knitting elements are positively timed to occur at the desired points in the knitting cycle. In the preferred embodiment this is accomplished by a response to movement of the needle cylinder, as an electrical pulse actuated by every revolution or half revolution of the cylinder, which pulse activates a stepwise advance of the program read by the control means.

In knitting some articles, such as ladies' hosiery, a large number of identical courses are knit in succession, as in the leg or foot of hosiery, and there is no need for the advancement of the program during this period of knitting as the operating components remain in one position throughout the knitting of the identical courses. To eliminate the inefficient advancement of the program and the repeated useless actuations of the control means, the present invention includes counting means that are actuated from the program to count a predetermined number of knitting element progressions, such as needle cylinder revolutions, and which deactivate the program advancing means during the counting period.

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Another significant aspect of the present invention is the provision of unique means for controlling the depth of draw of the yarn by the knitting elements to control stitch length and tension for various reasons, including fashioning. This is accomplished by shifting the needle cylinder axially in response to a program indication. In the preferred embodiment the cylinder shifting is controlled by a plurality of sensing components arranged at different cylinder levels with the component at the desired level being selected by the program and the cylinder shifting means operating to shift the cylinder until it reaches the selected position at which the sensing component deactivates the shifting means. These sensing components may be a series of electrical contacts arranged compactly and simply in association with the cylinder, and the shifting means may simply be a motor driven lead screw on which the cylinder is supported, or any other suitable operating device.

Other and further features and advantages of the present invention will be apparent from the following description and accompanying drawings, in which:

FIG. 1 is a top plan view of a knitting machine according to the preferred embodiment of the present invention;

FIG. 2 is a partial vertical sectional view of the knitting machine of FIG. 1 taken along line 2—2 of FIG. 1;

FIG. 3 is a vertical sectional view taken along line 3—3 of FIG. 2, illustrating the cylinder position sensing components;

FIG. 4 is a perspective view of the yarn tensioning device of the knitting machine of FIG. 1 as viewed along line 4—4 of FIG. 1;

FIG. 5 is a perspective view of the main yarn feed fingers of the knitting machine of FIG. 1 as viewed along line 5—5 of FIG. 1;

FIG. 6 is a perspective view of the gap closing mechanism of the knitting machine of FIG. 1 as viewed along line 6—6 of FIG. 1;

FIG. 7 is a perspective view of the main yarn cutting mechanism of the knitting machine of FIG. 1 as viewed along line 7—7 of FIG. 1;

FIG. 8 is a perspective view of the auxiliary yarn feed mechanism of the knitting machine of FIG. 1 as viewed along line 8—8 of FIG. 1;

FIG. 9 is a perspective view of the auxiliary yarn cutting mechanism of the knitting machine of FIG. 1 as viewed along line 9—9 of FIG. 1;

FIG. 10 is a perspective view of an auxiliary sinker cam of the knitting machine of FIG. 1, as viewed along line 10—10 of FIG. 1;

FIG. 11 is a perspective view of an auxiliary stitch cam of the knitting machine of FIG. 1 as viewed along line 11—11 of FIG. 1;

FIG. 12 is a perspective view of a needle lowering cam of the knitting machine of FIG. 1, as viewed along line 12—12 of FIG. 1;

FIG. 13 is a perspective view of a dropper cam of the circular knitting machine of FIG. 1, as viewed along line 13—13 of FIG. 1;

FIG. 14 is a perspective view of a switch cam of the knitting machine of FIG. 1, as viewed along line 14—14 of FIG. 1;

FIG. 15 is a perspective view of another needle lowering cam of the knitting machine of FIG. 1, as viewed along line 15—15 of FIG. 1;

FIG. 16 is a perspective view of a dividing cam of the knitting machine of FIG. 1, as viewed along line 16—16 of FIG. 1;

FIG. 17 is a perspective view of a console housing the components of the remote control means of the circular knitting machine of FIG. 1;

FIG. 18 is a perspective view of a section of the program tape that is read by the control means to control operation of the knitting machine of FIG. 1;

FIG. 19 is a schematic block diagram of the basic control sections of the remote control means of the knitting machine of FIG. 1;

FIG. 20 is a schematic electrical wiring diagram for one of the solenoid control circuits of the control means for actuating the operating components of the circular knitting machine of FIG. 1;

FIG. 21 is a schematic electrical wiring diagram of the tape reader and decoder sections of the remote control means of FIG. 19;

FIG. 22 is a schematic electrical wiring diagram of the cylinder positioning control section of the remote control means of FIG. 19;

FIG. 23 is a schematic electrical wiring diagram of the speed decoder and drive mechanism control sections of the remote control means of FIG. 19; and

FIG. 24 is a schematic electrical wiring diagram of the reader drive and counter section of the remote control means of FIG. 19.

For the purpose of providing a full disclosure of the present invention, one embodiment is herein illustrated and described in detail incorporated in a conventional model B-5, Scott & Williams circular knitting machine. However, it should be understood that the present invention could readily be embodied in various other types of circular knitting machines as it utilizes only the elements that perform the actual knitting function without modification of the elements themselves and need not involve any change in the basic cooperation of the elements in carrying out the knitting operation. Rather, the present invention deals with the means for controlling the cooperation of the elements. Thus, by the present invention it is possible to simplify the drive mechanisms, and completely eliminate the complex pattern drums, selector drums and cumbersome connecting mechanical linkages, substituting therefor simple individual operating components that are directly actuated by control means, such as the remote electrical program responsive means described hereinafter that inherently provide a high degree of selectivity of the various knitting operations and permit control of a multitude of knitting machines by a single, remotely located, control mechanism.

For clarity of discussion the embodiment illustrated will be considered as having four basic aspects, namely: needle, sinker and yarn control components (FIGS. 1, 4-16, 19 and 20); cylinder drive components (FIGS. 2, 19 and 23); cylinder positioning components (FIGS. 2, 3, 19 and 22); and remote, program responsive, control means (FIGS. 17-24), including counting means (FIG. 24), which remote control means control actuation of all of the various aforementioned components.

With regard to the needle, sinker and yarn control components, the actual movements of the needles and sinkers to form knit fabrics are conventional, and are not illustrated or described herein, but the operating components that control the variation in the cofunctioning of the knitting elements shall be described and are illustrated in FIGS. 1, 4-16, and the electrical circuitry of the remote control means for actuating these operating components shall be described and is illustrated in FIGS. 19, 20 and 21.

In the particular knitting machine 30 illustrated in FIG. 1, circular knit fabric, such as half-hose, is knit with two ends of main yarn 31 and a single end of an auxiliary yarn 32, such as a rubber yarn, that are drawn from supply packages 33.

With reference to FIGS. 1, 4 and 5, the two ends of main yarn 31 are trained around a tensioning wheel 34, through eyelet 35 at the ends of pivoted tensioning fin-

gers 36, and through eyes 37 at the end of pivoted feed fingers 38, from which the yarn passes to the needles and sinkers for forming into loops of the knitted fabric.

The tensioning wheel 34 is conventional in construction as are the tensioning fingers 36, which function to take up the slack in the yarn during reciprocal knitting in the usual manner. However, the control of the tensioning fingers 36 is modified according to the present invention by the elimination of the pattern drum controls and connecting linkages and substituting therefore simple actuating means in the form of an electrical solenoid C-5, which is energized during circular knitting to position the fingers 36 downwardly in inoperative position, and de-energized during reciprocal knitting to allow the usual spring 39 to pivot the tensioning fingers 36 upwardly and maintain a resilient tension of the yarn ends 31.

Similarly the feed fingers 38 are of conventional construction, but are actuated by individual electrical solenoids C-1, C-2, C-3 and C-4 that are normally energized during feeding of yarn by the particular finger to position the fingers downwardly in yarn feeding position. When it is desired that a yarn be held out of knitting position, the solenoid controlling the particular feed finger 38 is de-energized, which allows the finger 38 to pivot upwardly due to the bias of the spring 41, which causes the yarn to be positioned above and out of engaging relation with the needles.

When a feed finger 38 is raised to remove a yarn end from the knitting action, the yarn extends from the feed finger 38 to the last needle in which it is knit and as the needle progresses in its circular path the yarn advances into the main cutting mechanism 42 illustrated in FIGS. 1 and 7. This cutting mechanism 42 includes a guide bar 43 fixed immovably to the dial plate 44 for initial guiding of the yarn, a movable holddown arm 45 pivotally mounted for movement down onto a positioned yarn to hold the yarn as it is cut by a pivoted blade 46 acting against a fixed blade 47 secured to the dial plate 44. The holddown arm 45 is pivoted outwardly of the fixed blade 47 and is biased thereagainst by a spring 48 so that raising and lowering of the holddown arm 45 is controlled by pivoting of the blade 46 about the pivot 49. The pivoted blade 46 is operably connected to a rocker arm 50 by connecting rod 51. The rocker arm 50 is actuated by solenoid F-4, which when energized rocks the arm 50 to move the connecting rod 51 downwardly and thereby raise the pivoted blade 46 and associated holddown arm 45. When a yarn is in position for cutting, the solenoid F-4 is de-energized, allowing the spring 52 to pivot the rocker arm 50 to raise the connecting rod 51 and thereby lower the pivoted blade 46 and holddown arm 45 to effect cutting of the yarn between the blades 46 and 47. After cutting the solenoid F-4 is again energized to raise the pivoted blade 46 and holddown arm 45 so that when the yarn is again lowered into knitting position by the feed finger 38, the cut end can readily slip out from under the guide bar 43 as knitting progresses.

When knitting with some needles raised out of knitting position it may be necessary to protect against closing of the latches as they pass the position of feed fingers 38. This may conventionally be done by a gap closing section 53 formed in the usual latch ring for shifting into position at the tips of the feed fingers 38 (see FIG. 6). In the present invention, this gap closing section 53 is shifted by a connecting rod 54 actuated by an electrical solenoid E-5, which when energized shifts the gap closing section 53 circularly into operative position, and when de-energized allows the gap closing section 53 to be shifted by the spring 55 to its inoperative position.

The aforementioned auxiliary yarn 32 is fed to the needles through a guide 56 at one end of an auxiliary feed finger 57, as seen in FIGS. 1 and 8. The auxiliary feed finger 57 is pivoted to move the auxiliary yarn 32 into and out of knitting position and has an intermediate position at which the yarn is laid into raised needles so that one

or more revolutions of auxiliary yarns can be captured in a single course of knitted loops of the main yarn 31 as when making an elastic top in half-hose. The auxiliary feed finger 57 is pivoted to its raised, non-feeding, position by energization of electrical solenoid E-1 and is positioned in its intermediate position by electrical solenoid D-5, which is spaced farther from the pivot 58 of the feed finger 57 than the solenoid E-1 and thereby effects lesser movement of the operating end of the finger 57. When both solenoids are de-energized the spring 59 biases the auxiliary feed finger 57 in yarn feeding position for knitting with the auxiliary yarn 32.

When the auxiliary yarn 32 is raised out of feeding position by the auxiliary feed finger 57, it is cut by the auxiliary yarn cutting mechanism 60, which is illustrated in FIG. 9. This mechanism comprises simultaneously acting holddown and cutting blade arms 61 and 62, respectively, pivoted to the dial plate 44 and rocked by a connecting rod 63 extending from an operating rocker arm 64. The arms 60 and 61 are held in a raised inoperative position by energization of electric solenoid F-5 that pivots the rocker arm 64 to move the connecting rod 63 downwardly. Upon de-energization of the solenoid F-5 the spring 65 rocks the rocker arm 64 in the opposite direction to raise the connecting rod 63 and thereby pivot the holddown arm 61 and cutting blade arm 62 downwardly with the holddown arm 61 holding the auxiliary yarn 32 against the dial plate 44 and the cutting plate arm 62 cutting the yarn against a fixed blade 66 on the dial plate 44.

The knitting machine illustrated includes means for drawing loops of increased size when desired for any reason. These means include an auxiliary sinker cam 67 (FIG. 10) that is movable inwardly to advance the sinkers for drawing on the high top surfaces thereof and an auxiliary stitch cam 70 (FIG. 11) for lowering the needles deeper during drawing. The auxiliary sinker cam 67 is pivoted on the sinker cap 68 for movement into and out of operative position. The cam is moved into operative position by electrical solenoid D-3 and is moved to inoperative position by the spring 69, which pulls the cam outwardly upon de-energization of solenoid D-3.

The auxiliary stitch cam 70 is mounted in a bracket 71 for sliding movement radially into and out of operating position at the trailing edge of the main stitch cam 72. This auxiliary stitch cam 70 has an inclined camming surface 73 that extends downwardly from the end of the main stitch cam 72 so that when the auxiliary stitch cam 70 is in operating position it will engage the needle butts 74 and move them downwardly beyond the depth of draw caused by the main stitch cam 72. The auxiliary stitch cam 70 is actuated by an electrical spring biased solenoid D-2, which when energized shifts the auxiliary stitch cam 70 into operating position and when de-energized spring biases the cam to an outer or inoperative position.

After the stitches are drawn by action of the main stitch cam 72 and auxiliary stitch cam 70 or the main stitch cam 72 alone on the needle butts 74, the butts 74 ride up on the surface of the end cam 75 to position the needles for manipulation by subsequent operating components.

Following the end cam 75 is a needle lowering cam 76 that has a downwardly inclined camming surface 77 facing the end cam 75 for engagement of the needle butts 74 to lower the needles for jack selection for laying in or knitting with the auxiliary yarn 32. This needle lowering cam 76 is pivotally mounted on the base plate 78 for pivoting between an operative and inoperative position. Pivoting of the cam is actuated by electrical solenoid D-1, which is spring loaded. The cam is shifted to its inner operating position by energization of solenoid D-1 and is returned to its inoperative outer position by the spring loading of the solenoid when the solenoid is de-energized. To avoid breakage of needle butts 74 as cams, such as the

present needle lowering cam, are moved into operating position, half of the needles have short butts and the other half have long butts with the short butts arranged over 180° of the needle cylinder and the long butts arranged over the other 180° of the needle cylinder. With this arrangement of long and short butts the needle lowering cam 76 is first moved to its operating position when the short butts are adjacent the cam and the extended surface of the cam causes the cam to ride on the butts and remain inactive until the long butts reach the cam and engage the camming surface 77, riding down thereon and allowing the cam to shift fully to its operative position. When the short butts again reach the cam they will also engage the surface and be cammed downwardly.

The present knitting machine is constructed for both circular and reciprocal knitting, with reciprocal knitting being performed on the short butt needles. At the beginning of reciprocal knitting it is necessary to raise the long butt needles out of knitting position. This is done by the switch cam 79 of FIG. 14. This switch cam 79 extends into the path of the long butts only and is shiftable from a downwardly inclined position at which the long butts ride up on its top surface to inoperative positions, to an upwardly inclined position at which it engages the raised long butts and guides them along its lower surface to knitting positions at the end of reciprocal operation. The cam remains in this raised position during circular knitting.

Pivoting of the switch cam 79 is accomplished by mounting the cam 79 on shaft 80, which is journaled in the bracket 81 extending from the base plate 78. The shaft 80 and cam are pivoted by spring-loaded electric solenoid F-3, which when energized pivots the cam to one position and when de-energized pivots the cam by the spring loading to its other position.

During reciprocal knitting, conventional picks or lifters raise one short butt needle out of operation on each reciprocal stroke to effect narrowing of the fabric. This is a conventional operation and normally requires no extraneous control, being inherently inoperative during circular knitting, and therefore needs no further disclosure herein.

Widening of the fabric during reciprocal knitting is accomplished with a conventional dropper cam 82, illustrated in FIG. 13. This dropper cam 82 is mounted on a shaft 83, which in turn is pivoted in a slot 87 of a cross-shaft 84 that is oscillably mounted. Thus the cam can move both downwardly and laterally. The dropper cam 82 is pivoted from a lower inoperative position out of the path of needle butts to a raised operative position by action of spring loaded electrical solenoid E-4 acting to oscillate the cross-shaft 84. The dropper cam acts to drop two raised needles into knitting position at each stroke of reciprocation, functioning with the picks or lifters to produce a net addition of one needle to the knitting operation. The dropper cam 82 operates to engage the butts of the first two raised inoperative needles in the recessed portion 85 as the butts of the operating needles pass under the cam. When the first engaged butt contacts the inner surface of the recessed portion 85, it causes a pivoting of the cam laterally downwardly along a guide cam (not shown) so that the two needles are lowered into knitting position. As the lateral shifting continues the cam eventually moves out of the path of the engaged butts and moves back to its initial position at which its top surface 86 contacts the other raised butts, which hold the cam down sufficiently to avoid engagement of butts in the recessed portion 85. The opposite side of the cam operates in the same manner to drop two needles during the reverse stroke.

During circular knitting with both the main and auxiliary yarns, it is normally necessary to pull the needles down after passing the auxiliary yarn feed so as to position the auxiliary yarn in the needle hooks and align the needles

preparatory to receiving the main yarn. This is accomplished by a needle lowering cam 88 (FIG. 15), which engages the needle butts to lower all of the needles to a common position. Associated with this is a conventional sinker cam controlled by a spring arm 89, which, when held down, positions a sinker cam for alignment of the sinkers. As the sinkers and sinker cam are conventional and are not modified by the present invention, they are not illustrated herein.

Movement of the needle lowering cam 88 and spring arm 89 in and out of operating position is accomplished by the present invention with electric solenoids F-2 and E-3, which act through a bell crank 90 against a lug 91 fixed to a shaft 92 on the inner end of which is attached the cam 88 and on the outer end is attached a pivoted arm 93 that extends into engagement with the spring arm 89. The needle lowering cam 88 is moved from inoperative to operative position in two steps to avoid damage to the needle butts by first energizing solenoid F-2 that has a lesser stroke than solenoid E-3, so that the cam is positioned for engagement with the long butts but not the short butts. This movement is effected when the short butts are passing the cam so that the cam will be in proper position for engaging the long butts as they come around. While the long butts are being cammed, solenoid E-3 is energized to force the cam further inwardly in position for engaging the short butts. When the solenoids are de-energized, the spring arm 89 biases the cam to inoperative position.

After the needles leave the needle lowering cam 88 they ride up on the end cam 94 into position for knitting manipulation. However, when laying-in a number of revolutions of auxiliary yarn without knitting, it is necessary to retain the needles below a determinable level to prevent the layed-in yarn from sliding off the latches. This is accomplished by a divider cam 95 (FIG. 16) that guides the needles to the underside of the subsequent cams. This divider cam 95 is mounted for movement into and out of operating position in bracket 96 and is manipulated through an operating lever 97 pivoted at 98. The opposite end of the lever 97 has attached thereto the pistons from electric solenoids F-1 and E-2 at different spacings from the pivot 98. When the solenoids are energized the divider cam 95 is drawn to its inoperative position. When the solenoid E-2 is de-energized the divider cam 95 is positioned for engagement with the long butts only, and when both solenoids are de-energized the divider cam 95 is in operating position, due to spring loading of the solenoids, for engaging both the short butts and the long butts. The sequence of operation is the same as that indicated for the needle lowering cam 88 above.

From the above it is apparent that the present invention provides control components for the needles, sinkers and yarn and a highly simplified and compact arrangement with the actuating solenoids arranged efficiently at the locations where the actual operating components are located, thus providing a compact and simple knitting machine and also permitting easy access for repairs and replacement, as well as making repair and replacement easy due to the substantial reduction in operating parts.

Turning now to the cylinder drive components, reference is made first to FIG. 2, which shows the needle cylinder 99 driven by a small electric motor 100. Rotation of the motor shaft 101 is transmitted into rotation of the cylinder 99 by a small bevel gear 102 on the end of the motor shaft 101 and mating with a large diameter bevel gear ring 103 secured to the base of the knitting cylinder 99. The drive motor 100 is mounted on the supporting platform 104 on which the cylinder 99 is supported, and which platform moves up and down to change the axial position of the needle cylinder as will be described below. Thus the drive motor 100 is retained in proper relation for driving the cylinder at all times.

The drive motor 100 is operable at various speeds and

can be reversed to effect reciprocation. Control of the speed of rotation and reciprocal operation is obtained through the speed decoder and drive mechanism components of the remote control means illustrated diagrammatically in FIG. 19. The circuitry of the control is illustrated in FIG. 23 and will be described in detail below.

The cylinder positioning components are illustrated in FIGS. 2 and 3 and the control of these components through the remote control means are illustrated in FIGS. 19 and 22. The cylinder positioning components cooperate to adjust the axial position of the knitting cylinder 99 to control the depth of draw by the needles for conventional purposes. This shifting of the cylinder 99 is accomplished uniquely by the present invention through the operation of the electric positioning motor 105 mounted on the knitting machine below the cylinder platform 104 and driving a lead screw 106 extending vertically into threaded engagement in a nut 107 secured to the platform 104 so that rotation of the lead screw 106 by the positioning motor 105 causes the nut 107 and attached platform 104 to move up or down. Rotation of the platform is prevented by a fixed rod 108 secured to the knitting machine and extending through an opening in the platform 104 at a point spaced laterally from the lead screw 106.

Control of the positioning motor 105 to adjust the position of the cylinder 99 is accomplished through the series of selector switches 109 shown at the left of FIG. 2 and also in FIG. 3. The switches 109 are mounted on a bracket 110 on the movable platform 104 to move up and down with the cylinder. Vertically aligned with the switches 109 are a series of switch operating rods 111. These rods 111 are adjustably secured in the fixed platform 112 that supports the base plate 78 of the knitting machine. These rods 111 are threaded so that they can be advanced or retracted through the nuts 113 fixed to the fixed platform 112 to raise or lower their height in relation to the selector switches 109, and each of the rods 111 is preferably positioned at a different vertical level corresponding to desired cylinder positions during knitting operation.

The selector switches 109 are connected to the remote control means for selection in response to the program as will be described in more detail below, and the remote control means control energization of the positioning motor 105 with the circuit being so arranged that when the cylinder moves downwardly to a selected position at which the program selected selector switch 109 is closed the motor will be stopped and the cylinder held at that position, and similarly upward cylinder movement is stopped when a selected switch is opened. The cylinder position is changed by a change in the selection of the switches 109 and energization of the motor 105 to move up or down as desired.

From the above it is apparent that the present invention provides a simple, positive and compact means of positioning the cylinder adjustably for varying stitch size through automatic control means.

As all of the operating components described above are actuated or controlled electrically, they are readily adaptable to the remote, program-responsive control means now to be described. This electrical control facilitates convenient location of the control means remotely of the knitting machine, requiring only electrical wiring for connection of the control means and operating components on the knitting machine. Thus all of the electrical control elements may be located in a console 114, such as illustrated in FIG. 17, and the console can be placed at any convenient location either near or far from the knitting machine. For example, the console could be located in a control room or other office while the knitting machine is located in the knitting room. The console could even be located in a different building. The electrical connection of the control means to the

operating components also permits a single console to control a plurality or multitude of knitting machines simply by connecting the corresponding components of all machines to the same control element of the control means.

As illustrated in FIG. 19, the remote, program-responsive, control means of the embodiment illustrated comprises a Tape Reader section, a Tape Decoder section and a plurality of control sections responsive to the signal from the Tape Decoder. These control sections comprise a Cylinder Positioning Decoder that is responsive to a signal from the Tape Decoder to interpret that signal and apply it to the Cylinder Positioning Mechanism described above with reference to FIGS. 2 and 3, for moving the Knitting Cylinder 99 axially. Appropriate signals from the Tape Decoder provide pulses for actuation of the above described Cam Solenoids that control the needle, sinker and yarn operating components described above with reference to FIGS. 4 through 16. The Speed Decoder interprets appropriate signals from the Tape Decoder for control of the Drive Mechanism that rotates and reciprocates the Knitting Cylinder. Also responsive to signals from the Tape Decoder is the Reader Drive and Counter section, which controls advance of the program tape stepwise in relation to signals received from Position Switches that detect every half revolution of the Knitting Cylinder. The Reader Drive and Counter section also operates in response to signals from the Tape Decoder to deactivate tape advance and activate counters that count a predetermined number of cylinder revolutions as pulsed by the position Switches, during which counting period knitting is continued for the pre-determined number of courses with the operating components remaining in one position, following which counting period the tape is again advanced stepwise in relation to knitting cylinder rotation.

Each of the above mentioned sections of the remote, program-responsive, control means of the present embodiment will now be described.

The Tape Reader section is illustrated at the left of FIG. 21. Upon a signal from the Reader Drive and Counter section the reader drive coil 115 is energized as will be described further below, to advance the tape stepwise across the contact plate 116 for sensing by feeler fingers 117, which make contact with the contact plate 116 through holes punched in the tape in accordance with a pre-determined program. A section of tape 118 is illustrated in FIG. 18. This tape is an eight-hole tape, that is, it has eight hole positions that can be punched to provide the pre-determined program. The first three hole positions are utilized to designate address groups and are read by feeler fingers 117a, 117b, and 117c. The other five holes in the tape 118 are aligned with feeler fingers 117d, 117e, 117f, 117g, and 117h to provide an action signal within the address group sensed by the first three feeler fingers.

Each of the feeler fingers 117 is electrically connected to a corresponding electrical relay, R-1 through R-8, respectively, of the Tape Decoder section. These relays are provided to protect the feeler fingers from current surges. The first three relays R-1, R-2 and R-3 are connected in a decoding matrix 119 in a binary system to provide six address groups, A, B, C, D, E and F from the various combinations of one-off positions of the relays in response to the tape reading. The address group signal leads and the five action signal leads are connected to the various control sections that operate in response to a particular address group and action signal.

Address groups C, D, E, and F lead to the Cam Solenoids section of the control means for activation of the solenoids that actuate the operating components of the needle, sinker and yarn control element described in detail above. In the above description, the solenoids were given letter and number designations, which correspond to the address group and action number of the signal

from the control means that activates the particular solenoid.

The circuitry for a typical solenoid is illustrated in FIG. 20. The lower line on the left is the address group line, designated group C for illustration. The upper line at the left is the action number line, designated 3 for example. When group C and action 3 are energized, the relay 120 activates solenoid C-3, in this case lowering one of the main yarn feed fingers 38. The diode 121 is provided to prevent "sneak" circuits.

Circuits identical to that described above in FIG. 20 are provided for operating the other solenoids, all of which are pulse-type latching relays that remain in one position until a subsequent signal is received. Thus, one pulse would move the solenoid to one position and a second pulse would be necessary to move it back to the original position.

The Cylinder Positioning Decoder section of the control means is responsive to signals B-1, B-2 and B-5 from the Tape Decoder section. As seen at the left of FIG. 22, group B line and action 1 line are connected through relay 122, and group B line and action 2 line are connected through relay 123. These relays are arranged in a binary decoding matrix 124 that interprets the various combinations of activation and deactivation of the relays to energize one of four lines, each of which is connected to one of the four selector switches 109 illustrated in FIGS. 2 and 3 for selection of the desired axial position of the needle cylinder 99.

As illustrated in FIGS. 2, 3 and 22, the knitting cylinder 99 is in its uppermost position. To move the cylinder downwardly to a selected position, a pulse from group B line and action 5 line pulses relay 125 at the upper right of FIG. 22 to connect the drive circuit 126 to the line 127 from the upper contacts of the selector switches 109. This energizes the positioning motor 105 through the four contacts 128 of relay 125 for a rotation to cause downward movement of the cylinder on the lead screw 106. The other coil of the positioning motor is simultaneously energized through lead line 129. Lead line 129 is then routed by the relay contacts 128 to rheostat 130 to control overshoot of the positioning motor 105 in the downward direction due to the inertia of the cylinder in moving downwardly. When the selected cylinder position is reached, the selected switch 109 will be moved to the opposite contact to open the circuit and de-energize the positioning motor 105.

To raise the cylinder to a new position, relay 125 is pulsed by address group B and action 5 to reverse the relay contacts 128, thereby reversing the input to the positioning motor 105 and at the same time causing lead line 129 to bypass the rheostat 130. When the selected selector switch 109 is contacted and moved to the opposite contact, the drive circuit 126 will be de-energized and the cylinder will remain at that selected position until changed by the program.

The Speed Decoder section is illustrated at the left in FIG. 23 and the Drive Mechanism section is illustrated at the right in FIG. 23. These sections function to control operation of the drive motor 100 to control the speed of rotation and reciprocation of the needle cylinder 99. These controls are actuated by group B actions 3 and 4.

Address group B line and action 3 line are connected through relay 131 and address group B line and action 4 line are connected through relay 132. These two relays actuate a binary decoding matrix that selects contact with either one of three potentiometers P-1, P-2, and P-3, each of which can be preset at a desired voltage to provide different operating speeds for the drive motor 100. As an example, potentiometer P-1 may be set for high speed operation, potentiometer P-2 may be set for the operating speed during reciprocation, and potentiometer P-3 may be set for low speed operation. The particular potentiometer selected by the matrix 133 is connected by lead line 134 to an amplifier 135 and thence to the drive

motor 100, which is preferably a D.C. servo motor stabilized by a tachometer 136 responsive to position switches S-1 and S-2. These switches are located on the knitting machine adjacent the knitting cylinder 99 and are spaced 180° apart. They are tripped by an element carried by the needle cylinder 99 so that each switch is tripped each revolution of the cylinder with the two switches providing a signal each half revolution of the cylinder.

Also mounted for tripping by rotation of the knitting cylinder 99 is a reversing switch 137 that is tripped during reciprocation when the short butts are symmetrically opposite the main yarn feed fingers 38 in each direction of reciprocation. This reversing switch 137 is moved alternately to and from a positive voltage contact and a negative voltage contact to reverse the current to a reversing relay 138 and to the decoding matrix 133, which actuates the reversing relay circuit at the same time that the reciprocating speed potentiometer P-2 is selected. The reversing switch 137, through the reversing relay 138, operates a reversing matrix 139 in the circuit of the motor field 140 to effect reciprocal operation of the knitting cylinder.

The Reader Drive and Counter section is illustrated in FIG. 24. This section receives pulses from the position switches S-1 and S-2 and transmits these pulses to the reader drive coil 115 of FIG. 21 to advance the program tape stepwise through the Tape Reader section to position the holes in the tape for reading by the feeler fingers 117. Each pulse advances the tape one row of holes. During some knitting machine operations it is desirable that the operating components be actuated only in response to one or the other of the position switches, as when a cam is to be advanced when short butts are passing, or for any other desired reason. To accomplish this, the position switches S-1 and S-2 are connected to respective relays 141 and 142. Relay 141 is controlled by address group A line and action 4 line, and relay 142 is controlled by address group A line and action 5 line. When these relays are inactive, both position switches pulse the reader drive coil 115, but when either of the relays is actuated the associated position switch is deactivated so that only the other switch pulses the reader drive coil.

Also incorporated in the Reader Drive and Counter section are counting means that deactivate the reader drive coil 114 during a predetermined number of revolutions of the needle cylinder 99. In the embodiment illustrated there are two counters 143 and 144, each of which is activated at a different period of the knitting cycle, as for example, one could be activated during knitting of the leg portion of hosiery and the other could be activated during the knitting of the foot portion. These counters are of conventional construction and operation, having a switch 145 that is normally closed to connect the position switches with the reader drive coil and which is opened by activation of a counter clutch 146 that holds the switch 145 open as the pulses from the position switches are counted by a counter coil 147 that has been preset to count a selected number of pulses, after which it de-energizes the counter clutch 146, permitting the switch 145 to return to closed position and resume pulsing of the reader drive coil.

The counters are actuated by relays 148 and 149, respectively. These relays are not latching relays similar to the previously described relays, but return to their initial position as soon as the relay is de-energized. Relay 148 controlling counter 143 is energized by address group A line and action 2 line, and relay 149 controlling operation of counter 144 is actuated by address group A line and action 3 line.

All of the relay logic circuitry of the entire control means described above may be enclosed in the aforementioned console 114 of FIG. 17, which has on its front panel three control dials 150 for setting the potentiometers P-1, P-2 and P-3 for control of the operating speeds, two control dials 151 for setting the desired number of

pulses to be counted by the counters 143 and 144, and the bracket 152 on which the tape 118 is advanced and read. The panel also mounts eight manual switches 153 that correspond to the eight hole positions of the tape for manually energizing the control means in relation to a selected address group and action line pulse.

From the above it is apparent that the remote, program-responsive, control means of the present invention provide a high degree of selectivity in operation of the various components of the knitting machine without requiring complex structures at the machine. It should be understood that the present invention is not intended to be limited to the specific details of the embodiment described as the individual elements and control of the elements could be varied considerably within the scope of the present invention. With particular reference to the electrical elements of the control means, various changes in the circuitry, components and operation could be made within the purview of the present invention. Thus an electronic system of solid state diodes and transistors could be substituted for the relay logic described above to insure reliability and to reduce substantially the size of the console. Also, it should be understood that an optical tape reader or other type of tape reader could be substituted for the contact reader described above. Further redundant circuits could be added as well as feed back circuits to increase reliability and isolate malfunctions, particularly where a number of knitting machines are being controlled from a single remote control means. In a single control of a multitude of knitting machines, it could also be possible to set the individual machines for knitting different sizes of knitted articles by varying the counting for the different machines.

The present invention has been described in detail above for purposes of illustration only and is not intended to be limited by this description or otherwise except as defined in the appended claims.

We claim:

1. A circular knitting machine incorporating circularly movable elements cooperating with other elements to form circular knit fabric, drive means for rotating said circularly movable elements, an electrically controlled operating component associated with said drive means for selectively controlling operation of said drive means, a plurality of other operating components arranged at locations about said knitting machine for controlling the cooperation of said elements, individual electrically controlled actuating means at each of said locations associated with the independent operating component thereat to operate said components independently, and program responsive electrical control means connected to said actuating means for electrically controlling said actuating means selectively in response to a preselected program.

2. A circular knitting machine incorporating circularly movable elements cooperating with other elements to form circular knit fabric, respective remotely controlled means for controlling the cooperation of said elements, drive means for rotating said circularly movable elements, one of said respective remotely controlled means being associated with said drive means for selectively controlling operation of said drive means, program responsive means for remotely controlling selectively said respective controlled means, and means electrically responsive to rotation of said circularly movable elements for advancing a program bearing element for reading of the program by said program responsive means synchronous with the knitting element rotation.

3. A circular knitting machine according to claim 1 and characterized further by counting means electrically responsive to rotation of said circularly movable elements and activated by said program responsive means in response to a specific program indication for counting a preselected number of knitting element rotations and deactivating said program advancing means during said counting.

4. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, respective remotely controlled means for controlling the cooperation of said knitting elements, drive means for rotating said cylinder, one of said respective remotely controlled means being associated with said drive means for selectively controlling operation of said drive means, program responsive means for remotely controlling selectively said respective remotely controlled means, and means electrically responsive to rotation of said cylinder for stepwise advancing a program bearing element for reading of the program by said program responsive means in relation to cylinder rotation.

5. A circular knitting machine according to claim 4 and characterized further by counting means electrically responsive to rotation of said cylinder and activated by said program responsive means in response to a specific program indication for counting a preselected number of said cylinder rotations and deactivating said program advancing means during said counting.

6. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, respective electrically controlled means for controlling the cooperation of said knitting elements, drive means for rotating said cylinder, one of said electrically controlled means being associated with said drive means for selectively controlling operation of said drive means, another of said electrically controlled means being means for shifting said cylinder axially to change the depth to which yarn is drawn by said knitting elements, and program responsive means for electrically controlling selectively said respective controlled means.

7. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, independent, electrically controlled, operating components located about said machine and confunctioning to control the operation of said knitting elements, each operating component being independently operable to permit any desired operating combination, cylinder drive means for rotating and reciprocating said cylinder, an electrically controlled operating component associated with said cylinder drive means independently of other operating components for selectively controlling operation of said drive means, cylinder shifting means for shifting said cylinder axially to change the depth to which yarn is drawn by said knitting elements, an electrically controlled operating component associated with said cylinder shifting means independent of other operating components for selectively controlling the operation of said cylinder shifting means, and an automatic control system having electrical, program responsive, means electrically connected to said independent operating components for selectively operating said components in response to a preselected program.

8. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, respective electrically controlled means for controlling the cooperation of said knitting elements, means for shifting said cylinder axially to change the depth to which yarn is drawn by said knitting elements, means for sensing various axial positions of said cylinder and selectively operable to deactivate said cylinder shifting means when said cylinder is sensed at a selected one of said various positions, one of said electrically

controlled means controlling the operation of said sensing means to select a cylinder position at which said cylinder shifting means is to be deactivated, and program responsive means for electrically controlling selectively said responsive controlled means.

9. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, means for shifting said cylinder axially to change the depth to which yarn is drawn by said knitting elements, means for sensing various axial positions of said cylinder and selectively operable to deactivate said cylinder shifting means when said cylinder is sensed at a selected one of said various positions, means for controlling the operation of said sensing means to select a cylinder position at which said cylinder shifting means is to be deactivated.

10. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, means for shifting some of said knitting elements to change the depth to which yarn is drawn by said knitting elements, means for sensing various positions of said some elements and selectively operable to deactivate said shifting means when said some elements are sensed at a selected one of said various positions, means for controlling the operation of said sensing means to select an element position at which said shifting means is to be deactivated.

11. A circular knitting machine incorporating a circularly movable cylinder carrying knitting elements that cooperate with other knitting elements to form circular knit fabric, means for shifting said cylinder axially to change the depth to which yarn is drawn by said knitting elements, a plurality of cylinder position sensing components arranged at various cylinder levels to sense various positions of the cylinder and selectively operable to control said shifting means for shifting of said cylinder from one position to another, and program responsive means for controlling selection of said sensing components to effect shifting of said cylinder to a selected position.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,232,079

February 1, 1966

Richard G. Levine et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 10, for "likages" read -- linkages --;
column 9, line 64, for "one-off" read -- on-off --; column 12,
line 68, for the claim reference numeral "1" read -- 2 --;
column 14, line 5, for "responsive" read -- respective --.

Signed and sealed this 8th day of November 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents