No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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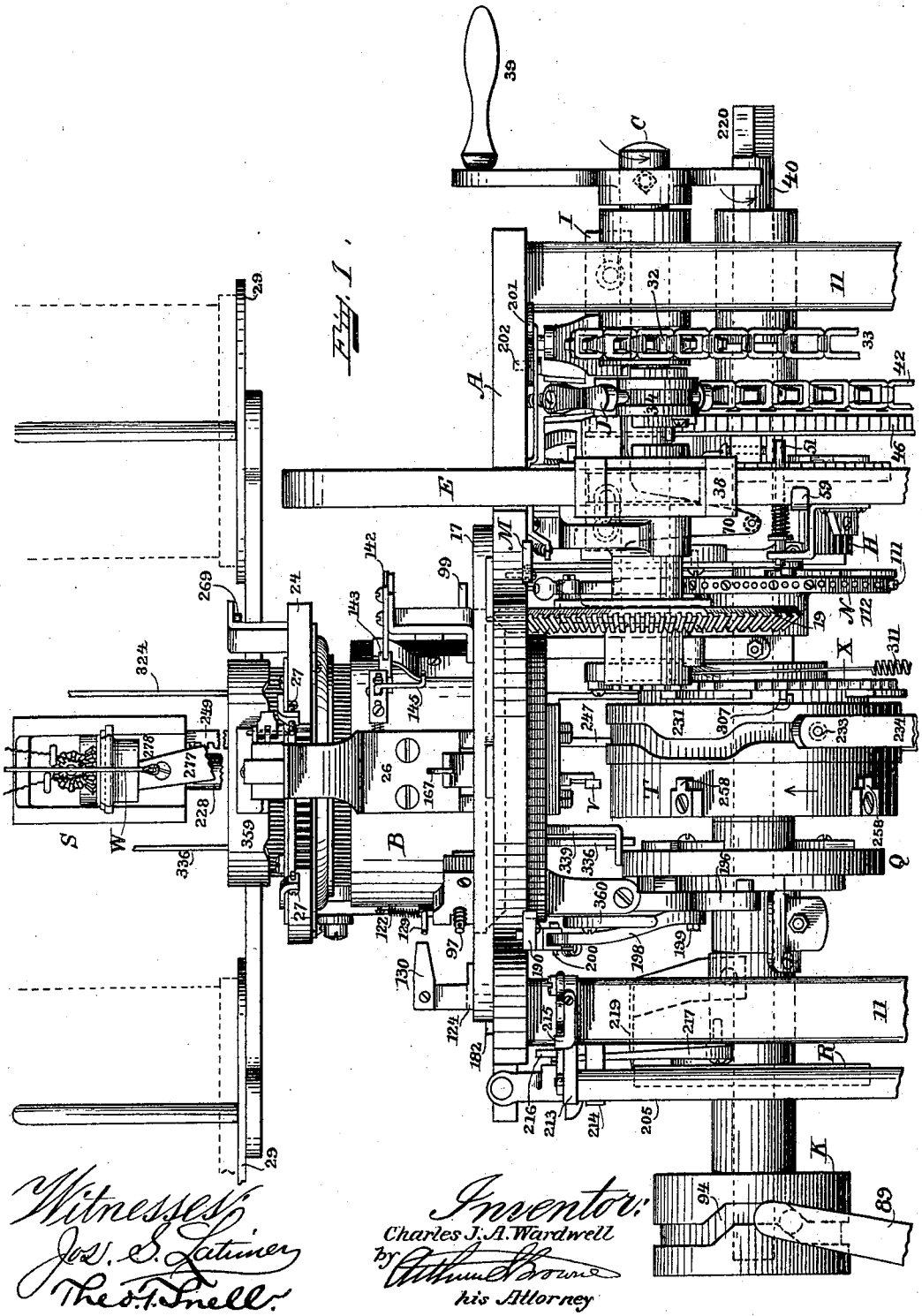

Witnesses:
Jos. D. Latimer
Theo. L. Snell.

Inventor:
Charles J. A. Wardwell
by Arthur Brown
his Attorney

No. 649,021. Patented May 8, 1900.

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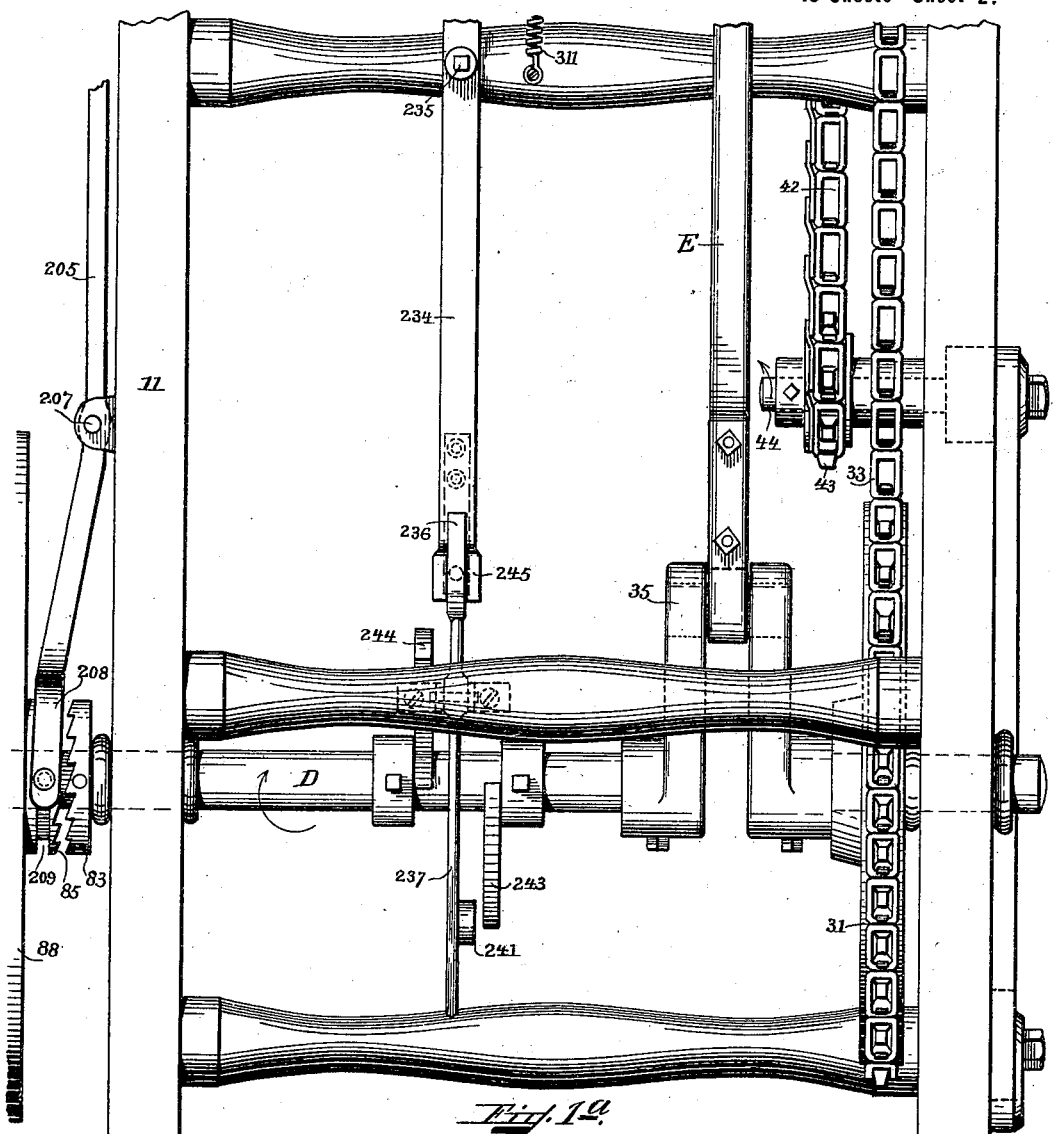

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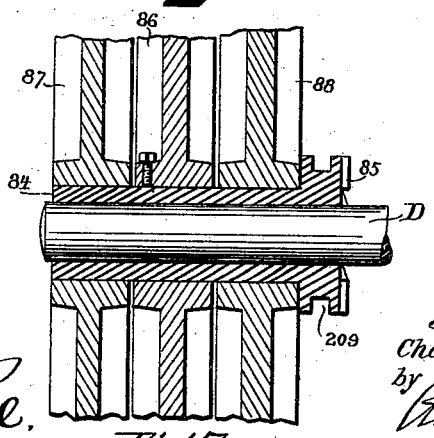

Fig. 7

Witnesses:
Jos. D. Latimer
Theo. T. Snell.

Inventor:
Charles J. A. Wardwell
by Arthur S. Bowie
his Attorney

No. 649,021. Patented May 8, 1900.

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(Application filed Mar. 7, 1898.)

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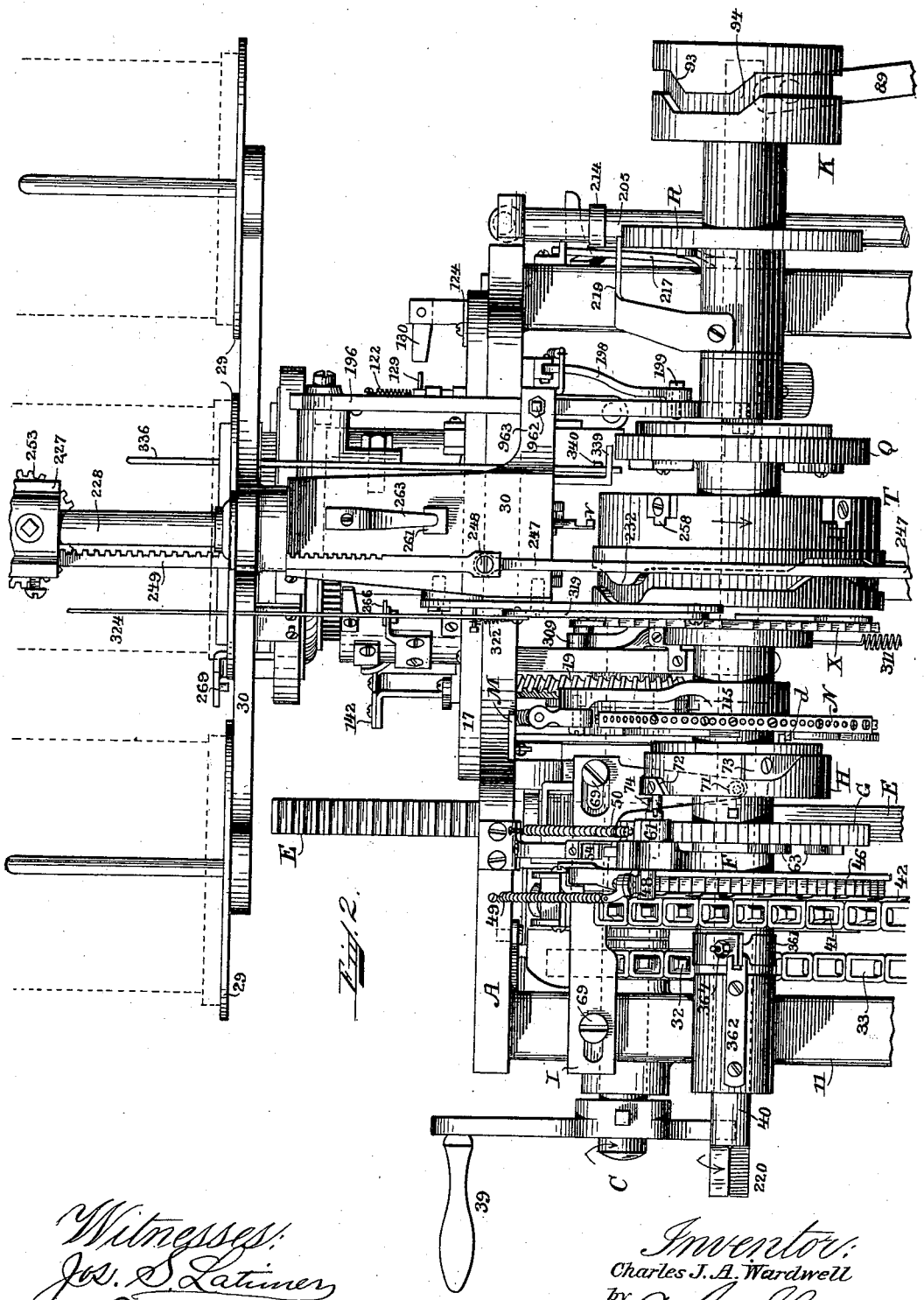

Fig. 2.

Witnesses:
Jos. D. Latimer
Theo. T. Snell.

Inventor:
Charles J. A. Wardwell
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No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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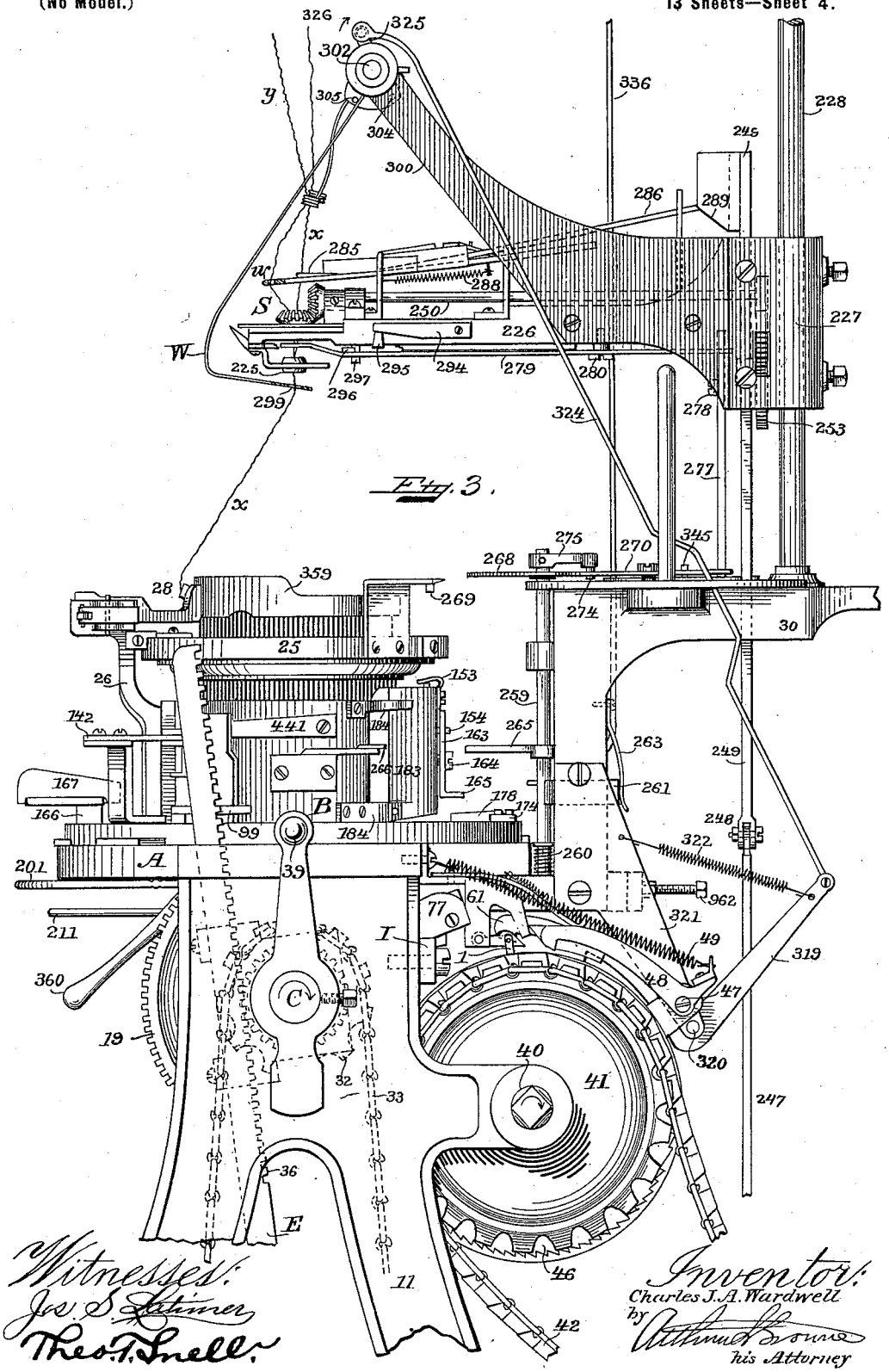

Fig. 3.

Witnesses:
Jos. S. Latimer
Theo. L. Snell.

Inventor:
Charles J. A. Wardwell
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No. 649,021. Patented May 8, 1900.

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KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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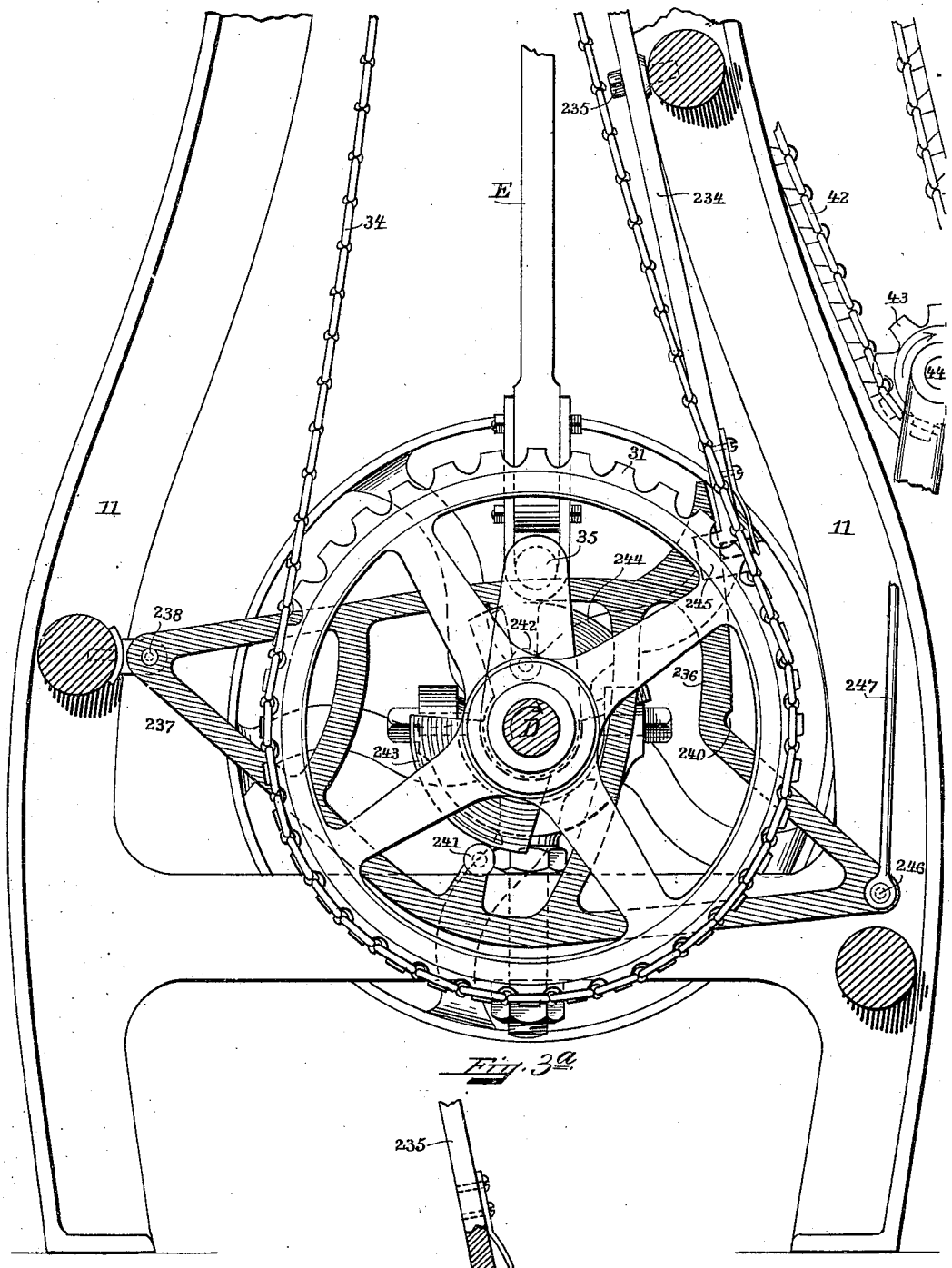

Fig. 3a.

Fig. 8.

Witnesses:
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No. 649,021. Patented May 8, 1900.

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KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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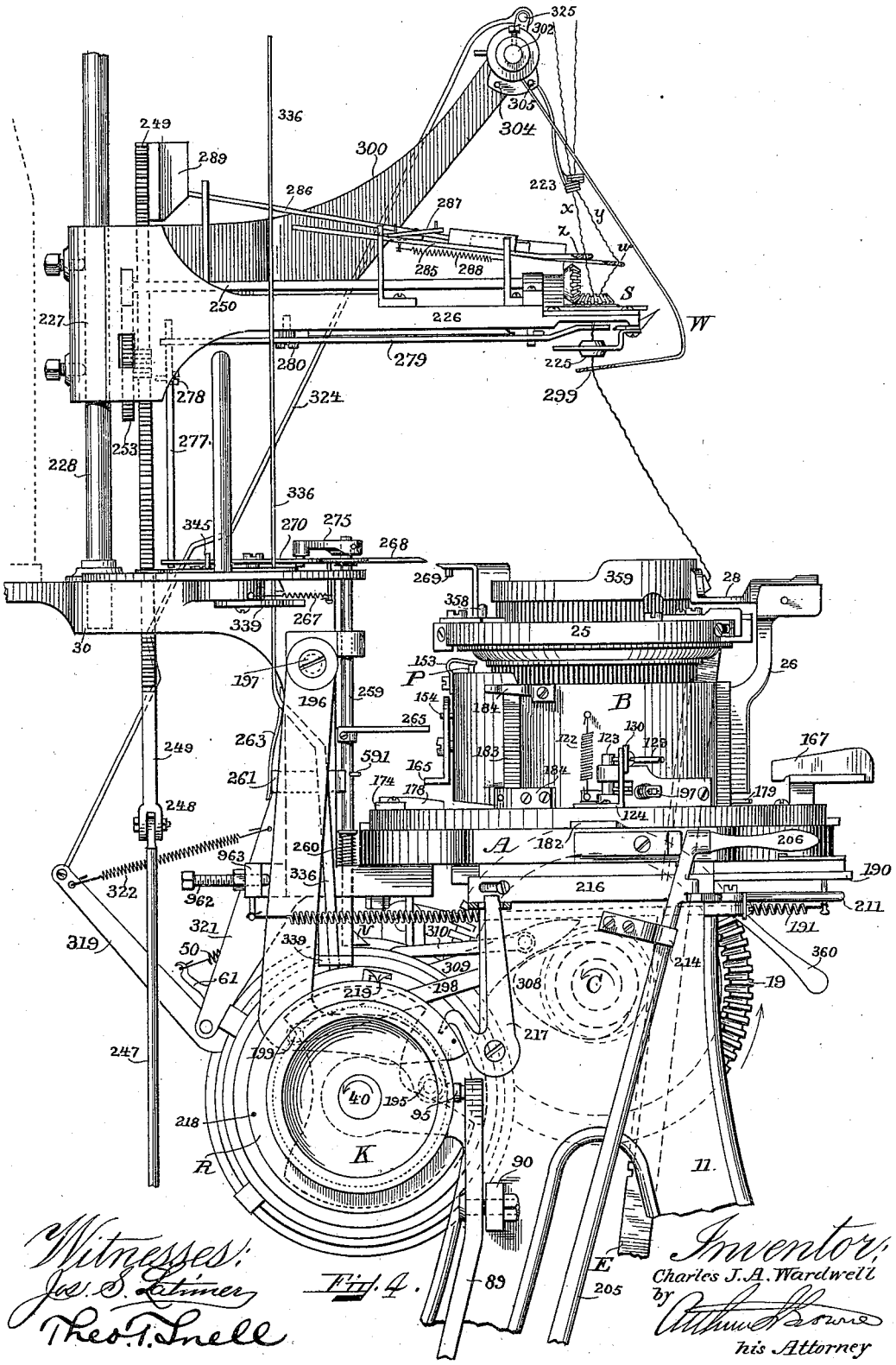

No. 649,021.

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C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

(No Model.)

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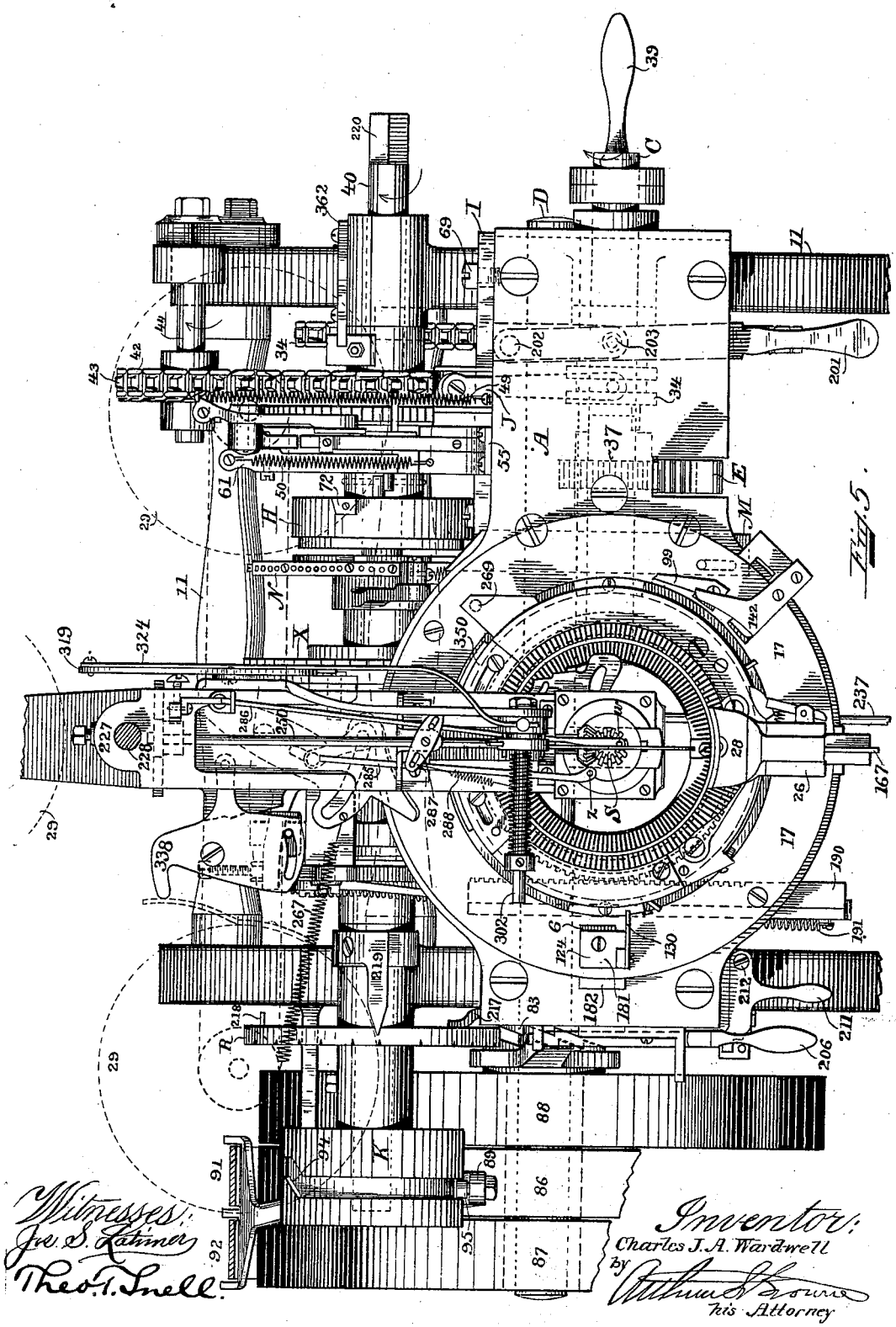

Fig. 5.

Witnesses:
Jos. S. Latimer
Theo. L. Snell.

Inventor:
Charles J. A. Wardwell
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his Attorney

No. 649,021. Patented May 8, 1900.

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KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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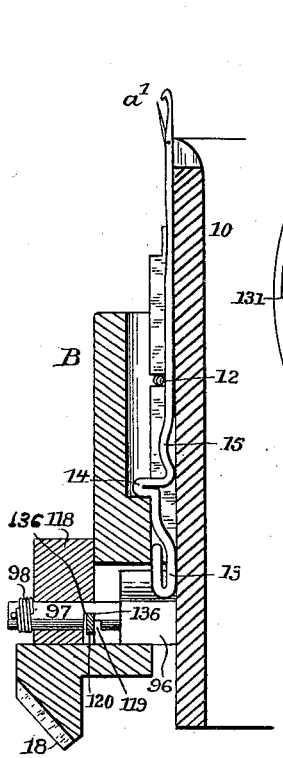

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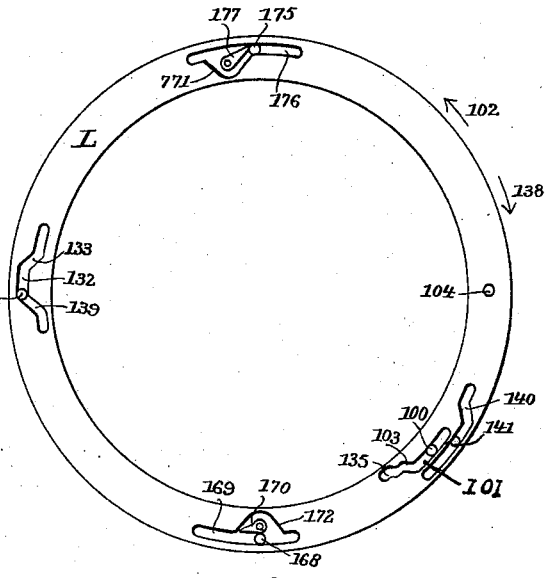

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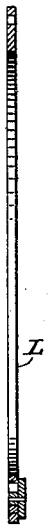

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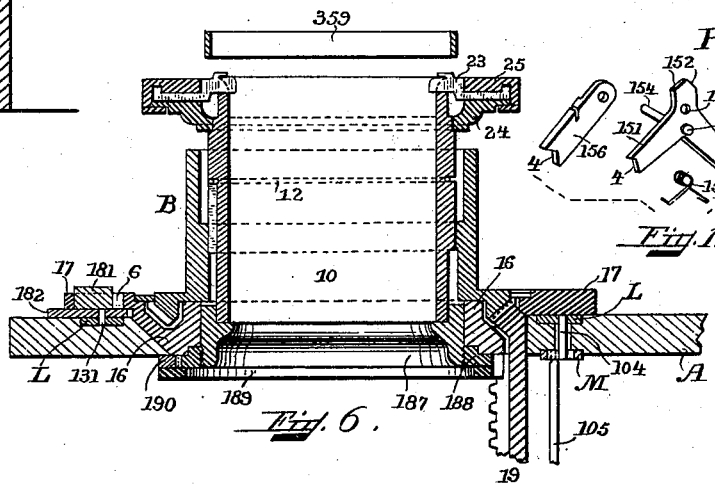
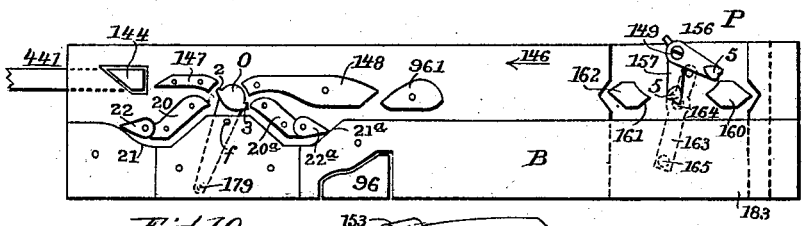


Fig. 6.

Fig. 12.



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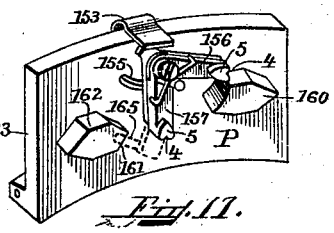

Fig. 11.

Witnesses:
Jos. D. Steiner
Theo. T. Snell.

Inventor:
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No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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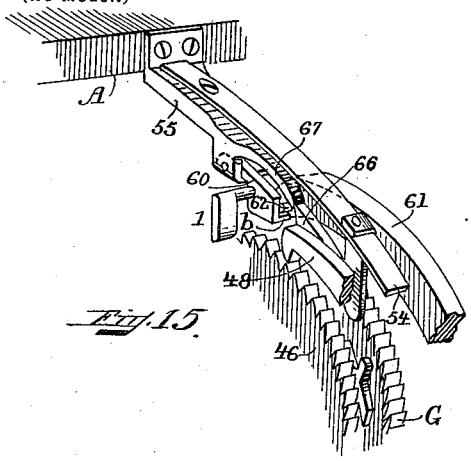

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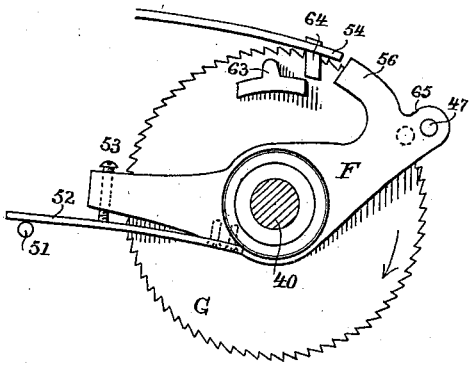

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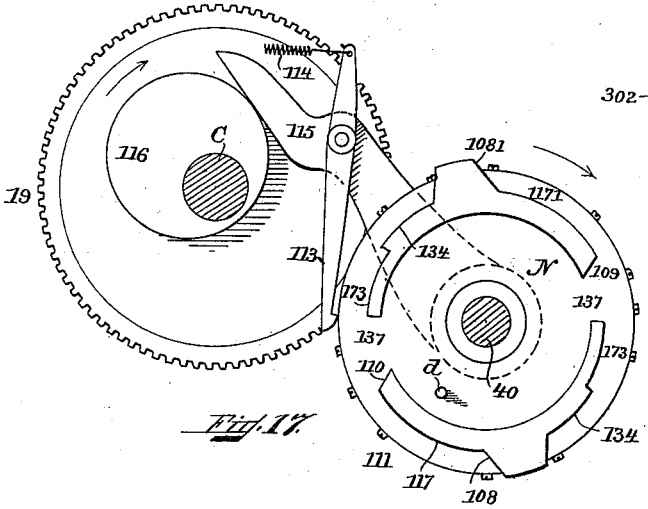

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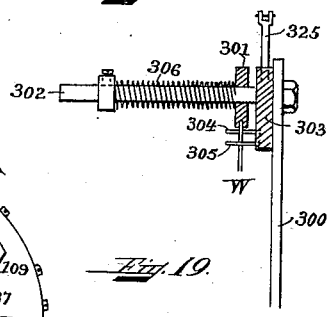

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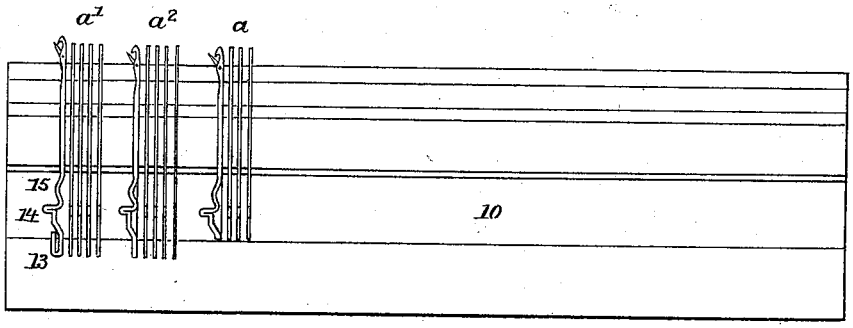

Fig. 18.

Witnesses:
Jos. S. Latimer
Theo. T. Snell.

Inventor:
Charles J. A. Wardwell.
by
Wilkinson & Browne
his Attorney

No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

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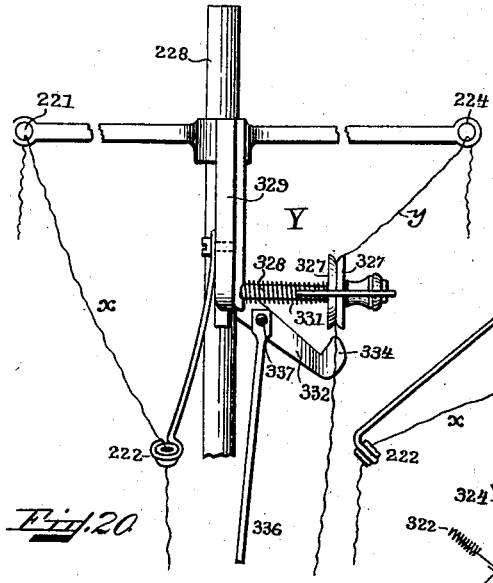

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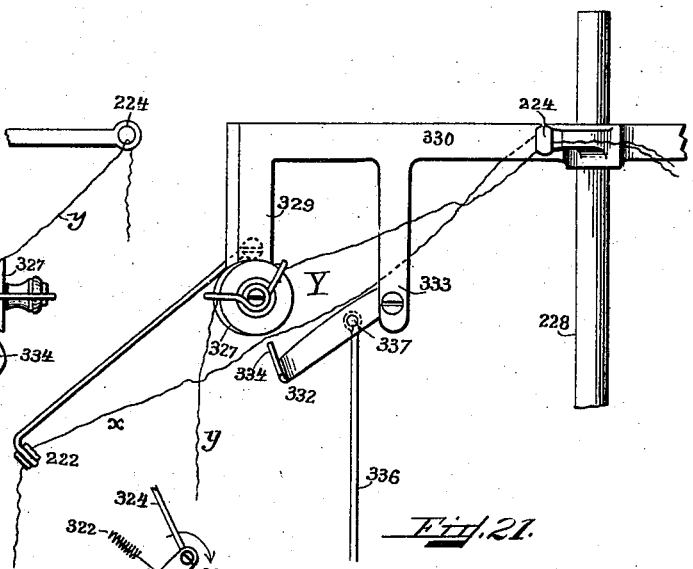

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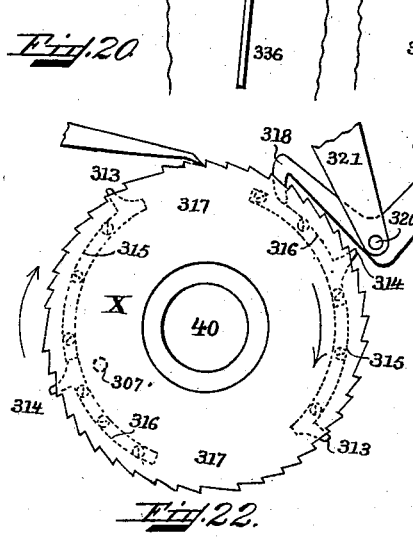

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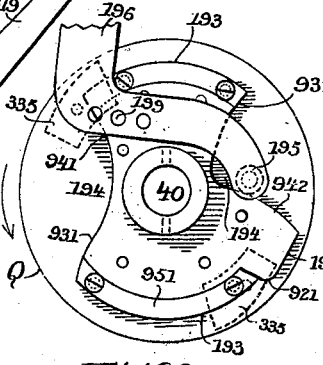

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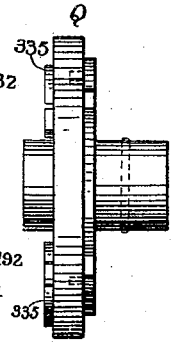

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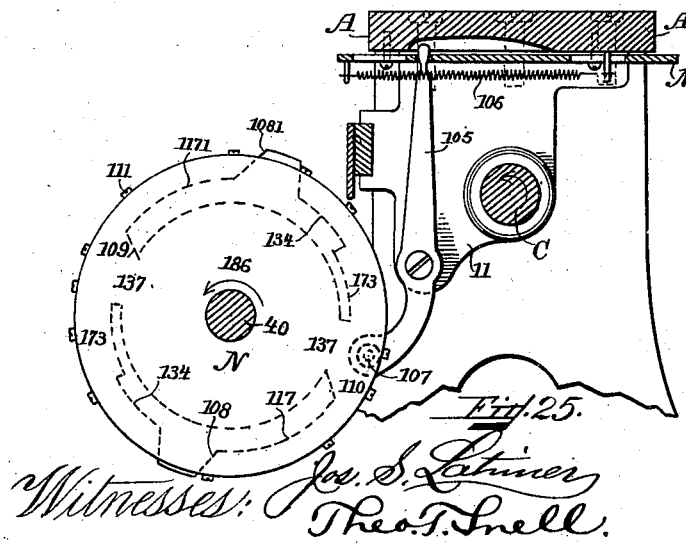

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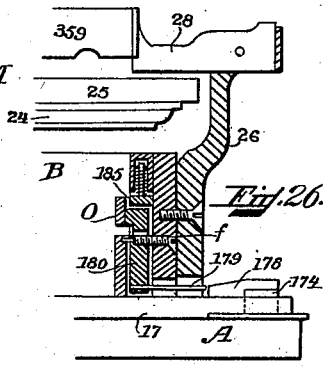

Fig. 26.

Witnesses:
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Theo. T. Snell.

Inventor:
Charles J. A. Wardwell
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his Attorney

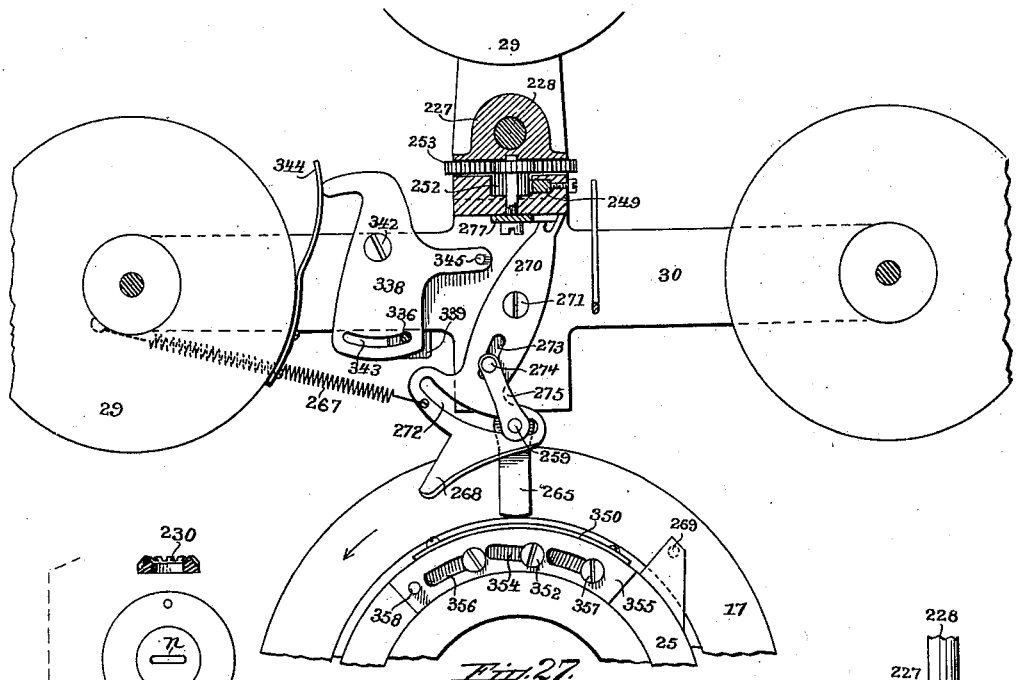
No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

(No Model.) 13 Sheets—Sheet II.



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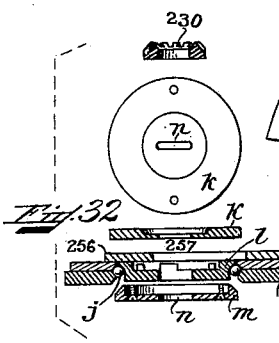

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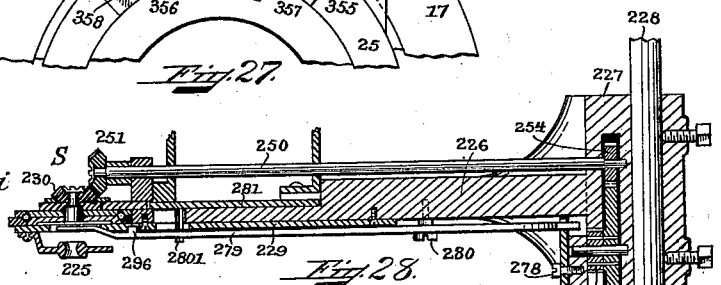

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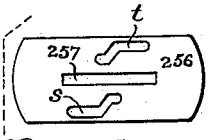

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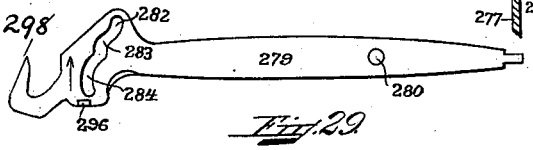

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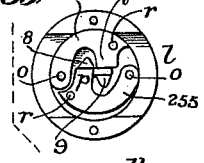

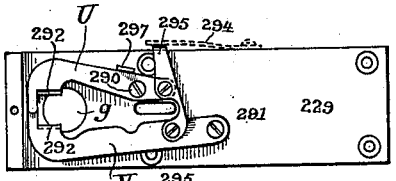

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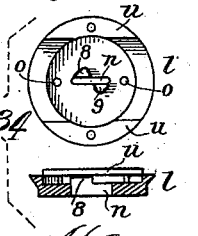

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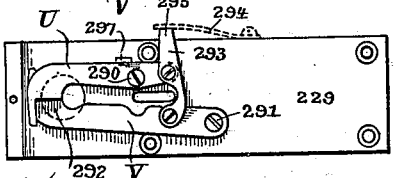

Fig. 31.

Witnesses:
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Theo. T. Snell.

Inventor:
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by Arthur A. Browne
his Attorney

No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

(Application filed Mar. 7, 1898.)

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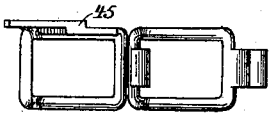

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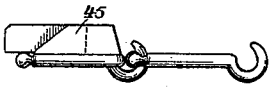

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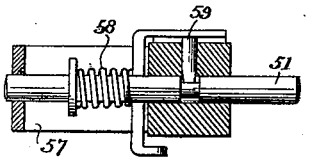

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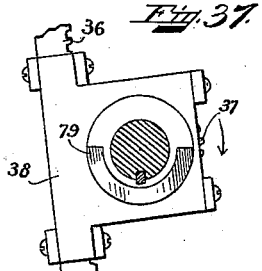

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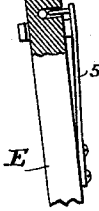

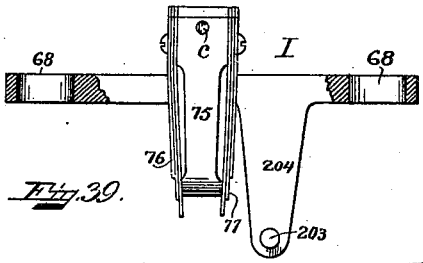

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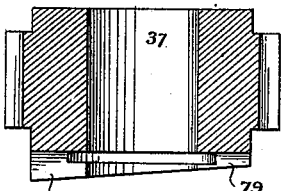

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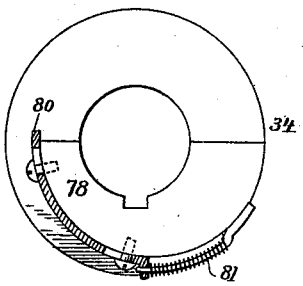

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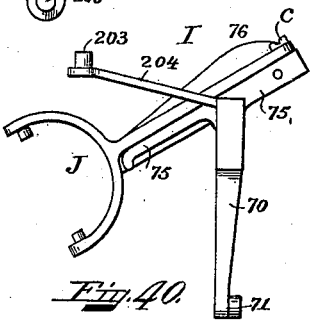

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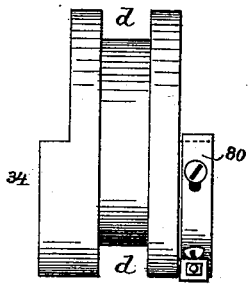

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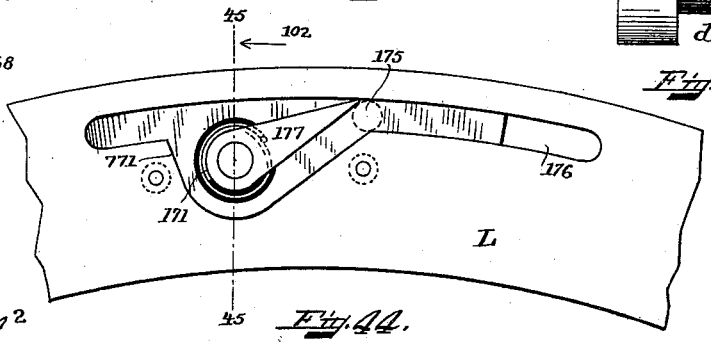

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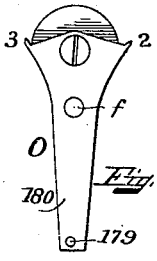

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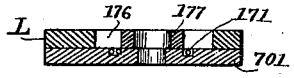

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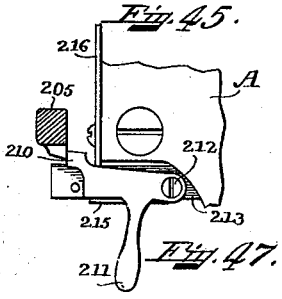

Fig. 47.

Witnesses:
Jos. S. Latimer
Theo. T. Snell.

Inventor:
Charles J. A. Wardwell
by Arthur S. Browne
his Attorney

No. 649,021. Patented May 8, 1900.

C. J. A. WARDWELL.

KNITTING MACHINE.

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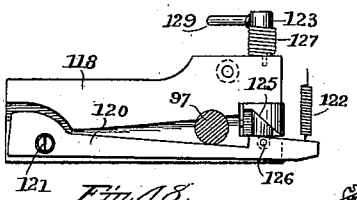

Fig. 48.

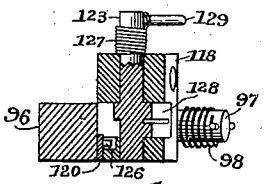

Fig. 49.

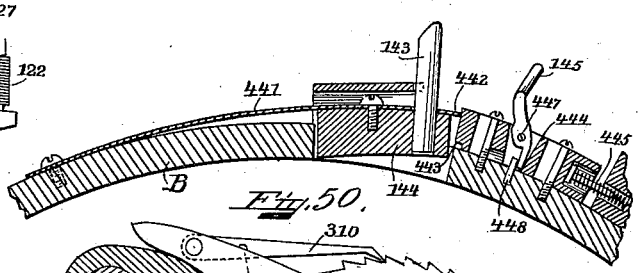

Fig. 50.

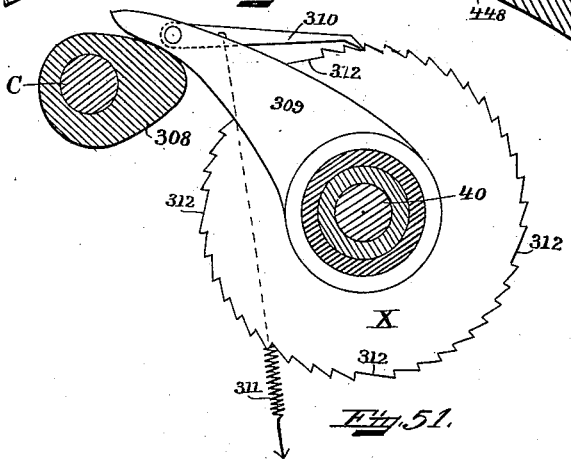

Fig. 51.

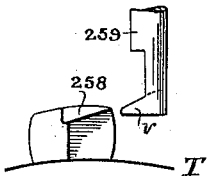

Fig. 52.

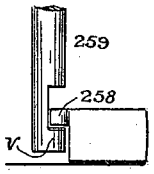

Fig. 53.

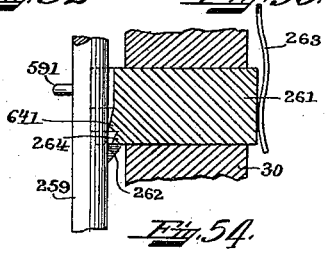

Fig. 54.

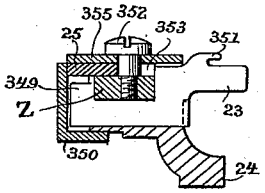

Fig. 57.

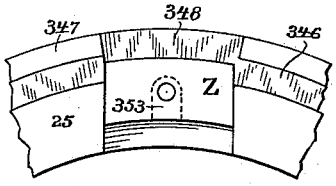

Fig. 58.

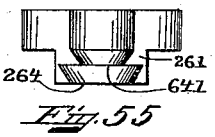

Fig. 55.

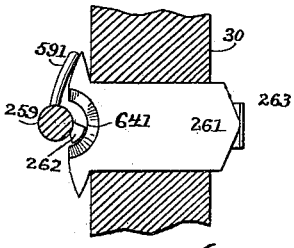

Fig. 56.

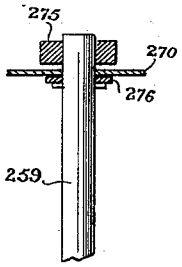

Fig. 59.

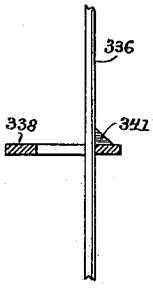

Fig. 60.

Witnesses:
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Theo. L. Snell.

Inventor:
Charles J. A. Wardwell
by Arthur O. Brown
his Attorney

UNITED STATES PATENT OFFICE.

CHARLES J. A. WARDWELL, OF LACONIA, NEW HAMPSHIRE, ASSIGNOR TO GEORGE H. TILTON, OF SAME PLACE, THOMAS S. FULLER, OF GILFORD, AND THE ASHLAND KNITTING COMPANY, OF ASHLAND, NEW HAMPSHIRE.

KNITTING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 649,021, dated May 8, 1900.

Application filed March 7, 1898. Serial No. 672,857. (No model.)

To all whom it may concern:

Be it known that I, CHARLES J. A. WARDWELL, of Laconia, in the county of Belknap and State of New Hampshire, have invented certain new and useful Improvements in Automatic Seamless-Knitting Machines, of which the following is a specification.

The present invention consists in certain improvements in a circular independent latch-needle knitting-machine which is capacitated to knit automatically a string of indefinite length of completely-knit stockings, each stocking having a seamless heel, a seamless toe, a foot, and a leg. The string of stockings after being knit is cut apart into individual stockings, the cut being between the toe of one stocking and the top of the leg of the adjacent stocking, thus requiring the toe to be subsequently seamed across its top to complete the stocking. The foot and leg of each stocking are knit in circular courses, the appropriate parts of the machine then rotating continuously in one direction, whereas the heel and toe are knit while the appropriate parts of the machine are reciprocating. When the heel is to be knit, somewhat less than one-half of the needles are thrown out of action, the loops being retained thereon, and the heel is knit by the usual narrowing and widening operations, one or more needles on each side of the heel-forming needles being first thrown out of action at each reciprocation, and then after the narrowing has thus proceeded sufficiently the needles are again brought into action in the same manner until all are restored. The toe is knit in the same way as the heel except that fewer needles are employed, so that the toe is smaller than the heel. During the reciprocating movement the machine is run at less speed than during the continuous circular movement. The toe and heel are knit more loosely than the foot and ankle and less loosely than the leg, thus conforming the shape of the stocking to its requirements, this being done by lengthening and shortening the stitches. The toe and heel are knit with two yarns, whereas the foot and leg are knit with a single yarn and preferably with a yarn separate and distinct from the two yarns for the heel and toe.

All of the foregoing results which are accomplished by a machine embodying the present improvements have heretofore been accomplished by automatic "whole-stocking" knitting-machines; and the present invention consists in improved mechanism for achieving these results, the purpose of the improvements being to produce a rapid, efficient, economical, and serviceable machine which is capable of turning out uniformly-good products, thus requiring the minimum care and attention, so that a single attendant can run a large number of machines.

The present improvements, besides including the general construction and organization of the machine and some special features of construction to be hereinafter more specifically mentioned, relate, first, to the mechanism for imparting alternately-reciprocating and continuously-rotating movements to the appropriate parts of the machine and for shifting automatically and at the proper times from one movement to the other; second, to the mechanism for imparting a slow speed during reciprocation and a rapid speed during continuous rotation and for changing automatically and at the proper times from one speed to the other; third, to the mechanism for automatically throwing into and out of action the appropriate needles in forming the heel and toe; fourth, to the mechanism for automatically stopping the machine after any given or predetermined cycle of movements; fifth, to the mechanism for automatically lengthening and shortening the stitches at the proper times; sixth, to the mechanism for automatically changing the yarns at the proper times; seventh, the mechanism for automatically taking up the slack yarn during reciprocation and for automatically slackening the yarn while changing yarns; eighth, to the mechanism for automatically relieving the tension on the heel and toe yarns when changing yarns, and, ninth, to the mechanism for shifting the sinkers to enable stitches to be placed on or taken off from the needles.

For the purpose of illustrating one concrete

embodiment of the present improvements they are shown in the accompanying drawings as embodied in a machine of the well-known type wherein the needle-cylinder is stationary and the knitting-cams rotate, and the illustrated machine is so organized as to knit the toe, foot, heel, and leg in the order named.

In the accompanying drawings, Figure 1 is a front view of the upper part of the machine, none of the parts above the plane of the yarn-changer being shown. Fig. 1ª is a front view of the lower part of the machine, a portion at one side being broken away. Fig. 2 is a rear view of the upper part of the machine, none of the parts above the plane of the yarn-changer being shown. Fig. 3 is a right side view of the upper part of the machine, looking at the same from the side which is at the right when facing the machine, and hence looking at the side which is shown at the right in Fig. 1. Fig. 3ª is a vertical section of the lower part of the machine, looking at the parts shown from the right. Fig. 4 is a left side view of the upper part of the machine. Fig. 5 is a plan view of the machine, the parts above the plane of the yarn-changer being removed. Fig. 6 is a vertical section through the needle-cylinder, knitting-cam ring, and bed-plate. Fig. 7 is a detail sectional view of a part of the drive-pulleys. Fig. 8 is a detail view of a part of the yarn-changer-operating mechanism. Fig. 9 is an enlarged detail sectional view of one side of the needle-cylinder and knitting-cam ring. Fig. 10 illustrates a development of the knitting-cams on a plane surface. Fig. 11 is a perspective view of the section of the cam-ring which carries the widening-cams. Fig. 12 shows details of the widening cams. Fig. 13 is a plan view of the ring which controls the movement of the parts which move the needles into and out of action. Fig. 14 is a sectional view of the said needle-controlling ring. Fig. 15 is a perspective view of a portion of the pattern-actuating devices. Fig. 16 is a vertical cross-section of the time-shaft, showing the initial portion of the pattern-actuating mechanism. Fig. 17 is a vertical cross-section through the main and time shafts, illustrating a portion of the mechanism timing the action of the needle-governing devices. Fig. 18 is a partial development on a plane surface of the periphery of the needle-cylinder, illustrating the different kinds of needles employed. Fig. 19 is a detail view of a portion of the take-up. Figs. 20 and 21 are detail views of the tension mechanism. Fig. 22 is a detail view of a portion of the take-up-governing devices. Figs. 23 and 24 are detail views of a portion of the devices for governing the length of the stitches and for governing the operation of the tension devices. Fig. 25 is a detail view of a portion of the needle-shifting mechanism for controlling the action of the needles. Fig. 26 is a detail view of that portion of the cam-ring where is located the narrowing mechanism and of the parts adjacent thereto. Fig. 27 is a plan view of a portion of the yarn-changer-operating mechanism. Fig. 28 is a vertical longitudinal section of the yarn-changer. Fig. 29 is a detail view of the yarn-separator and the actuator for the yarn gripper and cutter. Figs. 30 and 31 are detail views showing different positions of the yarn-cutter. Fig. 32 illustrates in detail the several parts of the yarn-twister. Figs. 33 and 34 illustrate details of the yarn-gripper. Figs. 35 and 36 illustrate details of the links of the pattern-chain. Fig. 37 is a cross-section of the reciprocating pitman, showing the means for rendering the time mechanism inoperative. Fig. 38 is a cross-section of the main shaft, showing a part of the reciprocating pitman. Fig. 39 is a plan view, and Fig. 40 a side view, of the clutch-carriage. Fig. 41 is a sectional view of the reciprocating pinion. Figs. 42 and 43 are detail views of the sliding clutch. Figs. 44 and 45 are detail views of the needle-controller. Fig. 46 is a detail view of the narrower. Fig. 47 is a detail view of the latch for the belt-shipper. Figs. 48 and 49 are detail views of the needle-lifter-actuating mechanism. Fig. 50 is a detail view of the needle-depressor-actuating mechanism. Fig. 51 is a detail sectional view through the main and time shafts, illustrating a portion of the yarn-slackener-operating mechanism. Figs. 52 and 53 are detail views of cams which operate the yarn-clamp. Figs. 54, 55, and 56 are detail views of parts of the yarn-clamp-operating devices. Figs. 57 and 58 are detail views of the sinker-ring. Fig. 59 is a detail view of a part of the yarn-clamp-operating devices. Fig. 60 is a detail view of a part of the tension-operating mechanism. Figs. 9, 11, 32 to 37, inclusive, 41, 42, 43, 46, 48, 49, 50, and 52 to 60, inclusive, are drawn to a scale double, and Figs. 44 and 45 to a scale four times, that of the remaining figures of the drawings.

Knitting instrumentalities.—Referring first to Fig. 6, 10 is the non-rotary needle-cylinder, which is mounted upon the bed-plate A of the machine by means of intervening instrumentalities, which will be hereinafter more fully described when considering the means for tightening and loosening the stitches. The bed-plate A is mounted upon a suitable frame 11, which is illustrated in Figs. 1, 1ª, 3, 3ª, and elsewhere.

The needles are reciprocating latch-needles and are guided in needle-grooves in the needle-cylinder in the usual manner and are maintained in place in the needle-cylinder by the commonly-employed circumferential coiled-spring band 12. The needles are of three kinds, as shown in Fig. 18. The short needles *a* occupy one-half the periphery of the needle-cylinder and are those which are employed in knitting both the heel and the toe. The long needles *a'*, having heels 13, occupy nearly one-half the periphery of the needle-cylinder and are those which are always

thrown out of action when knitting both heel and toe. The long needles a^2, having no heels, occupy the remainder of the needle-cylinder and are thrown out of action when the toe is to be knit, but are used in knitting the heel, so that the heel is knit larger than the toe. These needles a^2 are located on opposite sides of the needle-cylinder between the needles a and a' and are of such number as may be desired, depending upon the desired difference in size between the heel and toe. Six, three on each side, is a suitable number of the needles a^2. All of the needles are used in knitting the foot and leg. Since the needles a are employed in knitting the toe, they may be conveniently called the "toe-needles." Since the needles a' knit the instep portion of the foot, they may be conveniently called the "instep-needles," and since the needles a^2 are used in knitting the heel, but not the toe, they may be conveniently called the "heel-needles," and these designating terms will be hereinafter employed. All of the needles have the usual knitting-nibs 14 coöperating with the knitting-cams and have swells 15, which coöperate with the spring-band to hold the needles elevated, which is of utility when the instep and heel needles are moved upwardly into their inactive or idle position.

B is the rotating cam-ring, (see Fig. 6,) which surrounds the needle-cylinder and rests and turns on a bearing 16, constituting part of a top plate 17, which is secured to and partly overlies the bed-plate A. The cam-ring has, as usual, a beveled gear 18, which meshes with a beveled driving-gear 19 on the shaft C, Figs. 1 and 17, which will hereinafter be called the "main" shaft. The cam-ring is equipped with the usual knitting-cams 20 20^a and 21 21^a and switch-cams 22 22^a, (see Fig. 10,) the knitting-cams being duplicated and the switch-cams being provided to permit knitting during reciprocation, as is usual. The cam-ring is likewise equipped with devices to effect narrowing and widening and to throw the instep and heel needles into and out of action, which will be hereinafter specifically described.

The machine is equipped with web holders or sinkers 23, (see Figs. 6 and 57,) which cooperate with the needles and needle-cylinder verge in the usual manner to feed along the completed fabric and apply tension to the loops on the needles. These sinkers are carried by a sinker comb-ring 24, mounted in the needle-cylinder, and are operated in the usual manner by a sinker cam-ring 25, which is operatively connected with the cam-ring B, so as to partake of the movements thereof. To this end the cam-ring carries a vertical bracket 26, Figs. 1, 3, 4, and 5, which is straddled by two radial projections on the sinker cam-ring, each of which carries an adjustable screw-tappet 27, against one of which the bracket 26 comes in contact, (depending upon in which direction the cam-ring B is traveling,) thereby carrying the sinker cam-ring with it in the same direction. The two tappets 27, with a space between them greater than the width of the bracket 26, are provided, so as to time the operation of the sinkers properly with reference to the action of the knitting-cams, whichever way the cam-ring B turns, and the screw adjustment of the tappets compensates for wear and enables the timing to be regulated to a nicety.

The yarn is conducted to the needles by a leading-in yarn-guide 28, pivotally connected with the bracket 26, secured to the cam-ring B, (see Figs. 4 and 26,) so as to partake of the movements thereof. The yarns are supplied from three bobbins, one for the leg and foot and the others for the toe and heel, which are carried by three bobbin-plates 29, (see Figs. 1, 2, 3, 4, 5, and 27,) which are supported by a yarn-stand 30, secured to the bed-plate A. The several yarns are conducted from their respective bobbins to the leading-in yarn-guide 28 by suitable instrumentalities, which will be specifically set forth when describing the yarn-changer, yarn-slackener, and yarn-tension.

The mode of operation of the parts thus far described in knitting a fabric is similar to that common to circular latch-needle knitting-machines.

Driving mechanism.—The main shaft C, which drives the cam-ring B through the bevel-gears 19 18, is adapted to be driven continuously in one direction when the foot and leg are to be knit and to be oscillated or rocked when the toe and heel are to be knit. The change from one movement to the other is effected automatically by pattern mechanism.

At the lower part of the machine, Figs. 1^a and 3^a, is a drive-shaft D, which is actuated continuously in one direction by devices which will be described when considering the speed-changing mechanism. This shaft carries a large sprocket-wheel 31, which constantly drives at a greater speed a smaller sprocket-wheel 32, loose on the main shaft C, by sprocket-chain 33. A sliding clutch 34, splined to the main shaft C, Figs. 1, 5, 42, and 43, coöperates with the hub of sprocket-wheel 32, and when clutched therewith the main shaft and with it the cam-ring B are rotated continuously in one direction.

The drive-shaft D has a crank 35, Figs. 1 and 3, to which is pivoted a pitman E, having a rack 36 at its upper end, which meshes with a pinion 37, Figs. 3 and 5, loose on the main shaft C. The rack 36 is maintained constantly in mesh with the pinion 37 by means of a guide 38, which is hung loosely in the main shaft C, Figs. 1, 3, and 38, so as to compensate for the swing of the lower end of the rack-pitman E. The clutch 34 also coöperates with the pinion 37, so that when the clutch is engaged therewith the main shaft C and with it the cam-ring B are reciprocated. The clutch 34 is arranged to reciprocate on the main shaft C between the pinion 37 and

the sprocket-wheel 32, so that the cam-ring B may be alternately reciprocated and rotated in accordance with the requirements of the knitting, and when it occupies the intermediate position it is out of engagement with both pinion 37 and sprocket-wheel 32, so that knitting then ceases. When the clutch thus occupies its intermediate idle position, the cam-ring B may be operated by hand, the main shaft being equipped with a hand-crank 39, Figs. 1, 2, 3, and 5, for this purpose.

Pattern mechanism.—The clutch 34 is automatically moved between the pinion 37 and sprocket-wheel 32 at the appropriate times by means of a pattern mechanism, which also governs all the other movements of the machine. Parallel with, behind, and slightly below the main shaft C is a time-shaft 40, carrying near one end a sprocket-wheel 41, loose thereon, around which passes a pattern-chain 42. The pattern-chain also passes around a supporting sprocket-wheel 43, Figs. 1ª, 3ª, and 5, journaled on a stud 44, carried by the frame 11. The greater portion of the links of the pattern-chain carry projecting wings 45, Figs. 35 and 36, which afford a substantially-continuous elevated path or pattern-track, Figs. 3 and 3ª, except where it is interrupted by the omission of the wings from certain of the links at appropriate intervals, as shown in Figs. 35 and 36, the occurrence of these intervals or interruptions determining a variation in the product. The pattern-chain is moved step by step intermittently, and to this end a ratchet-wheel 46, fast to the pattern-chain sprocket 41, is provided, Figs. 1, 2, 3, 5, and 15. Loosely surrounding the time-shaft 40 is a pawl-lever F, Fig. 16, to the outer end of which is pivoted at 47 a pawl 48, which engages the ratchet 46. The pawl-lever F is moved in one direction by springs 49 and 50, Figs. 2, 3, and 5, both of which are attached at their inner ends to a fixed part of the machine, and one of which, 49, is attached at its outer end to the tail of the pawl 48, Fig. 3, so as to maintain it in coöperative relation with the ratchet 46. The outer attachment of the spring 50 will be hereinafter described. The movement of the pawl-lever F in the opposite direction is effected by a tappet 51, projecting from the reciprocating rack-pitman E, Figs. 1, 16, and 37, which on the upstroke of the pitman encounters the inwardly-extending arm 52 of the pawl-lever and moves it upwardly. In this manner the pattern-chain is moved intermittently a definite distance at each revolution of the drive-shaft D.

In order to properly adjust the length of the working stroke of the pawl-lever so as to move the pattern-chain the proper distance at each step, the inner arm 52, Fig. 16, of the pawl-lever F is a stiff spring secured to the pawl-lever and adjustable by a screw 53.

The length of the inward or return stroke of the pawl-lever F is limited by a stop 54, carried by a suitable fixed part of the machine, such as the bracket 55, Figs. 2, 3, 5, and 15, which is encountered by a detent 56 on the pawl-lever when pulled inward by the springs 49 50. The pawl-lever hence has a definite length of stroke, thus advancing the pattern-chain by uniform steps.

It is sometimes desirable to throw the pattern mechanism wholly out of action—as, for example, when it may be desired to knit a circular web of indefinite length—and this object is effected very simply by making the tappet 51 on rack-pitman E movable, so that it may be maintained in a position where it will not encounter the arm 52 of the pawl-lever F. The tappet 51 is a pin sliding in the pitman E and a bracket 57, attached thereto, Figs. 1 and 37, and a spring 58 tends to hold the tappet in and restores it to its idle position. A hand-controlled latch 59 locks the tappet in its active position when moved thereto by hand. By manipulating the latch to release the tappet the latter is thrown to its idle position by the spring 58.

The pattern-chain controls the movements of the machine by raising and lowering a rider 1, Figs. 3 and 15, which normally rides upon the pattern-track formed by the link-wings 45, and is thereby held elevated, and which drops down by gravity when an interval or interruption in the pattern-track arrives beneath it, this downward drop being its effective movement. This rider 1 is carried by a lever 60, pivoted to the bracket 55, so that the rider is capable of rising and falling. When the rider drops down, there is brought into action mechanism for rotating the time-shaft step by step. This mechanism includes as its primary instrumentality a ratchet-wheel G, which is adjacent to the ratchet 46 and fast to the time-shaft 40. The ratchet-wheel G, and with it the time-shaft, remains stationary for the greater part of the time, but is brought into action by the drop of the rider 1, which releases the normally-idle pawl 61 of the ratchet G. This pawl 61 is pivoted at the outer end of the pawl-lever F on the side thereof opposite to where the pawl 48 is located, as shown in Figs. 2 and 5. The spring 50, heretofore mentioned, is connected to the outer end or tail of pawl 61 and tends to force the free inner acting end of the pawl into operation with the ratchet G. Normally, however, the acting end of the pawl 61 is held uplifted out of contact with the ratchet G by means of a pin 62 thereon, Fig. 15, which rests on a horizontally-projecting flange *b* on the rider-lever 60, so that although the pawl constantly reciprocates with the pawl-lever F it has no effect upon the ratchet G and time-shaft. When, however, the rider and its lever drop down, the acting end of the pawl 61 descends into its active position and then actuates the time-shaft ratchet G step by step in consonance with the pattern-chain ratchet 46. Owing to this arrangement, which brings the time-shaft into operation only when needed, the time-shaft is arranged so as to make but a single revolution for the completion of one

stocking, and at the same time it becomes possible, as will be shown, to provide for the movement of the time-shaft through a large arc when needed, so as to render its effective movements easy and smooth. The first effect after the dropping of the rider 60 and the bringing of the pawl 61 into action is to move the ratchet G a few steps in consonance with the ratchet 46 until a change in the knitting is to be made. This change (or changes) is effected by cams, as will presently appear, and to render the cam rise gradual and its action smooth and easy the ratchet G is moved through a large arc, which in the illustrated machine is seven times the length of the arc through which it moves in taking its usual step. This long step is taken by giving a long throw to the pawl-lever F. When such a long throw is to be given, a cam 63 on the side of the ratchet G, Figs. 2 and 16, encounters a depending tongue 64 near the outer end of the stop 54, (which is made resilient or as a spring for this purpose,) thereby lifting said stop out of the path of the detent 56 of the pawl-lever F, so that the springs 49 50 thereupon pull the pawl-lever inwardly a greater distance than usual and until an outwardly-projecting abutment 65 on the end of the pawl-lever encounters the stop 54. Then when the tappet 51 again encounters the inner arm 52 it gives the pawl-lever F its long stroke, (in the construction shown seven times the usual stroke,) thus moving the ratchet G and time-shaft through a large arc. This long stroke frees the cam 63 from the tongue 64, thereby permitting the stop 54 to resume its normal position, so that but one long stroke is made at a time. It is not expedient or desirable, however, to move the pattern-chain ratchet 46 more than its usual step, and hence its actuating-pawl 48, although partaking of the long stroke, is arranged so as to then feed the ratchet 46 only its usual step. To this end the free inner end of the pawl 48 has a beveled projecting stud 66, Figs. 3 and 15, on one side, in the path of which when the long stroke is taken is an inclined lifter 67 on the bracket 55, which is sufficiently far away as to have no effect when the pawl 48 takes its usual stroke. When, however, the long stroke is taken, the stud 66 rides up the lifter 67 out of the way, and consequently on the working or outer stroke operates upon the ratchet 46 only sufficiently to move it the usual step.

In Fig. 16 only one cam 63 is shown on the ratchet G. There are, however, as indicated in Fig. 2, a plurality of such cams, there being a sufficient number and properly spaced to give the desired number of long strokes at the proper times.

Direction-changing mechanism.—The automatic change between continuous rotation and reciprocation is effected by moving the clutch 34, and the principal instrumentalities for this purpose are a cam-wheel H, loose on the pattern-shaft, a laterally-sliding shifting carriage I, mounted on the framework, and a shifting-fork J, carried by the carriage and connecting with the clutch.

The carriage I is a slide, Figs. 2, 39, and 40, having slots 68, embracing screw-studs 69 on the frame 11, which constitute the ways for the carriage. At its inner end the carriage has a depending operating-arm 70, having a bowl 71 at its lower end close to the periphery of the cam-wheel H. The cam-wheel has on its periphery two pairs of cams 72 and 73, the cams 72 acting upon the bowl 71 to shift the carriage I to the right, Fig. 2, to bring the reciprocating mechanism into action, while the cams 73 act in the opposite direction to bring the continuously-operating mechanism into action. The cam-wheel H is rotated from the pattern-shaft ratchet G by means of two laterally-projecting studs 74, mounted on said parts, respectively. The wheel H and ratchet G might, however, be fast with each other.

The shifting-fork J is pivoted at *c*, Figs. 39 and 40, at its rear end to the carriage I, and its front forked end embraces a peripheral groove *d* in the clutch 34, Figs. 1, 5, and 42. Stiff flat springs 76 and 77, secured at the rear to the carriage I, bear at their forward ends upon opposite sides of the fork J, and consequently the fork and clutch partake of the lateral movements of the carriage, and hence the wheel 32 and pinion 37 (controlling the rotary and reciprocating movements, respectively) are alternately brought automatically into action at the proper times, as determined by the pattern-chain. The purpose of the springs 76 and 77 and of pivoting the fork J is to insure the proper action of the clutch in case, when the shift occurs, the proper clutch-face of the clutch is not exactly coincident with the corresponding clutch-face on the wheel 32 or pinion 37. For example, in case the position of the pinion 37 should be such that when the shift of the clutch takes place the clutch projection 78 on the clutch should encounter the clutch projection 79 on the pinion the carriage I would still be moved positively its entire distance by the positive action of one of the cams 72, and the result would be to swing the fork J against the spring 77, thereby increasing its tension, the other spring 76 being then prevented from acting upon the fork, because it is carried out of contact therewith by the stop-arm 75, forming part of the carriage. Then as soon as the pinion 37 turns sufficiently far to bring its clutch-recess into coincidence with the clutch projection 78 on the clutch the spring 76 snaps the clutch into place. Similarly the other spring 77 acts to insure the engagement of the clutch with the wheel 32.

For the proper timing of the mechanism to insure a perfect product by avoiding the skipping of the needles by the yarn the clutch should engage the pinion 37 only when the pinion is oscillating in the right direction, and hence the respective members are properly constructed to insure this correct engage-

ment. The opposing clutch projection 78 on the clutch has a sliding tongue 80, Figs. 42 and 43, which is normally projected by a spring 81, thus making the clutch projection 78 normally larger than the corresponding recess on the pinion 37 and rendering the clutch projection "contractible." Consequently when the pinion is oscillating in the wrong direction the projection 78 will not enter the pinion-recess, being too large. When, however, the pinion is oscillating in the proper direction, the then leading end 82 of its clutch projection 79 (which extends laterally outward farther than its tail end) encounters the tongue 80 of the contractible clutch projection, thereby pushing it in against its spring, thus contracting the projection 78 sufficiently to enable it to fit within the pinion-recess.

Speed-changing mechanism.—It has already been stated that owing to the relative sizes of the sprocket-wheels 31 and 32 the speed of the cam-ring is greater during rotation than during reciprocation. It is desirable, however, to still further reduce the speed during reciprocation, to effect the slowing down before reciprocation begins, and to afterward start rotation before speeding up, so that the operation of the clutch 34 in both directions shall occur during the slow movement, thereby avoiding shock to the machine.

Referring to Figs. 1ª, 5, and 7, it will be seen that the drive-shaft D has a fixed clutch member 83 fast thereto and carries a loose sleeve 84, having a clutch-face 85, adapted to the clutch member 83. The purpose of this clutch arrangement is to provide for the automatic stopping of the machine, as hereinafter set forth. Ordinarily, however, the said parts 83 84 are clutched together and are now to be so considered. The sleeve 84 carries an intermediate pulley 86, fast thereto, and two loose pulleys 87 88 on opposite sides thereof. With these pulleys coöperate two constantly-running belts, Fig. 5, one of which runs faster than the other, as by passing around a larger pulley on the usual overhead power-shaft. Both belts run in turn over the driving-pulley 86, and the fast belt coöperates with the inner idler 88, while the slow belt coöperates with the outer idler 87. The action of these belts is immediately controlled by a belt-shipper 89, which is centrally pivoted, Fig. 4, at 90 to a suitable part of the frame 11. The lower end of the belt-shipper has two forks 91 92, the former for the fast belt and the latter for the slow belt. In one position of the shipper the slow belt runs on the driving-pulley 86, and in its other position the fast belt runs thereon. The movement of the shipper from one position to the other is automatically controlled at the proper moments by cams 93 94 on a cam-drum K, which is fast to the time-shaft 40, a bowl 95 at the upper end of the shipper being in the paths of the said cams. The cams 93 move the shipper in its proper direction to slow down the machine, and the cams 94 move the shipper in the opposite direction to speed it up.

The movement of the cams 93 94 (since their drum K is fast to the time-shaft 40) is controlled by the ratchet G, which in turn is governed, as already set forth, by the pattern-chain.

When a change is to be made from fast to slow preparatory to knitting a heel or a toe, the pattern-chain brings the ratchet G into action, which then proceeds several steps in consonance with the pattern-chain ratchet 46, and during this time one of the cams 93 is brought into action and shifts the driving-belts so as to bring the slowly-running belt into action. The length of the cams 93 (and also of the cams 94) is such as to require several steps of the ratchet G to effect the throw of the belts, thus rendering the transition from fast to slow gradual and without shock to the machine and at the same time enabling the incline of the cam to be made gradual and easy. As soon as the speed of the machine is thus slowed down the long stroke of the pawl 61 occurs, thus shifting the clutch 34 and changing from rotation to reciprocation, the movement of the clutch thus taking place when the machine is running slowly. The pattern-chain then throws the pawl 61 out of action, so that the time-shaft stands still. As soon as the heel or toe, as the case may be, is nearing completion the pattern-chain again brings the pawl 61 into action and a long stroke is made, thereby changing back from reciprocation to rotation while the machine is still running slowly. This movement also preferably brings one of the cams 94 into operative position, so that a few short steps of the pawl 61 shifts the shipper and brings the fast-running belt into play, thus driving the machine rapidly during continuous rotation. The pattern-chain then moves the pawl 61 out of action, so that the time-shaft remains stationary while knitting circular courses. Owing to this arrangement both movements of the clutch 34 take place while the machine is running slowly.

Throwing the instep-needles out of action.—The change from rotation to reciprocation occurs when a toe or a heel is to be knit, and when the toe or heel is completed the reverse change from reciprocation to rotation occurs. Now during the knitting of the heel or toe and during reciprocation only a portion of the needles are in action, and the idle needles are thrown out of action when the change from rotation to reciprocation occurs, and they are again brought into action when the toe or heel is completed and when the change from reciprocation to rotation occurs. The only difference in the knitting of the heel and toe is that when the heel is knit only the instep-needles a' are thrown out of action, whereas when the toe is knit the heel-needles a^2 are also thrown out of action.

The governance of the instep-needles a' will be first taken up and then that of the heel-needles a^2.

The instep-needles a' are thrown out of action by being elevated so far as to raise their knitting-nibs 14 above the path of the knitting-cams, and this elevation of the needles is immediately effected by a needle-lifter 96, Figs. 9, 10, and 49, which is mounted on and carried by the knitting cam-ring B. This lifter is normally wholly outside of the plane of the needles, so that it is normally idle. When, however, the instep-needles are to be elevated out of action, the lifter 96 is pushed radially inward at the proper moment. This inward push occurs when the needle-lifter is opposite a portion of the short toe-needles a, which are wholly above the highest part of the lifter. When thus pushed in, the heels 13 of the instep-needles a' are in the path of the elevating-incline constituting the upper edge of the lifter, and consequently when the lifter reaches the instep-needles it lifts them all up to their inactive position. As soon as this is accomplished the lifter retires into its idle position.

In order to avoid making the elevating-incline of the needle-lifter so high as to interfere with the regular knitting action of the needles, as would be the case if in the construction shown the entire lift should be accomplished thereby, a supplementary lifter 961 is employed, which is fixed to the cam-ring B, Fig. 10. The needle-lifter lifts the instep-needles high enough to bring their usual knitting-nibs 14 into the path of the supplementary lifter 961, which thereupon completes the lifting action.

It will be observed, Fig. 10, that a guard-cam 148 is extended over the leading points of the needle-lifter 96 and auxiliary lifter 961, so as to prevent their strike throwing the needles up too far.

The needle-lifter has a stem 97, which extends outwardly through a block fixed to the cam-ring B, and a spring 98, surrounding stem 97, holds and pushes the lifter outwardly. The needle-lifter is pushed inwardly to its acting position by needle-lifter-operating cam 99, Figs. 3 and 5, which is mounted to slide radially in a slot in the stationary top plate 17. This cam 99 normally occupies its outward position where it is out of the path of the needle-lifter stem 97, and it is pushed inward at the appropriate time by the action of the pattern mechanism, so as to be within the path of said stem 97, whereby the needle-lifter is pushed inwardly, and thus acts to elevate the instep-needles.

Beneath the top plate and turning in an annular groove in the bed-plate A is a ring L, Figs. 6, 13, and 14, which controls all of the movements of the needles, and which is hence hereinafter termed the "needle-controller."

Depending from the needle-lifter-operating cam 99 is a stud 100, Fig. 13, which enters a cam-path in the needle-controller. The stud 100 normally stands in a concentric portion 101 of the cam-path; but when the needle-controller is oscillated in the direction of the arrow 102 the cam-rise 103 encounters the stud 100, which is moved radially inward, thereby bringing the needle-lifter-operating cam 99 into the path of the stem 96 of the needle-lifter.

The oscillation of the needle-controller L is governed by the time-shaft. The needle-controller is capable of oscillation through strokes or arcs of different lengths for purposes which will hereinafter appear, one of which strokes in the direction of the arrow 102 (which direction is that of the "forward" strokes) is that which controls the movement of the needle-lifter to lift the instep-needles.

The needle-controller L is connected by a pin 104, Fig. 6, with a slide M, Figs. 6 and 25, which is mounted beneath the bed-plate A to slide back and forth, and thereby oscillate the needle-controller. The slide M is moved forward by a lever 105, pivoted to the frame 11 and connected at its upper end to the slide, and is moved backward by the spring 106, which spring maintains a bowl 107 at the lower end of the lever in contact with cams 108, 1081, 109, and 110 on a ratchet-wheel N, which is loose on the time-shaft 40. This ratchet-wheel N, which will be hereinafter termed the "needle-pattern" wheel or ratchet, as shown in Figs. 2, 17, and 25, has ratchet-teeth 111, consisting of the heads of screws which are inserted at proper intervals in threaded holes 112 in the periphery thereof. Coöperating with this needle-pattern ratchet is a pawl 113, Fig. 17, maintained in coöperative relation by a spring 114 and pivoted to a rocking arm 115, which swings on the hub of the ratchet N. The outer end of the arm 115 is held by the spring 114 in contact with an eccentric 116 on the main shaft C, so that the pawl 113 is constantly oscillated during the operation of the machine. Normally, however, the tooth of the pawl plays idly between groups of the ratchet-teeth 111 without moving the ratchet N, and it is brought momentarily into action from time to time by the action of the pattern-chain.

The needle-pattern wheel N is rotated step by step from cam-wheel H (which, as already shown, moves in consonance with the pattern-shaft ratchet G) by means of pins d on the wheels N H, respectively, which arrangement enables the wheel N to be advanced by its actuating-pawl 113 without affecting the wheel H, the wheel N being afterward unaffected by the advance of the wheel H until the pin d on H catches up with the pin d on N.

During the circular knitting of a stocking-foot the bowl 107 rests on the dwell 117, Fig. 25, on the wheel N, thereby maintaining the slide M and needle-controller L in a position of rest, with the stud 100 in the dwell 101 of the controller L. Just before the pattern-shaft-ratchet pawl 61 makes its long stroke to produce the reciprocating movement for

beginning the heel the instep-needles must be thrown out of action, and hence the same long stroke moves the wheel N, so as to bring the first of a group of its ratchet-teeth 111 within reach of the next stroke of its pawl 113, whereupon the wheel N is advanced, thus causing its cam 108 to act upon the bowl 107 to move the lever 105, whereupon through slide M the needle-controller L is moved sufficiently far to cause the cam-rise 103 to move the needle-lifter-operating cam 99 into the path of the needle-lifter stem 96, so that the instep-needles are thrown out of action.

Since the needle-lifter must remain inward against the tension of its spring 98 during a half-revolution of the cam-ring and since it is held inward only momentarily by the action of the cam 99, special means are provided for locking the needle-lifter in its acting position until the instep-needles are all thrown out of action and for then automatically unlocking the needle-lifter, so that it is restored to its normal idle position by the action of the spring 98. The stem 97 of the needle-lifter extends through a block 118, Figs. 9, 48, and 49, removably fixed to the cam-ring B, and has a notch 119, to which is adapted a latch 120, pivoted at 121 to the block 118 and playing vertically in a recess in the face of said block adjacent to the periphery of the cam-ring B. This latch is pulled upwardly against the stem 97 by a spring 122. When the stem is pushed inwardly by the cam 99, its notch 119 is brought into register with the latch 120, which is pulled into said notch by its spring 122, thereby locking the needle-lifter in its inner position, where it remains during somewhat more than a half-revolution of the cam-ring or until all of the instep-needles are elevated. The latch 120 is then automatically released from the notch 119 by the automatic action of a releaser 123 and tripper 124, whereupon the spring 98 restores the needle-lifter to its idle position. The releaser 123 is a vertical shaft journaled in the block 118, adjacent to the free end of latch 120, and having a cam 125 coöperating with a pin 126 on the latch. A torsional spring 127 moves the releaser in one direction, a stop 128 limiting this movement. The releaser carries an outwardly-projecting operating-arm 129, by which it is adapted to be moved in opposition to the spring 127 at the proper times by the action of the tripper 124. The tripper 124 is a slide mounted to move radially in the top plate 17 and having a tripping-arm 130, which is normally out of the path of the releaser-arm 129, but which is adapted to be moved into said path at the proper times by the action of the needle-controller L. The tripper 124 has a depending stud 131, Fig. 13, which normally stands in a dwell 132 of a cam-groove in the needle-controller. The same movement of the needle-controller which brings the cam 99 into action also causes the cam-rise 133 to act on the stud 131 to move the tripper 124 radially inward to bring its arm 130 into the path of the releaser-arm 129. The relative peripheral location of the cam 99 and tripper 124 is such that just after all of the instep-needles have been raised the releaser-arm 129 encounters the tripper-arm 130, whereby the releaser is turned so that its cam 125 acts on the latch-pin 126 to depress the latch and release the needle-lifter. As soon as the releaser-arm 130 passes beyond the tripper-arm 129 the spring 127 restores the releaser to its normal position, where its cam 125 is out of the way of the path of the latch-pin 126 when rising.

Just after the needle-lifter has accomplished its work and before its operating devices can again encounter cam 99 or tripper 124 the bowl 107, Fig. 25, under the influence of spring 106, drops down onto dwell 134 of the needle pattern-wheel N, which has been moved forward by the continued action of its pawl 113, and thereupon the slide M moves to its original position, (dwell 134 being concentric with dwell 117,) whereby the needle-controller L is likewise restored to its original normal position, as shown in Fig. 13. This movement causes the cam-rises 103 and 133 to restore the needle-lifter, actuating-cam, and tripper to their idle position. When, however, the toe is to be knit, the heel-needles a^2, as well as the instep-needles a', have to be thrown out of action. This is effected by giving the needle-lifter 96 a longer inward movement. When moved inward by its short stroke, the needle-lifter encounters the instep-needles a', having the heels 13, and does not reach the tails of the heel-needles a^2, which are not provided with heels. When, however, the needle-lifter is given its long inward stroke, it also encounters the tails of the heel-needles, thereby lifting all of the needles, except the toe-needles a. The extra long stroke is given to the needle-lifter by an additional rise 135 (see Fig. 13) in the needle-controller and by an extra long stroke in the direction of arrow 102 to the needle-controller L, which is effected by the cam 108^1 on the needle pattern-wheel N, Fig. 25, which is higher than the cam 108.

The only other variation in the mechanism required for the elevation of the heel-needles is an additional holding-notch 136, Fig. 9, in the stem 97 of the needle-lifter, with which the latch 120 engages to maintain the needle-lifter in its innermost position while throwing the needles a' a^2 out of action. As soon as the needles are thrown out of action for the heel or toe the clutch 34 is shifted and the reciprocation begins.

Bringing the instep-needles into action.— After a toe or a heel has been knit and circular knitting is to be resumed the instep (or instep and heel) needles which have been thrown out of action must be brought again into action. For this operation there is no variation in the mechanism on account of the heel-needles a^2.

At the proper moment, through the action of the pattern-chain and intervening instru-

mentalities, the needle pattern-wheel N is rotated so as to bring one of the two lowest portions 137 of its cam-track, Fig. 25, (in the illustrated construction formed by the entire cutting away of the cam-surfaces,) opposite the bowl 107, whereupon the spring 106 acts to pull the needle-controller L its farthest distance backward in the direction of arrow 138, Fig. 13. The result is to cause a cam-rise 139, acting upon stud 131, to move the tripper 124 radially inward, and also to cause a cam-rise 140, acting upon a stud 141, depending from a radially-sliding needle-depressor-operating cam 142, Figs. 1, 2, 3, and 5, to move said cam inwardly, said cam 142 being mounted to slide upon the stationary top plate 17. The inward movement of cam 142 brings the same into the path of an outwardly-projecting arm 143 of a needle-depressor 144, Figs. 1, 10, and 50. This depressor is a radially-sliding cam mounted on the cam-ring B and normally occupying its outer idle position remote from the butts 14 of the elevated instep and heel needles. When, however, the inwardly-moved cam 142 encounters the arm 143, the needle-depressor is pushed inward, so that its cam incline is in the path of the butts 14 of the elevated needles. Thereupon as the cam-ring rotates the depressor encounters the butts 14 and depresses the idle needles to within the reach of the usual knitting-cams.

The needle-depressor is held in its acting position against the restoring pressure of a restoring-spring 441 during somewhat more than a half-rotation of the cam-ring or until all of the elevated needles are depressed and is then released by a releasing-arm 145, Figs. 1 and 50, which depends so as to strike the tripping-arm 130 of the tripper 124, whereby the depressor is restored to its outer idle position.

The depressor 144 extends through a slot in the cam-ring B, Fig. 50, and is carried at the free end of a flat spring 441, secured to the periphery of the cam-ring B and which normally holds said depressor outward in its inactive position. The outer end of the spring is extended beyond the depressor to constitute a latch 442, which coöperates when the depressor is pushed in with a lip 443 on a sliding catch 444, which is mounted to slide on the periphery of the cam-ring, a spring 445 moving it in one direction and a lever 446, carrying arm 145 and pivoted at 447 to the catch 444, engaging a fixed stud 448 on the cam-ring to move the catch 444 in the opposite direction. When the depressor is moved inward by the depressor-cam 142, the lip 443 automatically engages the latch 442 and holds the depressor in until all the needles have been lowered. The releasing-arm 145 encounters the tripper-arm 130, thus disengaging lip 443 from latch 442, whereupon spring 441 restores the depressor 144 to its idle position and spring 445 restores catch 444 to its original position. Thereupon the needle pattern-wheel N again moves so as to cause one of its cams 109 or 110, Fig. 25—in case the heel has just been completed cam 109 and in case the toe has just been completed cam 110—to operate upon the bowl 107, whereupon the bowl is moved upward upon one of the dwells 117 or 1171, where it occupies its normal position, thereby moving the needle-controller L, Fig. 13, forward, so that the cam-rises 139 and 140 restore the tripper 124 and depressor-operating cam 142, respectively, to their normal idle position. The clutch 34 is then moved to change from reciprocation to continuous rotation.

Narrowing mechanism.—The narrowing mechanism is the same when knitting both heel and toe. As is usual with such mechanism, the narrowing commences with the beginning of reciprocation, and one needle at a time alternately on the ends of the gang of needles then in action is thrown out of action by being lifted up out of action at each complete reciprocation of the cam-ring. The narrowing is automatically effected by a narrower O, Figs. 10 and 46, which is pivoted to the cam-ring B at *f*, so as to oscillate between the two stitch-cams 20 20^a. The narrower O has two needle-raisers 2 and 3 on opposite sides. During continuous rotation the cam-ring B rotates in the direction of the arrow 146. The needle-butts 14 then travel over switch-cam 22, up cam 20, beneath guard-cam 147, the head of narrower O, cam 20^a, and switch-cam 22^a, and up cam 21^a, Fig. 10 showing the narrower in the right-hand position, which it then occupies. When, however, the cam-ring B makes its first reversal in reciprocation, the butt of the first toe-needle *a* (assuming that a toe is being knit or of the first heel-needle a^2 if a heel is being knit) rides over switch-cam 22^a, up over cam 20^a, beneath guard-cam 148, and then strikes the head of narrower O, causing it to swing on its pivot, whereby its raiser 3 enters beneath the butt 14 of said needle, thereby elevating it and causing it to pass over the head of the narrower O and above guard-cam 147, the result being that said needle is elevated into an idle position and into the same plane as the instep-needles. At the same time the tilting of the narrower O opens a pathway beneath it for the following needles, which then execute their usual knitting movements, passing down beneath cams 20 and 22 and up cam 21.

The tilt of the narrower O to the left leaves it in such position that when the cam-ring B reverses and moves again in the direction of the arrow 146 the butt of the leading needle encounters the head of the narrower, tilts the same back to the right, and is itself lifted up to its idle position by the raiser 2, at the same time opening up the knitting-path beneath cams 20^a 22^a and up cam 21^a.

The narrower O thus alternately raises one needle at a time on the right and left until the desired narrowing has been finished. It is then manipulated so as to no longer effect

narrowing. This manipulation, however, can be best set forth after describing the widening mechanism, which, it will be seen, requires manipulation during the narrowing operation.

Widening mechanism.—After the narrowing has been completed in knitting either the heel or toe the machine begins at once to widen in the usual manner, bringing into action the needles thrown out in narrowing one at a time alternately at right and left.

The widener P is shown in Figs. 10, 11, and 12, and it will now be assumed to be ready for operation. The widener P is shown in detail in Fig. 12 and has a base-plate pivoted at 149 to the inner face of the cam-ring B. This base-plate has two downwardly-projecting diverging legs 150 151, and its head has two diverging facets 152, against which the flat spring 153, Fig. 11, rests in alternation, thereby holding the widener in each of its two positions of rest, the swing of the widener being limited in both directions by a pin 154 thereon, riding in a slot 155 in the cam-ring B.

Pivoted at 149 to the widener-base are two needle-droppers 156 and 157, which are maintained normally parallel with and overlying their respective legs 150 151 by the torsional spring 158, which keeps their inner edges bearing against a stud 159 on the base-plate. Each dropper and its corresponding leg has a notch 4 in its lower end, and each dropper has its lower working end or head 5 projected inwardly into the plane of the needle-butts 14.

Assuming that the parts are in the position shown in Fig. 10, the cam-ring to be moving in the direction opposite to that of the arrow 146, and that widening is about to be begun, then the butt 14 of the leading needle of those elevated out of action will strike the notch 4 of the right-hand dropper 156, thereby swinging the widener on the pivot 149. At the same time the needle is itself pushed downward by the dropper 156, the opposing concentric face of the dropping-cam 160 compelling the needle-butt to move downward until it arrives at a sufficiently-low position either to be in the working path of the knitting-cams or, if not, to be at least in the path of the lowering face 161 of the dropping-cam 162, which completes the restoration of the needle to its knitting position. This downward swing of the dropper 156 also lowers its active end or head 5 below the plane of the butts 14 of the succeeding elevated needles, which are hence unaffected thereby. The swing or tilt, however, of the widener has resulted in elevating the acting end or head 5 of the other or left-hand dropper 157 into the path of the succeeding elevated needle-butts; but it encounters them without effect because, being pivoted at 149, it is swung upward out of the way by the needle-butts and after passing them all is brought back to its position in their path by the spring 158. When now the cam-ring reverses, the leading needle at the other end of the gang of the idle needles encounters the left-hand dropper, and the previous action is repeated in the reverse direction. In this manner the needles which were elevated by the narrower are restored one by one by the widener.

Narrowing and widening operating mechanism.—Now it is obvious from the preceding description of the narrower and widener that means must be provided for rendering the widener inoperative during narrowing and the narrower inoperative during widening, since otherwise each would at once undo the work of the other.

To render the widener inoperative during narrowing, its pin 154 projects out through the cam-ring and is there pivoted to an operating-lever 163, which is pivoted at 164 to the cam-ring and has an outwardly-projecting operating-arm 165, Figs. 3 and 4.

When narrowing is being done, a widener-operator 166, Figs. 1, 3, and 4, is in action, so that the tappet 167 thereof is in the path of the arm 165. The widener-operator 166 is mounted to slide radially on the stationary top plate 17, so that its tappet 167 can be moved into and out of the path of the widener-arm 165. The operator 166 has a depending pin 168, Fig. 13, which enters a cam-groove 169 in the needle-controller L. Normally the pin 168 stands in the concentric portion of the groove 169 just outside of a pivoted spring-actuated dog 170, (the construction and arrangement of which is similar to those of the dog 177, hereinafter specifically described.) When the needle-controller moves in the direction of arrow 102 to throw the instep-needles out of action, the dog 170 is carried beyond the pin 168, so that its spring 171 pushes it outwardly. When, then, the needle-controller moves back (by virtue of the bowl 107 dropping down upon one of the dwells 134, (see Fig. 25,) which occurs just as soon as the instep-needles have been thrown out of action,) the pin 168, and with it the widener-operator 166, is pushed inward by the dog 170, (pin 168 then riding on the inner face of the dog,) so that the tappet 167 then stands in the path of the widener-operating arm 165. The narrowing then begins, and the widener is rendered inoperative because its arm 165 encounters the tappet 167 at each reciprocation in each direction, so as to swing the widener to an inoperative position. To explain this action more fully, it should be noted that at each reciprocation in each direction the cam-ring B swings through a little more than a complete revolution and the tappet 167 is made of resilient metal, so as to be elastic. Now, referring to Fig. 10, if we assume that the cam-ring is making a reciprocation in the direction opposite to that of the arrow 146 and that the widener occupies the position there shown, it would, if undisturbed, lower an elevated needle into action. This result, however, is obviated when narrowing, because just before recipro-

cation in the assumed direction begins and while the cam-ring is still moving in the direction of the arrow 146, the widener-operating arm 165 encounters the tappet 167, so that the widener is tilted to the left. Consequently when the cam-ring reverses and travels in the direction opposite to the arrow the nibs of the elevated needles pass unaffected over the head 5 of dropper 156 and strike the head of dropper 157 on its inner side, so that said dropper 157 swings upwardly out of the way on its pivot 149. Consequently the elevated needles pass the widener without being affected. The cam-ring B continues then to travel in the assumed direction until it completes a revolution, thereby bringing the widener-operating arm 165 again into contact with the tappet 167, but on the opposite side thereof, so that the widener is tilted in the opposite direction to its position shown in Fig. 10. The cam-ring B then reverses and travels in the direction of the arrow 146, with the widener in the position shown in Fig. 10, and the widener is then inoperative upon the elevated needles because their nibs pass unaffected over the head 5 of dropper 157 and encounter the inner side of the head of dropper 156, thereby swinging it upwardly on its pivot 149 against the tension of the spring 158, so that all of the elevated needles pass the widener without being affected. This operation of tilting the widener alternately at each reciprocation so as to render it inoperative, occurs until the narrowing has been completed and the widening is to begin. The tappet 167 is then moved radially outward to its inactive position out of the path of the widener-operating arm 165, this movement occurring at such time as to leave the widener in position to drop the next needle it encounters, and thereafter the widener operates automatically, as already set forth.

The inward movement of the tappet 167 is effected by a movement of the needle-controller L backward in the direction of the arrow 138, which suffices to cause the cam-rise 172, Fig. 13, to move pin 168, and with it the tappet 167, outward. It will be noted that this movement of the needle-controller is in the same direction as that which brings the needle-depressor 144 into action to restore the instep-needles into action; but to avoid doing so the movement is not sufficiently large. The proper amount of movement is given the needle-controller by moving the needle pattern-wheel N, Fig. 25, sufficiently far to permit the bowl 107 to drop from one of the dwells 117 onto one of the dwells 173, and the subsequent drop from said dwell 173 to one of the dwells 137 effects the further movement of the needle-controller to bring the needle-depressor 144 into action. Now as soon as the widener is thus brought into action the narrower O must be rendered inoperative. This is effected by a narrower-operator 174, Figs. 3, 4, and 26, which is mounted to slide radially on the top plate 17. This operator has a depending pin 175, Fig. 13, which normally rests in the outer concentric portion 176 of a cam-groove in the needle-controller L, in which position the operator 174 is inoperative and the narrower is free to act. The same movement of the needle-controller which takes the widener-operator out of action brings the narrower-operator into action by virtue of the pin 175 riding upon a spring-pressed dog 177, (similar in its construction and mode of operating to the dog 170, heretofore described,) whereby the narrower-operator is pushed into action. The construction and arrangement of the dog 177 are shown in detail in Figs. 44 and 45, which serve equally well to illustrate the dog 170. The dog is pivoted to a plate 701, secured to the under side of the controller L, which is recessed to receive a spring 171, which presses the point of the dog outwardly. This inward movement of the narrower-operator brings its resilient tappet 178 into the path of an operating-arm 179, Figs. 10, 26, and 46, carried by the portion 180 of the narrower which extends below its pivot *f*.

The action of rendering the narrower inoperative during widening is the same as that involved in rendering the widener inoperative during narrowing. Assume that when the last narrowering-needle has been lifted the narrower is left in the position shown in Fig. 10 and that the cam-ring B is just finishing its reciprocation in the direction of the arrow 146. Before finishing this movement the narrower-operator 174 has been brought into action, so that tappet 178 is encountered by arm 179, thereby tilting the narrower to the left. Consequently when the cam-ring reverses the nibs of all of the needles still in action pass beneath the head of the narrower and perform their knitting movements. Just as the cam-ring completes its reverse movement the narrower-operating arm 179 encounters the tappet 178, but on its opposite side, so that the narrower is tilted to the right into the position shown in Fig. 10. Consequently when the cam-ring then moves forward in the direction of the arrow 146 the nibs of the needles then in action pass beneath the narrower-head and execute their usual knitting movements. This operation continues until all of the needles employed in widening and narrowing are brought into action. As soon as this is done and just before the movement from reciprocation to continuous rotation takes place the narrower-operator 174 is moved outwardly out of action at such time as to leave the narrower in an operative position when the direction of the cam-ring in continuous rotation is considered. This outward movement of the narrower-operator 174 to its original normal position is effected by the action of the cam-rise 771, Figs. 13 and 44, on pin 175, when needle-controller L is moved in the direction of the arrow 138 by the action of the bowl 107 dropping upon one of the

lowermost dwells 137. Then when the needle-controller L is restored to its normal position (that shown in Fig. 13) by the action upon the bowl 107 of one of the cam-rises 109 or 110 on the needle pattern-wheel N, the position of the narrower-operator is not affected, because its pin 175 passes beneath the dog 177, whose spring yields for this purpose. Likewise this same movement while not affecting the operativeness of the widener-operator restores it also to its normal position, with its pin 168 behind the dog 170, whose spring 171 yields for this purpose.

It will be observed that the movement of the widener-operator out of action and of the narrower-operator into action takes place at a time when no change is made between reciprocation and rotation, and hence requires for its control a separate track depression on the pattern-chain, and in the illustrated construction, in order to preserve the timing of the various pattern devices, a long stroke of the pattern-pawl lever F, and hence two additional cams 63, Fig. 16, on the time-shaft ratchet G, one for the heel and the other for the toe.

While in the illustrated machine only one needle is moved out of and into action at a time in narrowing and widening, the needles may be moved in groups of two or more, as may be desired, by simply lengthening the raisers 2 3 and enlarging the notches 4 correspondingly and altering the pattern-chain, so as to compensate for the consequent reduction in the required number of reciprocations of the cam-ring in making the heels and toes.

Certain structural features.—Certain details of construction may here be conveniently mentioned.

Each of the several parts—to wit, the needle-lifter-operating cam 99, the tripper 124, the depressor-operating cam 142, the widener-operator 166, and the narrower-operator 174—is mounted to slide radially on the stationary top plate 17 in the same manner, and hence the illustration and description of the mounting of one will suffice for all. Fig. 6 illustrates the mounting for the tripper 124. As here shown and as shown in Fig. 5, the tripper comprises a sliding block 181, (at the top of which the tripping-arm 130 is secured,) which fits and slides radially within a rectangular slot 6 in the top plate 17. The block 181 is secured to and rests upon a sliding plate 182, which slides on the bed-plate A in a groove in the under side of the top plate 17, Fig. 4, thereby preventing the block 181 being lifted up. This slide 182 carries the downwardly-projecting pin 131, which enters the appropriate cam-groove in the needle-controller L. Said parts 99, 124, 142, 166, and 174 also have their operating parts at different heights above the top plate 17, so as to act on their own proper devices without interfering with the other devices. As shown in Fig. 3, cam 142 is above cam 99 and tappet 166 is above tappet 178, while tripper-arm 130, Figs. 1 and 4, occupies an intermediate position. In reciprocating it is necessary for the cam-ring B to make a nearly-complete revolution in each direction in order to properly clear the knitting-cams from the acting needles. By making it reciprocate slightly more than a full revolution and by making the tappets 167 and 178 elastic it is necessary to employ but two tappets. Otherwise these tappets and their operating devices would have to be duplicated. Of course such duplicates would be within the scope of this portion of the present invention in its broader aspects; but the specific arrangement set forth constitutes an important though subsidiary feature of the invention. The extent of revolution of the cam-ring while reciprocating is determined by the stroke of the crank 35, the diameter of the pinion 37, and the number of its teeth. The narrower is double-acting, thus simplifying the construction. It is obvious, however, that the narrower might comprise two needle-raisers acting alternately. The same is likewise true in reference to the widener.

To facilitate construction and examination, the widener P and the parts immediately cooperating therewith are mounted upon a removable section 183 of the cam-ring B, Figs. 3, 4, and 11, which is secured to the cam-ring by suitable fasteners 184.

The narrower O is held in its two operative positions by a spring-pressed plunger 185, Fig. 26, which presses upon oppositely-inclined shoulders back of its head, Fig. 46.

The needle-controller L has five different positions, the normal position, that occupied during round-and-round knitting, being shown in Fig. 13, at which time the bowl 107, Fig. 25, rests on one of the dwells 117 or 1171 on needle pattern-wheel N. From this normal position the needle-controller is moved two steps forward in the direction of arrow 102 by the cams 108 and 1081 to operate the needle-lifter-operating cam 99 its two different strokes and also to operate the tripper 124. The pattern-wheel N then moves to bring one of its dwells 134 into action, thus putting the cam 99 and tripper 124 out of action and causing the dog 170 to put the widener-operator 166 into action. The needle-controller is then moved one step back from its normal position by the action of one of the two intermediate dwells 173 on wheel N, the effect of which is to put the widener into action and the narrower out of action. The needle-operator is then moved a second step back from its normal position by the action of one of the dwells or drops 137, whereby the needle-depressor-operating cam 142 and the tripper 124 are brought into action and the narrower-operator is put out of action, and, finally, the needle-controller is brought back to its normal position by the action of one of the cams 109 or 110 in the wheel N, whereby the cam 142 and tripper 124 are put out of action.

Knitting operation.—The mechanism has now been sufficiently described to enable the entire knitting operation to be understood. Assume at the start that the leg of a stocking is being knit in circular courses. The needle-operator rests in the position shown in Fig. 13, the bowl 107 then resting on dwell 1171 of needle pattern-wheel N, Fig. 25. When the toe is to be knit, the pattern-chain brings the pattern-shaft ratchet G into operation, and the sequence of operations is then as follows: First, the machine is slowed down; second, the needle pattern-wheel N is rotated in the direction of arrow 186, Fig. 25, thereby bringing cam 1081, and through it the needle-lifter-operating cam 99 and tripper 124, into action, thus throwing all of the instep and heel needles out of action and leaving only the toe-needles *a* in action; third, the cam-ring changes from continuous rotation to reciprocation, and, fourth, at the same time the needle pattern-wheel N is again moved forward, thus bringing the first dwell 134 into action, whereby the cam 99 and tripper 124 are thrown out of action and the widener-operator 166 is brought into action; fifth, the narrower O then acts until the toe is half made; sixth, the needle pattern-wheel N is again moved forward, bringing the first dwell 173 into action, thus putting the widener-operator out of, and the narrower-operator into, action; seventh, the widener P then acts until the toe is completed; eighth, the needle pattern-wheel again moves forward, thus bringing the first lowermost dwell 137 into action, whereby the needle-depressor-operating cam 142 and the tripper 124 are brought into action, thus putting all of the instep and heel needles into action, and the narrower-operator is at the same time put out of action; ninth, the cam-ring changes from reciprocation to continuous rotation, and, tenth, at the same time the needle pattern-wheel N is again moved forward, thus bringing cam 110 into action, the effect of which is to throw the widener-operator 174 and tripper 124 out of action and to restore the needle-controller L to its normal position; eleventh, round-and-round knitting is renewed for making the stocking-foot, and, twelfth, the machine changes back to its high speed. After the foot is completed the seamless heel is knit by exactly the same series of operations as employed in knitting the toe, the only variations being a smaller inward movement of the needle-lifter, so that the heel-needles a^2 are left in action, and a somewhat longer duration of the reciprocation of the cam-ring due to the heel being larger than the toe. This requires the duplication of the cams on the needle pattern-wheel N to embrace the cams and dwells 117, 1171, 108, 1081, 134, 173, 137, 109, and 110, heel-cam 108 being lower than the corresponding toe-cam 1081. The leg is then knit, thus completing the cycle of operations, which cycle continues indefinitely as long as the machine is left running and yarn is supplied continuously to it.

Regulating length of stitches.—The length of the stitches is immediately regulated by the well-known way of raising and lowering the needle-cylinder 10, which is accomplished by a well-known expedient, consisting of a vertically-movable sleeve 187, on which the needle-cylinder rests, which sleeve is screw-threaded to engage an exterior rotary lifting-ring 188, which is mounted to rotate between the bottom of the bed-plate and the usual retaining-ring 189. There is no novelty in this means for raising and lowering the needle-cylinder, the present improvements in this respect consisting in the mechanism operated by the time-shaft 40 to rotate the needle-cylinder-adjusting ring 188 automatically at the desired moments.

The ring 188 has gear-teeth on its outer periphery, Fig. 5, which mesh with those of a horizontally-movable rack 190, mounted to slide back and forth beneath the bed-plate A, Fig. 1. This rack is moved backward (thereby lowering the needle-cylinder and tightening the stitches) by means of a spring 191, and it is moved forward to raise the needle-cylinder and loosen and lengthen the stitches by means of appropriate cams 192, 193, and 194 on a cam-wheel Q, Figs. 23 and 24, on the time-shaft 40. Coöperating with these cams is a bowl 195, Figs. 4 and 23, on the free end of a lever 196, which is pivoted at 197 to the yarn-stand 30. A link 198 is pivoted at opposite ends at 199 to the lever 196, Figs. 1 and 4, and at 200, Fig. 1, to an appropriate part on the rack 190. As indicated in Fig. 23, the pivot 199 is adjustable, so as to regulate the foundation lengths of the stitches throughout the entire knitting operation.

The cam-wheel Q is fast to the time-shaft 40, so as to partake of the movements thereof, and it hence moves in consonance with the pattern-shaft ratchet G.

Normally and while the leg is being knit the bowl 195 rests on the highest dwell 192 on the wheel Q, and consequently the leg is knit loose and full. When the toe is to be knit, the wheel Q is moved forward, (by the same movement of pattern-shaft which changes from rotation to reciprocation,) so that the bowl 195 runs down incline 921 upon the first intermediate dwell 193, where it remains during the knitting of the toe, and hence the toe is knit more tightly than the leg. When the foot is to be knit, the wheel Q is again advanced, (by the same movement of the time-shaft which changes from reciprocation to rotation,) so that the bowl 195 drops down the incline 931 into the first low depression or dwell 194, where it remains during the knitting of the foot, and hence the foot is knit tightly. When the heel is to be knit, the wheel Q is again advanced, (by the same movement of the time-shaft which changes from rotation to reciprocation,) so

that the bowl 195 is elevated by the rise 941 upon the second intermediate dwell 193, (which in the case shown is the same height as the first dwell 193,) where it remains during the knitting of the heel, and hence the heel is knit with the same tightness as the toe. When the ankle is to be knit, the wheel Q is again advanced, (by the same movement of the time-shaft which changes from reciprocation to rotation,) so that the bowl 195 drops down the incline 932 into the second low dwell 194, where it remains during the knitting of the ankle, and hence the ankle is knit tightly and as tightly as the foot. When the ankle is completed and the knitting of the loose leg is to be resumed, the wheel Q is advanced another step by a special rotation of the time-shaft for that purpose, which is effected by the pattern-chain, so that the bowl 195 is lifted by the rise 942 upon the dwell 192, thus completing the cycle of operations.

The relative tightness of the heel and toe as compared with the leg is rendered adjustable by an adjustment of the cams 193. As shown, the cams 193 are constituted by cam-shoes 951, which are removably attached by screws to the wheel Q, and it is evident either by adjusting them radially or by replacing them by other shoes of different radial widths the tightness of the heel and toe can be regulated. Likewise the tightness of the foot and ankle relatively to the heel, toe, and leg is rendered adjustable by adjusting the extent of the drop of the bowl 195 into the dwells 194. For this purpose the backward swing of the bowl-carrying lever 196 under the stress of spring 191 is limited by an adjustable limiting screw-stop 962, Figs. 2 and 4, adjustable in a suitable fixed bracket 963.

Stop-motion.—The action of the knitting mechanism can be stopped by hand by simply moving the clutch 34 to a half-way position between wheel 32 and pinion 37 at any time except when one of the clutch-operating cams 72 or 73 is in its operating position. To enable this to be conveniently done, a hand-lever 201, Figs. 1 and 5, is pivoted at 202 beneath the bed-plate A and is pivotally connected with a stud 203 on an arm 204, rigidly attached to the shifting carriage I, Figs. 39 and 40.

The entire machine can be stopped at will by manipulating the stop-lever 205, Figs. 1, 1^a, 2, 4, 5, and 45, which is provided with a handle 206 for this purpose. This stop-lever 205 is pivoted at 207, Fig. 1^a, to the framework and has a fork 208 at its lower end, which embraces a peripheral groove 209 in the driving-pulley sleeve 84, which is slidable on the drive-shaft D. Normally the clutch member 85 on sleeve 84 couples with clutch 83 on the shaft D, in which position the handle end of the stop-lever is held outwardly by a detent 210, Figs. 5 and 45, on a handle-lever 211, pivoted at 212 to a bracket 213 on the framework. On swinging this lever 211 by hand the detent 210 releases the stop-lever 205, and thereupon a spring 214, Figs. 2 and 4, moves the handle end outward, thus uncoupling the clutch members 83 and 85 and stopping the machine. When the stop-lever 205 is swung in again by hand to start the machine, a spring 215, Figs. 1 and 45, causes the detent 210 to automatically lock the stop-lever in place.

The machine may be automatically stopped at the completion of any cycle of movements. To this end a slide 216, Figs. 4 and 45, is arranged in the path of the detent-lever 211, to which is connected an operating-lever 217. By moving the lower end of the operating-lever in the right direction the detent will be tripped and the machine stopped. This may be done automatically by a removable pin 218, adjustable on the wheel R, Fig. 5, fast on the pattern-shaft, which when in place would stop the machine automatically after knitting one stocking. By introducing any ordinary counting mechanism the machine may be automatically stopped after the completion of any desired number of stockings.

The machine is adapted by simply changing the pattern-chain to knit a continuous string of stocking-feet, in which event the stop-motion may be employed to stop the machine on the completion of any desired number of feet.

Pattern-shaft indicator.—It is desirable to be able to tell at a glance, when the machine is at rest, the location of the pattern devices, so as to facilitate the moving of the pattern devices at once to any desired starting-point both in beginning work and in restarting in case of any defect appearing in the product. To this end an index 219, Fig. 5, is fixed to the framework, with its pointer in proximity to the periphery of the indicator-wheel R, which is graduated to indicate the various positions of the pattern-shaft. The farther end of the time-shaft 40 is squared at 220 for the application of a wrench to turn it, and the pattern-chain ratchet 41 being loose on the pattern-shaft the pattern-chain can be quickly adjusted to any desired position. The entire machine is thus under the easy control of the operator.

By stopping the machine by the stop-lever 205 and by operating the hand-lever 201 to render the clutch 34 inoperative the machine is converted into a simple hand-machine and can be run by hand, the handle 39 being placed on shaft C for this purpose.

Yarn-changer.—It is desirable to knit the heel and toe of different yarn from the foot and leg, and hence an automatic yarn-changer is provided. In the illustrated machine, x is the main thread or yarn from which the foot and leg are knit, and two yarns are used together for knitting the heel and toe; but for all purposes, in considering the yarn-changer, they may be regarded as a single yarn, (a single yarn might be employed,) and hence

for convenience these heel and toe yarns or threads will be called the "heel-yarn," and they can be indicated by the single letter *y*.

It is necessary in a wholly-automatic whole-stocking machine, especially when it is expected that one attendant shall run a large number of them, that the yarn-changer should always operate with certainty, since a single miss spoils one stocking and necessitates the stopping of the machine.

The improved yarn-changer comprises a yarn-twister which twists the main and heel yarns together, so that the running or working yarn carries the idle yard into the needles; a clamp which clamps the idle yarn, releases it when the twisting has taken place, and then after the idle yard is carried into the needles and when the previously running or working yarn is being severed clamps the end thereof; a yarn-shifter for bringing the appropriate yarns within the range of the cutters; a yarn-cutter for severing the previously-running yarn, and a yarn-separator for keeping the two yarns apart during the cutting. These several instrumentalities will be described in order under appropriate heads.

Yarn-twister.—The main yarn *x* passes from its bobbin through thread or yarn guides 221 and 222, Fig. 20, to and through a yarn-guide 223, immediately above the yarn-twister S, Figs. 3 and 4. Likewise the heel-yarn *y* passes from its bobbin (or bobbins) through yarn-guide 224, Fig. 20, to and through a separate eye of the yarn-guide 223. Beneath the yarn-twister S is a yarn-guide 225, Figs. 3 and 4, from which the yarn or thread passes to the leading-in thread-eye or yarn-guide 28, which feeds the yarn to the needles.

The yarn-twister S is supported at the outer end of a horizontally-projecting arm 226 of a bracket 227, fastened to a vertical post 228 on the yarn-stand 30.

The details of the twister are shown in Figs. 28, 32, 33, and 34, which illustrate the specific construction. Beneath the bracket-arm 226 is secured a plate 229, Figs. 30 and 31, upon which the yarn-twister is mounted, this plate also carrying the yarn-guide 225. This plate has a circular aperture *g* for the passage of the yarn. Mounted upon the outer end of plate 229 are a pair of plates *h i*, secured together, which constitute the journal for the twister. They have a circular aperture in which the twister turns and a recessed channel in the periphery of said aperture, which retains a series of balls *j*, constituting a ball-bearing for the twister. The twister S includes three circular plates *k l m*, securely fastened together by screws, so as to be separable. The two lower plates *l m* have a recessed channel in their common periphery to receive the balls *j*. This construction thus enables the twister to turn freely on the balls, and at the same time the twister is held against vertical movement by the balls. The twister has an elongated yarn-slot *n*, which is formed in coincidence in each of its three plates *k*, *l*, and *m*. The axis of rotation of the twister is coincident with the center of the aperture *g* in the plate 229 and the diameter of said aperture is at least equal to the length of said yarn-slot *n*. Secured to the upper side of the top plate *k* is a beveled pinion 230, which has a central aperture at least as large in both directions as the slot *n*.

Ordinarily the yarn-twister is stationary, and the running or working yarn passes freely through the slot *n* and aperture *g*, the end of the idle yarn being clamped within the yarn-twister, as hereinafter explained. When the yarns are to be changed, the twister is automatically rapidly rotated a number of times, (in the illustrated machine thirteen and one-half times,) thereby twisting the two yarns securely together, so that (the idle yarn being then released, as hereinafter explained) the running or working yarn then carries the end of the idle yarn twisted about it to the needles with certainty and no chance of failure. This automatic twist of the yarns occurs four times in knitting each stocking, at the commencement and finish of the toe and of the heel, and, hence, when the changes occur between reciprocation and rotation; and, consequently, the yarn-changing is controlled by the same variations in the pattern-chain which control the change in the direction of the movements of the machine.

Fastened to the same sleeve which constitutes the hub of the needle pattern-wheel N, and hence partaking of the movements thereof, is a cam-drum T, Figs. 1 and 2, having a peripheral cam-groove with right and left cam-rises 231 232. Located in this cam-groove and actuated by its cam-rises is a bowl 233, Fig. 1, at the upper end of a lever 234, pivoted to swing laterally at 235, Figs. 1ª and 3ª, to a part of the framework 11. The lower end of this lever has a fork 245, Figs. 1ª and 8, which embraces a curved flange 236 on a lever 237, which is pivoted at 238 between suitable ears in the framework, so as to have both a vertical movement through a considerable arc and a limited lateral movement which is sufficiently provided for by the lost motion at the pivot 238. Any form of universal or gimbal joint could be substituted. The flange 236 is concentric with the pivot 238, so that the lever 237 can swing freely through its vertical stroke without said flange becoming disengaged from said fork. The lever 237 is retained yieldingly in its uppermost position by a spring-detent 239, Fig. 8, at the fork 245 of lever 234, which engages a recess 240, Fig. 3ª, in the flange 236. This connection permits the lever 237 to be readily disengaged by a positive action thereupon. The lever 237 is made in skeleton form, so as to embrace the drive-shaft D, and has two bowls 241 and 242 projecting at the right and left, respectively, which are respectively be-

low and above said shaft and are adapted to coöperate, respectively, with cams 243 and 244 on the said shaft.

To the rear free end of the lever 237 is pivoted, at 246, Fig. 3ª, the lower end of a connecting-rod 247, the upper end of which is pivoted at 248, Figs. 2, 3, and 4, to the lower end of a vertically-sliding rack 249, which is mounted to slide in the yarn-stand 30 and bracket 227. This rack when reciprocated rotates a horizontal shaft 250, having on its forward end a beveled pinion 251, meshing with the pinion 230 of the yarn-twister S, through multiplying-gearing consisting of small pinion 252, with which the rack directly engages, a large pinion 253 on the same shaft as said pinion 252, and a small pinion 254 on the shaft 250, engaging said pinion 253, Figs. 27 and 28. Consequently a relatively-small vertical movement of rack 249 suffices to rotate the twister S a sufficient number of times.

Normally when the leg of the stocking is being knit with the main yarn x the rack 249 is down and the lever 237 occupies its lowest position and likewise its central (as between left and right) position, with both of its bowls 241 and 242 out of the paths of their respective operating-cams 243 244, and the lever 234 at the same time occupies its central position, its bowl 233 being in one of the straight portions of the cam-groove in the yarn-changer cam-drum T. When, however, the toe is to be knit and the change is made from rotation to reciprocation by the movement of the time-shaft 40, the drum T is moved forward, so as to bring one of its right cam-rises 231, Fig. 1, into action on the bowl 233, whereby the lower end of the lever 234, Fig. 1ª, is swung to the left, thereby swinging the lever 237 the same way, so that its upper bowl 242 is brought into the path of the lifting-cam 244 on the drive-shaft D, and hence said lever 237 is swung upwardly until it is caught and retained uplifted by the yielding detent 239 of the lever 234, Figs. 3ª and 8. The effect of this upward swing of lever 237 is to lift the rack 249, and hence to rotate the yarn-twister S. The further immediate advance of the drum T restores the levers 234 and 237 to their central positions, but the lever 237 is upheld by the detent 239 until the toe is completed, and when time-shaft 40 then moves forward to change back to rotation the drum T is again moved forward, bringing one of its left-hand rises 232, Figs. 1 and 2, into action, thereby swinging levers 234 and 237 to the right, Fig. 1ª, so that the lower bowl 241 on lever 237 is put into the path of the depressing-cam 244 on the main shaft D, whereby the lever 237 is lowered, (the detent 239 yielding to permit it,) and, as a consequence, the rack 249 descends, thus again rotating the yarn-twister. The same operations occur on beginning and finishing the heel, other like cams 231 and 232 being provided on the drum T for this purpose.

Yarn-clamp.—The end of the idle yarn is clamped within the yarn-twister during the twisting and is immediately thereafter released to permit both yarns to run together, and then the other yarn is clamped.

The middle plate l of the yarn-twister, Figs. 32, 33, and 34, is recessed at its center and is provided at opposite ends and opposite sides of the slot n with two projecting yarn-clamping jaws 8 and 9. It is also equipped with two projecting pivot-studs o, on which two movable levers 255 swing, carrying the movable yarn-clamping jaws p q, which coöperate, respectively, with said fixed jaws 8 and 9. Projecting upwardly from each of the two jaw-levers 255 is a pin r, and these pins enter, respectively, into cam-grooves s t in a sliding clamp cam-plate 256. This cam-plate is mounted to slide parallel with the yarn-slot n between the two plates k and l of the yarn-twister, being guided by suitable upwardly-projecting flanges u, Fig. 34, on the middle plate l. The clamp cam-plate 256 has a yarn-slot 257, parallel with the yarn-slot n and as much longer than slot n as the extent of the sliding movement of the cam-plate, so that in whatever position the cam-plate may be the slot 257 furnishes a free passage for the yarns. The clamp-plate 256 has three positions, and the cam-grooves s and t are so arranged, as shown, that when said plate is in its middle position both clamps are open. When the plate is in one extreme position, the main yarn-clamp 8 p is closed and the heel yarn-clamp 9 q is open, and when the plate is in its other extreme position the clamp 8 p is open and the clamp 9 q is closed, cam-groove s coöperating with jaw p and groove t with jaw q.

The operation of the yarn-clamp is controlled at the proper times by overhanging draw-down cams 258 on the yarn-changer pattern-drum T, Figs. 1, 2, 4, 52, and 53, which coöperate with the inclined face of a projecting toe v, Figs. 2 and 4, on the lower end of a yarn-clamp controller 259, which comprises a rod mounted to slide vertically on the yarn-stand 30. The yarn-clamp controller 259 is normally held elevated by a spring 260, Figs. 3 and 4, and is depressed from time to time by the cams 258. When pulled down, the yarn-clamp controller is held down by a latch 261, Figs. 54, 55, and 56, which engages a stud 262 on the controller. This latch slides horizontally on the yarn-stand 30 and is pushed forward by a spring 263, and on its front edge it has two lips 264 and 641 at different vertical heights and projecting forwardly to different extents. When the controller 259 is pulled down by one of the cams 258, the stud 262 is engaged by the lower lip 264, and in this position a horizontally-projecting arm 265 on the controller is in the path of a tappet 266, projecting radially from the cam-ring B, Figs. 2 and 3, which strikes said arm, causes said controller 259 to rock, so that an arm 591 on said controller, Figs. 54 and 56, comes in contact with the front face of the latch 261,

thereby pressing said latch partly outward, and hence releasing the stud 262 from lip 264, whereupon the spring 260 lifts the controller partly up until its stud 262 is caught by the upper lip 641 by virtue of the action of a spring 267, Figs. 4, 5, and 27, which rotates the controller 259 in the direction opposite to that in which it is moved by the tappet 266, as will presently appear. This partial upward movement of the controller takes the arm 265 out of the path of tappet 266 and brings a second upper arm 268 into the path of a projecting tappet 269, moving with the cam-ring B, (but, as shown in Figs. 3, 4, 5, and 27, carried by the sinker cam-ring 25,) which on the reverse movement of the cam-ring again rotates the controller 259 and through a greater arc than before, thus again pushing the latch 261 outward and to a greater extent, thus releasing stud 262 from the upper lip 641 of the latch 261, whereupon the spring 260 elevates the controller to its normal position, with both of its arms 265 and 268 out of the path of their respective tappets 266 and 269, and the spring 267 thereupon rotates the controller back to its normal position, where its stud 262 is again in position to be caught by the lips 264 and 641 upon the controller. The yarn-clamp controller thus, in addition to its normal position, has two different vertical positions and is oscillated through two different arcs.

The upper arm 268 of the controller 259 is not on the controller itself, but is on a lever 270, pivoted at 271 to the yarn-stand 30, Fig. 27, to swing horizontally and having a concentric slot 272, through which the controller-shaft extends. Said lever likewise has a radial slot 273, in which enters a pin 274 on the outer end of a crank-arm 275 on the upper end of the controller. A flange 276, Fig. 59, on the controller beneath the lever 270 causes the outer end of said lever to partake of the vertical movements of the controller, the lost motion at its pivot 271 permitting it.

Owing to the crank-pin 274 entering the radial slot 273, it will be noted that the lever 270 swings when tappet 266 strikes arm 265 of the controller, that the controller oscillates when the tappet 269 encounters arm 268, and that during both movements the slot 272 permits the free swing of the lever 270. The restoring-spring 267 is connected with the outer end of the lever 270.

By the described arrangement it will be noted that the lever 270 is oscillated, first, through a short arc by the action of tappet 266, and then after one reciprocation of the cam-ring is oscillated through a long arc by the action of tappet 269, and both of these movements are effected by the action of the cams 258 on the drum T four times in the knitting of one stocking—to wit, at the beginning and completion of the toe and of the heel.

The inner end of the lever 270 is pivotally connected with the lower end of a lever 277, pivoted at 278 to the bracket 227, so as to swing in a vertical plane, Figs. 3, 4, and 28. The upper end of the lever 277 is pivotally connected with the inner end of a cam-lever 279, which is pivoted at 280 to the under side of the bracket-arm 226, Fig. 28. The cam-lever 279 near its outer end has a cam-slot in which plays a pin 2801, Fig. 28, depending from a slide 281, constituting the yarn-clamp operator, which is mounted on the arm 226 to slide back and forth horizontally in the plane of the yarn-clamp cam-plate 256. This cam-slot has a dwell 282, which pin 2801 normally occupies, a low cam-rise 283, which is brought into play on the first and smaller swing of the yarn-clamp controller 259 and which moves the yarn-clamp operator 281 partly forward, and a high cam-rise 284, which is brought into play on the second and longer swing of the yarn-clamp controller 259 and which moves the yarn-clamp operator 281 wholly forward.

Just as soon as the yarn-twister has operated to twist the two yarns together the operator 281 moves partly forward, thereby moving the cam-plate 256 (which is left by the twister directly in line with operator 281) halfway, thus leaving both yarn-clamps open. The previously-running yarn thereupon carries the leading end of the idle yarn into the needles, and as soon as this is accomplished (a reciprocation of the cam-ring B sufficing) the operator 281 moves wholly forward, thereby clamping the previously-running thread, which is immediately cut off below the clamp by the cutter, as will presently appear.

The gear of the yarn-twister is so organized that at each twisting operation the twister is rotated a plurality of complete revolutions plus a half-revolution—in the illustrated machine thirteen and one-half revolutions, as previously stated. This extra half-revolution is of importance, since it enables a single operator 281 and operating mechanism therefor to be used to move the yarn-clamp cam-plate 256 in both directions to operate both clamps. Assuming that when first the plate 250 is moved outward it closes the outer clamp 8 *p* and leaves the inner clamp 9 *q* open, then when the twister again operates it leaves the clamps just reversed, so that the closed clamp 8 *p* is the inner one and the open clamp 9 *q* is the outer one, and hence when the operator 281 again operates it opens clamp 8 *p* and closes clamp 9 *q*, since it is always the clamp which is the outer one for the time being which is closed by the action of the operator 281.

Yarn-shifter.—Now since it is always the yarn-clamp which is the outer one for the time being which clamps the yarn it is obvious that automatic means must be provided for shifting the position of the main and heel yarns alternately with reference to the twister, so that when a toe or a heel is to be commenced the main yarn will be clamped and cut, and so that when the toe is finished the heel-yarn will be clamped and cut. This

mechanism is illustrated in Figs. 3, 4, and 5. Mounted to slide in suitable provisions on the bracket-arm 226 are two yarn-shifters 286 and 285 for the heel and main yarns *y* and *x*, respectively, each having yarn-eyes *w* and *z* in their respective front ends, through which pass the respective yarns, the normal position of the shifters being that shown in Fig. 5, wherein the yarn-eyes *w z* are just below the yarn-guide 223 and above the yarn-twister S, the main yarn-eye *z* being just forward thereof. The yarn-shifters 285 286 are compelled to move in unison, but in opposite directions, by a reversing-lever 287, pivotally connected with both. The yarn-shifters are moved in one direction by a spring 288 and in the opposite direction by a cam 289 on the upper end of the twister-operating rack 249, which acts against the rear end of the shifter 286.

Normally the rack 249 occupies its lowest position, with the cam 289 holding the shifters in the positions shown in Fig. 5. When then the rack 249 rises to twist the yarns, carrying with it cam 289, the spring 288 reverses the positions of the shifters, carrying the main yarn forward and the heel-yarn backward. Consequently when the yarn-clamps are both open (on the partial forward movement of the yarn-clamp operator 281) the run of both yarns together brings the heel-yarn into the rear end of the yarn-slot *n* in the twister S and brings the main yarn into the front end of the said slot between the then outer clamp-jaws 8 *p*, which are immediately thereafter closed by the full outward movement of the yarn-clamp operator 281, thus clamping the main yarn and leaving the heel-yarn running freely. Then when the rack 243 descends on the completion of a heel or toe, thus again operating the yarn-twister and shifting the position of the yarn-clamp, the cam 289 encounters the rear end of yarn-shifter 286, thus shifting the positions of the yarns, carrying the main yarn in and the heel-yarn out into position to be clamped by its then outer clamp-jaws 9 *q*.

Yarn-cutter.—The yarn which is to be rendered idle after being clamped might be left to be broken below the clamp by the knitting operation. This, however, is objectionable on account of danger of accident to the running yarn and also because the yarn might break anywhere between the needles and the twister, thus endangering leaving a loose end, which might become knotted during the next twist, thus injuring the product. Hence a cutter is employed for positively severing the clamped yarn just below the yarn-twister and above the yarn-guide 225. The cutter is mounted just below the plate 229 and is best shown in Figs. 30 and 31, which are under side views of said plate, showing the cutter in its two positions—open and shut. The cutter consists of a pair of shears U V, pivoted rotatively at 290 and 291 to the plate 229 and having their cutting-blades 292 arranged to extend across only the front part of the yarn-opening *g*, leaving the rear part of said opening always free for the passage of the running yarn.

The shears U V are connected together by the reversing-lever 293, pivotally connected with each, so as to move in unison, but in opposite directions. The shears are normally held open in the position shown in Fig. 30 by a spring 294, which acts upon a tang 295 on the outwardly-projecting end of the lever 293. To close the shears to cut the clamped yarn, the cam-lever 279 has a projecting tappet 296, Figs. 3, 28, and 29, which encounters a downwardly-projecting stud 297, located on the shear U forward of its pivot 290, thereby closing the cutting-blades and severing the clamped yarn. This operation of the cutter only occurs when the cam-lever 279 makes its long movement, its small movement which opens the clamp, not sufficing to bring its tappet 296 into contact with stud 297.

Yarn-separator.—At its forward end the cam-lever 279 has a wedge-shaped yarn-separator 298, Fig. 29, the point of which enters between the two yarns just in advance of the cutting operation, and as the separator advances its separating edges, which diverge from said point, separate the yarns, thus insuring the operation of the cutter only upon the proper yarn.

Operation of yarn-changer.—In knitting the leg the main yarn *x* is running, passing through the rear end of slot *n* in the yarn-twister, the shifter 285 and clamp 8 *p* then occupying their rearmost positions, the clamp being open and the main operating-lever 237 being down. At the same time the heel-yarn *y* is idle its shifter 286 and clamp 9 *q* are forward and its end is held in said clamp. The cutter is open. When a heel or a toe is to be knit, the lever 237, Fig. 3ª, moves up, starting the twister and reversing the position of the yarn-shifters 285 286, thus carrying the main yarn forward and the heel-yarn backward. The twister revolves rapidly during the upstroke of lever 237, during which twisting operation the heel-yarn is still clamped and the main yarn is still running, so that the end of the heel-yarn is carried around and around the main yarn, thus thoroughly twisting the two yarns together. The twister rotates a plurality of times plus a half-revolution, thus reversing the position of the yarn-clamps. The heel-yarn clamp then opens, the main-yarn clamp remaining open. The two yarns then run together to the needles until the heel-yarn is well taken by the needles, and during this time the two yarns have positioned themselves properly in the yarn-slot *n* in the yarn-twister, the main yarn being now located in the forward end of the slot in the path of its clamp-jaws 8 *p* and in that of the cutter-blades 292, while the heel-yarn runs in the rear of the slot out of reach of the cutter-blades. The yarn-clamp operator then closes the main-yarn-clamp jaws

8 *p* upon the main yarn, firmly gripping it, and simultaneously the yarn-separator 293 positively insures the proper positions of the two yarns and the cutter severs the main yarn. When the toe or heel has been knit, the lever 237 descends and the foregoing operations are repeated, except in reverse directions, so far as the yarn-twister, yarn-clamp, and yarn-shifter are concerned, thereby carrying in the main thread and clamping and cutting out the heel-thread.

Yarn-slackener.—There is a liability of breaking the running yarn, especially if tender or fragile yarns are in use, by the yarn-twisting action, and to obviate this a yarn-slackener is employed which slackens the running yarn just as the twisting is about to take place, so that the twist occurs in the slackened portion of the running yarn.

The yarn-slackener W, Figs. 3 and 4, consists of a rod having a thread-eye 299 at its lower end, which during the normal operation of the machine while continuously rotating is located immediately beneath the yarn-guide 225, below the yarn-twister S. The yarn-slackener is mounted to swing vertically at the outer upper end of an arm 300 of the bracket 227, above the yarn-twister. To this end the hub 301, Fig. 19, of the yarn-slackener turns freely on a horizontally-projecting pintle 302, secured to the outer upper end of arm 300. Also turning on said pintle is a collar 303, having two horizontally-projecting spaced pins 304 and 305, between which the yarn-slackener extends. A torsional lifting-spring 306, connected with the yarn-slackener tends always to lift the slackener; but the front pin 305 acts as a stop to limit and hold the slackener, the collar 303 being normally maintained in such position as to hold the yarn-slackener in its normal place, with its thread-eye below the yarn-twister.

The yarn-slackener is automatically moved at the appropriate times, at the beginning and completion of a heel or of a toe, by proper connection with the time-shaft 40. Its movements are controlled by a pattern ratchet-wheel X, Figs. 1, 2, 5, 22, and 51, turning loosely on the pattern-shaft or, rather, on the hub of the drum T, with which it is operatively connected by pins 307, Fig. 1, by which the wheel X is driven from the drum T, while still permitting the wheel X to be independently advanced. The wheel X is brought into action at the appropriate times by the movement of the drum T under the control of the pattern chain, and as a result the wheel X is thereafter moved by a cam 308 on the inner end of the main shaft C, Figs. 4 and 51. This cam 308 acts upon the outer end of a pawl-lever 309, which is hung concentrically and loosely on the hub of ratchet-wheel X, and it carries a ratchet-pawl 310, which engages the ratchet-wheel X, Figs. 22 and 51, a spring 311 holding pawl 310 to ratchet X and the lever 309 to cam 308.

During the major part of the knitting the cam 308 and pawl 310 are rendered inactive by virtue of the point of the pawl 310 riding idly on one of the blanks 312 on the ratchet-wheel X. When, however, the wheel X is advanced by the movement of the time-shaft 40, the pawl 310 is brought into action, thus continuing the advance of the wheel X until the next blank 312 is reached.

The yarn-slackener pattern-wheel X has (see Fig. 22) abrupt operating-cams 313 314, high dwells 315 316, and low dwells 317. The office of the high dwells 315 316 need not now be considered, since they have to do with the "take-up" operation to be hereinafter discussed. The cams 313 314 and dwells 317 cooperate with the nose 318 of a bell-crank lever 319, which is pivoted at 320 to an arm 321, depending rearwardly from the yarn-stand 30, Fig. 3. A spring 322 keeps the nose 318 in coaction with the said cams and dwells. To the upper outer end of the lever 319 is pivoted at 323 an upwardly and forwardly extending connecting-rod 324, which at its upper end is pivoted to a crank-arm 325 on the collar 303, Figs. 3, 4, and 19.

Normally the nose 318 of the yarn-slackener-operating lever 319 rests in one of the lowermost dwells 317, thus maintaining the yarn-slackener in its normal position. When, however, the yarn-twister is about to act, one of the cams 313 (depending upon whether a heel or toe is to be knit) acts upon operating-lever 319, thereby swinging collar 303 in the direction of arrow 326, Fig. 3, through a considerable arc, and thereupon the yarn-slackener swings upwardly through a considerable arc both under the stress of its lifting-spring 306 and by the positive action of the rear pin 304, which abuts against its rear side, thus paying down from the bobbin a considerable excess of the then running main yarn. The lifting action of cam 313 is momentary only, and it at once passes from under the nose 318 of operating-lever 319, thus dropping the yarn-slackener, and hence slackening the excess of yarn, and therefore providing a slack section of yarn for the action of the yarn-twister. The cams 314 repeat this action of the yarn-slackener upon the completion of a heel or of a toe, hence slackening the then running heel-yarn and preventing its being broken. The certain action of the yarn-changer without failure is thus secured.

Yarn take-up.—During reciprocation while knitting heels and toes it is desirable to take up the slack yarn which results from the running of the cam-ring B, necessarily being through a greater arc than that occupied by the then active needles, this slack being liable to catch on the idle needles and be thereby broken, and hence an automatically acting and controlled take-up is here provided. For this purpose the yarn-slackening mechanism is utilized for the purpose of simplicity, since the only additional mechanisms rendered necessary for this utilization are the high dwells 315 on the pattern-wheel X. When the yarn-

slackener is operated by one of the cams 313, it does not drop all of the way back to its normal position, but only part way back, due to the nose 318 of operating-lever 319 resting on one of the high dwells 315, the drop being, however, sufficient to efficiently slacken the yarn. The yarn-slackener occupies this intermediate position during the knitting of heels and toes and when so doing acts as an efficient take-up. When in this position, it plays between the two spaced pins 304 and 305 a sufficient distance to take up the slack yarn in knitting. When the heel-yarn is running and knitting, its tension suffices to overcome the lifting-spring 306 and to hold the take-up W against the rear (and the then lower) stop-pin 304. As soon, however, as the cam-ring B reverses the slackening yarn is taken up by the upward movement of the take-up under the stress of its lifting-spring 306.

The purpose of the high dwells 316, which uphold the yarn-slackener and take-up a short time after circular knitting has been resumed and when the take-up action ceases, is to prevent the excessive slackening of the yarn which would be caused if the yarn-slackener and take-up were to at once drop its entire distance.

Yarn-tension.—The heel-yarn should be under tension while knitting the heel and toe, so that the action of the take-up shall be expended upon the slack yarn at the needles without danger of the heel-yarn being payed out thereby from its bobbin. It is also important that the tension device should be rendered inoperative at the beginning of the heel or toe, so as not to interfere with the freedom of the heel-yarn during the twisting operation, which puts the heel-yarn again into action, and so as not to interfere with the feeding in to the needles of the heel-yarn by its end twisted around the main yarn. For these purposes a heel-yarn tension Y, Figs. 20 and 21, is provided which is automatically rendered inactive at the proper times.

The tension Y is similar in construction to a well-known type of sewing-machine tension, consisting of two friction-disks 327, mounted loosely upon a spindle 328, carried by an arm 329 on a bracket 330, secured to the upper end of the post 228, said disks being normally held together with the requisite pressure (which is adjustable in the usual manner) by a spring 331. The heel-yarn *y* in passing between guides 224 and 223 passes over spindle 328 between the friction-disks 327, whereby the requisite tension is imparted.

The tension upon the heel-yarn is relieved at the proper times by separating the friction-disks, which is effected by a tension-reliever 332, which is a lever pivoted to an arm 333 on the bracket 330, which has a wedge-shaped separator 334, adapted to enter between and separate the disks 327 when the tension-reliever 332 is swung upwardly. The upward swing of the reliever 332 is effected by two appropriately-located cams 335 on the same pattern-wheel Q which governs the length of the stitches, Figs. 1, 2, 23, and 24, these cams operating, respectively, at the beginning of a heel and of a toe. These cams operate to lift upon the lower end of a rod 336, which at its upper end is pivoted at 337, Figs. 20 and 21, to the reliever 332, and which extends thence downwardly through appropriate guides 338, Figs. 5, 27, and 60, and 339, Figs. 2 and 4, to the vicinity of the cams 335, gravity maintaining the rod 336 in its lower position, and a stop 340, Fig. 2, limiting its downward movement. The reliever and its operating-rod 336 are upheld during the twisting of the yarns and the feeding in of the heel-yarn by the guide-lever 338, which coöperates with a beveled catch 341, Fig. 60, on the rod 336. The lever 338 is pivoted at 342, Fig. 27, to the yarn-stand 30 and has a concentric guide-slot 343, through which the rod 336 extends and by which it is guided. A spring 344, Fig. 27, normally holds the lever 338 in the position shown, yields under the action of beveled catch 341 when the rod 336 is lifted, and restores the lever 338 beneath said catch to hold the reliever up, separating the tension-disks. The reliever is released to bring the tension again into operation at the moment the main yarn is severed by the yarn-cutter by the movement of the lever 270 when making its longest stroke to effect the cutting, which then encounters an upwardly-projecting stud 345, Fig. 27, on the lever 338, and thereby moves the lever to release catch 341, thus permitting the rod 336 and tension-reliever to drop.

It will be observed that the tension need not be relieved when the main yarn is brought into action, because the yarn-slackener then operates on the heel-yarn to give sufficient slack to it, thus relieving it from tension during the operation of the twister, and the heel-yarn then requires no release of tension while carrying the main yarn into the needles.

Sinker-shifter.—It is desirable when occasion demands—as, for example, in case of the failure of a needle to take a stitch—to elevate by hand the fabric in the vicinity of such needle, so as to restore the stitch to the needle, and to this end the sinkers when at a point opposite the knitting-point are in the present machine arranged so as to be moved outward by hand manipulation, so as to be cleared from the adjacent needles. For this purpose a sinker-shifter Z, Figs. 57 and 58, is mounted on the sinker cam-ring 25 opposite the knitting-point. Normally this shifter occupies its innermost position within the cam-track 346 of the cam-ring 25. The usual depending flange 347 of the cam-ring 25, outside of the cam-track, is omitted opposite the shifter Z, so as to constitute an opening 348 to permit the outward radial movement of the sinkers 23 when their butts 349 are acted upon by the shifter. An exterior cap-plate 350 may be employed opposite the opening 348 to prevent access of dust or lint to the sinkers at this point. By moving the shifter

Z radially outward the hooks 351 of the sinkers, which are then opposite the shifter, may be moved outwardly entirely free from the needles, thus giving access to the loops or stitches thereon.

Rising from the shifter Z is a shoulder-screw 352, playing in a radial slot 353 in the cam-ring 25 and extending through an inclined cam-slot 354, Fig. 27, in a slide 355 on the top of the cam-ring. The slide 355 is mounted to turn concentrically on the cam-ring 25 by means of slots 356 and shoulder-screws 357, Fig. 27, and it is manipulated by a suitable handle 358. By sliding the slide 355 the shifter Z and sinkers can be moved in or out at will.

Miscellaneous features.—Several features of construction are illustrated in the drawings which, having nothing to do with the knitting operation, have not been referred to, but will now be briefly mentioned.

The leading-in yarn-guide 28 is shown as a swinging one with means for locking it in place and also as carrying a latch-needle-opener ring 359 for insuring the opening of the latches of the elevated needles; but as these features are all old no further description is deemed necessary.

The handle 360 (shown in Figs. 1, 3, and 4) is for clamping the sleeve 187 to the needle-cylinder in a well-known manner possessing no novelty and necessitating no further description.

The several wheels on the time-shaft, which turn at times with it and at times independently of it—such as the pattern-chain wheel 41, the needle-pattern ratchet N, (and with it drum T,) and the wheel X—require for their proper operation means, such as friction devices, for preventing their rotation except when positively actuated. In each of these cases a frictional device is employed grasping the hub of each wheel, and consequently a reference to one device will suffice for all, the pattern-chain wheel 41 being selected. The friction device 361 is essentially an ordinary brake-band held in position by a holder 362 on the frame, its two ends being adjustable by nut 363, screwing onto the threaded end of the brake-band, to adjust the friction upon the hub of wheel 41.

It will be noted that all of the operating parts which effect a variation in the knitting or a change in the motions of the machine are automatically moved and are under the control of the single time-shaft. The several instrumentalities which immediately effect variations in the knitting or changes in the motions of the machine are actuated automatically by operatively-connected mechanisms, so that the proper sequence of action of the several instrumentalities and their proper conjoint action are secured and insured.

The invention is not limited to the form and construction of the machine selected for illustration and specific description, and in addition to modifications already alluded to it is obvious that numerous changes can be made without departing from the spirit of the invention and that many features can be usefully employed in other types of knitting-machines. For example, while in the machine selected for illustration the toe, foot, heel, ankle, and leg are knit in the order named, it is obvious that these parts may be knit in the reverse order by a simple transposition of the actuating-cams and the operating parts of the pattern-chain.

In the subjoined claims it has been found necessary in a number of instances (on account of the large number of separate features involved, many of which necessarily could not be given distinctive names) to employ reference letters and numerals to distinguish them; but such references are to be regarded as designations and not as limitations.

I claim as my invention—

1. A knitting-machine having, in combination, a rotary yarn-twister which when rotated rotates a plurality of times and a half-revolution in addition; a yarn-clamp rotating with said yarn-twister, said clamp having two sets of clamping-jaws which are alternately brought into operative position by the said rotation; and connected mechanisms for automatically rotating said yarn-twister and yarn-clamp and for opening and closing said clamping-jaws, substantially as set forth.

2. A knitting-machine having, in combination, a yarn-twister with an elongated yarn-eye and with rigid clamp-jaws on opposite sides and at opposite ends of said eye; movable clamping-jaws pivoted at diametrically-opposite points to the twister and coöperating with said fixed jaws respectively; and an operating-slide for opening one pair of jaws and thereafter closing the other pair of jaws, substantially as set forth.

3. A knitting-machine having, in combination, a rotary yarn-clamp comprising two pairs of clamping-jaws, one of said pairs of jaws being normally closed and the other pair being normally open; and means for first opening the previously-closed jaws so that for a time both sets of jaws are open, and for thereafter closing the previously-open jaws, substantially as set forth.

4. A knitting-machine having, in combination, the rotary yarn-twister and yarn-clamp comprising connected plates k, l, m, having elongated yarn-eye n, jaws 8, 9, pivot-studs o, o, and guides u, u; the levers 255, pivoted to said studs and having jaws p, q, adapted to said jaws 8, 9, respectively, and having also projecting studs r, r; the clamp cam-plate 256, located and sliding between said plates k, l, and guides u, u, said plate 256, having cam-slots s, t, in which said studs r, r, respectively enter, and having elongated eye 257, registering at all times with the eye n, throughout the length of said eye n, substantially as set forth.

5. A knitting-machine having, in combina-

tion, a rotary yarn-twister and yarn-clamp having a rotation through a plurality of revolutions plus a half-revolution, and having two sets of clamping-jaws, the outer of which is normally closed and the inner of which is normally open; a clamp cam-plate rotating with said twister and clamp for opening and closing said jaws; and means acting upon the inner end of said clamp cam-plate for moving the same, substantially as set forth.

6. A knitting-machine having, in combination, a yarn-clamp having a movable-clamp cam-plate 256; yarn-clamp operator 281, having stud 2801; cam-lever 279, having cam-groove 282, 283, 284, in which said stud enters; lever 277, operatively connected with said lever 279; lever 270, operatively connected with lever 279, said lever 270, having slots 272, 273, and arm 268; spring 267; clamp-controller 259, extending through slot 272, having flange 276, for lifting-lever 270, stud 262, arms 591, and 265, toe *v*, crank-arm 275, and pin 274, said pin 274, entering said slot 273; spring 260, for elevating said controller; time-shaft 40; means for automatically moving said time-shaft; cam-drum T, operatively connected with said time-shaft, and having cams 258, 258, coöperating with said toe *v*, to pull down said controller 259; latch 261, having two lips 264, and 641, adapted to said stud 262, for holding said controller in different positions, said latch being moved in one direction by arm 591; a spring 263, moving said latch in the opposite direction; moving tappet 266, which encounters arm 265, when said controller is in its lowest position; and moving tappet 269, which encounters said arm 268, when the controller is in its intermediate position, substantially as set forth.

7. A knitting-machine having, in combination, yarn-guides for two yarns; two sets of yarn-clamping jaws adapted to said respective yarns; one of said yarns being normally clamped and the other normally running, the action of said clamping-jaws being reversed when the yarns are changed, and said action being such that for a time both yarns run together; a yarn-separator which enters between said yarns when both are running to insure the action upon the proper yarn of the clamping-jaws about to close; and connected mechanisms for automatically operating said separator and clamping-jaws, substantially as set forth.

8. A knitting-machine having, in combination, a swinging yarn take-up normally occupying an idle position; a pair of rocking stops 304, and 305, between which said take-up plays; automatic mechanism controlled by a time mechanism for moving said stops in one direction; and a spring normally holding said take-up in contact with one of said stops, substantially as set forth.

9. A knitting-machine having, in combination, a yarn tension comprising tension-disks 327; spring 331; tension-reliever 332; rod 336, connected with said reliever said rod having catch 341, and occupying normally by gravity its lowest position; time-shaft 40; pattern-wheel Q, operatively connected with said shaft and having cams for lifting said rod 336; spring-lever 338, engaging said catch 341, to hold said rod uplifted; and means controlled by the time-shaft to move said lever to release said catch and permit the said rod to drop, substantially as set forth.

10. A knitting-machine having, in combination, needles; a knitting cam-ring which in reciprocating moves through more than a complete revolution; an automatic oscillating narrower; and a narrower-operator for rendering said narrower inoperative, said operator comprising an arm adapted when in operative position to be encountered on opposite sides by a part of said narrower, whereby said narrower is automatically oscillated back and forth, substantially as set forth.

11. A knitting-machine having, in combination, needles; a knitting cam-ring which in reciprocating moves through more than a complete revolution; an automatic oscillating narrower; and a narrower-operator for rendering said narrower inoperative, said operator comprising an elastic yielding arm adapted when in operative position to be encountered on opposite sides by a part of said narrower, whereby said narrower is automatically-oscillated back and forth, substantially as set forth.

12. A knitting-machine having, in combination with its knitting instrumentalities, an automatic oscillating widener comprising a swinging base, two needle-droppers independently pivoted to said base, and a spring for yieldingly holding said needle-droppers in normal position while permitting each to swing idly out of the way if encountered on its inner face by a needle, substantially as set forth.

13. A knitting-machine having, in combination, needles; a knitting cam-ring which in reciprocating moves through more than a complete revolution; an automatic oscillating widener; and a widener-operator for rendering said widener inoperative, said operator comprising an arm adapted when in operative position to be encountered on opposite sides by a part of said widener, whereby said widener is automatically oscillated back and forth, substantially as set forth.

14. A knitting-machine having, in combination, needles; a knitting cam-ring which in reciprocating moves through more than a complete revolution; an automatic oscillating widener; and a widener-operator for rendering said widener inoperative, said operator comprising an elastic yielding arm adapted when in operative position to be encountered on opposite sides by a part of said widener, whereby said widener is automatically oscillated back and forth, substantially as set forth.

15. A knitting-machine having, in combination, needles; a knitting cam-ring; a nee-

dle-lifter normally in its idle position but adapted to be pushed inwardly beneath parts of certain needles to elevate the same out of action; a needle-lifter operator normally in its outer idle position but adapted to be moved inwardly into position to push the needle-lifter inwardly; a spring-actuated latch which automatically engages and holds the needle-lifter when pushed into its inward position; a tripper for moving said latch out of engagement with the lifter; a spring for automatically restoring the needle-lifter to its outer idle position; and automatic mechanism for controlling the movements of said needle-lifter operator, substantially as set forth.

16. A knitting-machine adapted to knit stockings with seamless heels and toes having, in combination, instep, toe, and heel needles; a knitting cam-ring; a needle-lifter occupying normally an outer idle position but capable of two inward movements of different lengths, whereby when moved inwardly its shorter distance it elevates the instep-needles, and when moved inwardly its full distance it elevates both the instep and heel needles; and means controlled by a pattern mechanism for automatically moving said needle-lifter at the proper times the desired distances, substantially as set forth.

17. A knitting-machine having, in combination, a needle-lifter having two catches; a spring-latch for engaging said catches to hold said lifter in different positions; means for automatically moving said lifter different distances; and means for releasing said latch, substantially as set forth.

18. A knitting-machine having, in combination, the needle-lifter 136, having a catch; a spring 98, for moving said lifter in one direction; a pivoted latch 120, having stud 126; spring 122, causing said latch to engage said catch; releaser 123, having cam 125, engaging said stud to release said latch from said catch, and having also arm 129; spring 127, moving said releaser in one direction; tripper 124, acting on arm 129, to move said releaser in the other direction; and needle-lifter operator acting to move the needle-lifter in a direction opposite to that imparted by said spring 98, substantially as set forth.

19. A knitting-machine having, in combination, needles having knitting-nibs; a knitting cam-ring; a needle-lifter carried by said cam-ring adapted to operate upon the butts of a portion of said needles to partially lift the same; a fixed cam carried by said ring adapted to operate upon the nibs of the partially-lifted needles to complete the elevation of the same; and automatic mechanism for moving said needle-lifter into and out of its operative position, substantially as set forth.

20. A knitting-machine having, in combination, needles; a knitting cam-ring; a needle-depressor carried by said cam-ring and movable in and out; a spring for automatically moving said needle-depressor outwardly; a movable needle-depressor operator for moving said needle-depressor inwardly; automatic mechanism for moving said needle-depressor operator; a spring-actuated latch which automatically engages and holds said needle-depressor in its inward position; and a tripper for releasing said latch thereby permitting said needle-depressor to be moved by its spring to its outward idle position, substantially as set forth.

21. A knitting-machine having, in combination, needles; a knitting cam-ring; a needle-depressor 144; a spring 441, holding said needle-depressor in its outward position; an arm 143, carried by said needle-depressor; a movable needle-depressor operator adapted to act upon said arm to move said needle-depressor inwardly; automatic devices controlled by a pattern mechanism for moving said needle-depressor operator; a catch 444, carried by the cam-ring and adapted to hold said needle-depressor in its inward position; a spring 445, for moving said catch into its engaging position; a lever 446, pivoted to said catch; a fixed stud 448, upon which said lever acts to disengage said catch from the needle-depressor; a releasing-arm 145, connected with said lever; and a tripper which engages said releasing-arm, substantially as set forth.

22. A knitting-machine having, in combination, a sinker comb-ring; sinkers having butts; a sinker cam-ring having the usual track 346, occupied by said butts, and having an opening 348, communicating with and outside of said track at a position remote from the sinker-cams; a movable sinker-shifter Z, carried by the sinker cam-ring opposite said opening 348, so that when said shifter is moved outwardly it encounters the sinker-butts and moves them outwardly into said opening, thereby freeing the hooks of the sinkers from the needles; and means carried by said sinker cam-ring accessible from the exterior and connected with said sinker-shifter for moving the same, substantially as set forth.

23. A knitting-machine having, in combination, the constantly-reciprocating pinion 37, having a clutch projection 79, one end 82, of which is higher than the other; and a sliding clutch 34, having a contractible clutch projection 78, provided with a spring-actuated tongue 80, whereby said two clutch projections will not interengage except when said pinion is moving in such direction that the projecting end 82, of its clutch member is the leading end, whereupon said leading end encounters said projecting tongue 80, and forces it back against the tension of its spring, thereby contracting the clutch projection on the clutch and thus permitting the interengagement of the clutch projections, substantially as set forth.

24. A knitting-machine wherein the length of the stitches is regulated by a relative move-

ment between the needle-cylinder and the knitting cam-ring having automatic mechanism for effecting such regulation which includes, in combination, a transmitting-lever 196, having an adjustable connection with its operating device; a pattern-wheel Q, having cams which operate upon said lever to move it in one direction; a spring 191, moving it in the opposite direction; an adjustable stop 962, limiting the movement of said lever under the stress of said spring; said cams alternating with dwells which are as follows and which produce in conjunction with said cams the following results: (*a*) dwell 192, is in operation when the leg is being knit, whereby said leg is knit loose and full; (*b*) first dwell 193, is in operation when the toe is being knit, whereby the toe is knit with medium tightness; (*c*) first dwell 194, is in operation when the foot is being knit, whereby said foot is knit tightly; (*d*) the second dwell 193, is in operation when the heel is being knit, whereby the heel is knit with medium tightness; and (*e*) the second dwell 194, is in operation when the ankle is being knit, whereby said ankle is knit tightly; said two dwells 193, being adjustable to vary the tightness of the heel and toe; and automatic means controlled by a pattern mechanism for moving said pattern-wheel Q, substantially as set forth.

25. A knitting-machine wherein the length of the stitches is regulated by a relative movement between the needle-cylinder and the knitting cam-ring, having automatic mechanism for effecting such regulation which includes, in combination, a transmitting-lever 196; a pattern-wheel Q, having cams and dwells which operate upon said lever, said dwells being as follows and producing in conjunction with said cams the following results: (*a*) dwell 192, is in operation when the leg is being knit, whereby said leg is knit loose and full; (*b*) first dwell 193, is in operation when the toe is being knit, whereby the toe is knit with medium tightness; (*c*) first dwell 194, is in operation when the foot is being knit, whereby said foot is knit tightly; (*d*) the second dwell 193, is in operation when the heel is being knit, whereby the heel is knit with medium tightness; and (*e*) the second dwell 194, is in operation when the ankle is being knit, whereby said ankle is knit tightly; and automatic means controlled by a pattern mechanism for moving said pattern-wheel Q, substantially as set forth.

26. A knitting-machine wherein the length of the stitches is regulated by a relative movement between the needle-cylinder and the knitting cam-ring, having automatic mechanism for effecting such regulation which includes, in combination, a transmitting-lever having an adjustable connection with its operating device; a pattern-wheel having cams and dwells which operate upon said lever to knit the leg loose and full; to knit the heel and toe with medium tightness more tightly than the leg; and to knit the foot and ankle tightly; and automatic means controlled by a pattern mechanism for moving said pattern-wheel, substantially as set forth.

27. A knitting-machine wherein the length of the stitches is regulated by a relative movement between the needle-cylinder and the knitting cam-ring, having automatic mechanism for effecting such regulation which includes, in combination, a transmitting-lever having an adjustable connection with its operating device; an adjustable stop limiting the movement of said lever in one direction; a pattern-wheel having cams and dwells which operate upon said lever to knit the leg loose and full; to knit the toe and heel with medium tightness; and to knit the foot and ankle tightly; and automatic means controlled by a pattern mechanism for moving said pattern-wheel, substantially as set forth.

28. A knitting-machine wherein the length of the stitches is regulated by a relative movement between the needle-cylinder and the knitting cam-ring, having automatic mechanism for effecting such regulation which includes, in combination, a transmitting-lever, a pattern-wheel having cams and dwells which operate upon said lever to knit the leg loose and full; to knit the toe and heel with medium tightness; and to knit the foot and ankle tightly; two dwells being adjustable to vary the tightness of the heel and toe; and automatic means controlled by a pattern mechanism for moving said cam-wheel, substantially as set forth.

29. A knitting-machine organized so as to knit in circular and reciprocating courses and to produce stockings having seamless heels and toes, said machine having, in combination, a time-shaft which moves from time to time and by intervening mechanism controls the variations in the knitting, said time-shaft being given from time to time an intermittent step-by-step motion and a movement through a greater extent than that of its usual steps; and automatic means controlled by a pattern mechanism for moving said time-shaft, substantially as set forth.

30. A knitting-machine having, in combination, a time-shaft, a cam the movement of which is effected by said time-shaft and which in turn, through intervening mechanism, effects a variation in the operation of the machine, means for imparting a step-by-step movement to said time-shaft for bringing said cam into operation, means for actuating said cam, and means for moving said shaft through a longer stroke when effecting the operation of said cam upon the mechanism moved by it, substantially as set forth.

31. A knitting-machine having, in combination, a timer, a cam the movement of which is effected by said timer and which in turn, through intervening mechanism, effects a variation in the operation of the machine, means for imparting a step-by-step movement to said timer for bringing said cam into operation, means for actuating said cam, and means

for moving said timer through a longer stroke when effecting the operation of said cam upon the mechanism moved by it, substantially as set forth.

32. A knitting-machine having, in combination, a timer, a cam the movement of which is effected by said timer and which in turn, through intervening mechanism, effects a variation in the operation of the machine, means for imparting a step-by-step movement to said timer, and means for moving said timer through a longer stroke when effecting the operation of said cam upon the mechanism moved by it, substantially as set forth.

33. A knitting-machine adapted for both circular and reciprocating knitting, having a movable clutch which controls, through intervening mechanism, the character of said knitting, in combination with a movable carriage; automatic means controlled by a pattern mechanism for automatically moving said carriage; a clutch-operator pivotally connected with said carriage and engaging said clutch; springs on said carriage adapted to press against opposite sides of said clutch-operator; and stops for limiting the movement of said springs so that each spring will not follow the clutch-operator when swinging from it, substantially as set forth.

34. A knitting-machine adapted for both circular and reciprocating knitting, having a movable clutch which controls, through intervening mechanism, the character of said knitting, in combination with a movable carriage; automatic means controlled by a pattern mechanism for automatically moving said carriage; a clutch-operator movably connected with said carriage and engaging said clutch; springs on said carriage adapted to press against opposite sides of said clutch-operator, and stops for limiting the movement of said springs, so that each spring will not follow the clutch-operator when moving away from it, substantially as set forth.

35. A knitting-machine having, in combination, a time-shaft 40; a ratchet 46, loose on said shaft; a chain-wheel 41, fast to said ratchet 46; a pattern-chain 42, engaging said wheel 41; a ratchet-wheel G, fast to the time-shaft; a rocking lever F, loose on said shaft between said ratchets 46, and G; means moving with the machine for rocking said lever in one direction; a spring for moving said lever in the opposite direction; a stop 54, for limiting the stroke of said lever under the action of said spring; a pawl 48, carried by said lever F, and engaging said ratchet-wheel 46, to impart a step-by-step movement to said pattern-chain; a pawl 61, carried by said lever and engaging said ratchet G, to give a step-by-step movement to the time-shaft; a lifter 60, engaging said pawl 61; a rider 1, on said lifter riding on said pattern-chain and thereby uplifting the pawl 61, out of coöperation with said ratchet-wheel G, and adapted to drop when a variation in the pattern-chain registers therewith, thereby permitting said pawl 61, to engage its ratchet-wheel G; a cam 63, carried by the ratchet-wheel G, for lifting said stop 54, out of the path of said lever F, thereby permitting said lever to move through a long stroke; and a lifter 67, in the path of a part of the pawl 48, for rendering inoperative said pawl during the portion of said long stroke which is in addition to its customary length of stroke, so that said pattern-chain is advanced only its usual step when the long stroke is taken, substantially as set forth.

36. A knitting-machine having, in combination, a time-shaft; a ratchet loose on said shaft; a chain-wheel movable with said ratchet; a pattern-chain engaging said chain-wheel; a ratchet-wheel fast to the time-shaft; a pawl engaging said loose ratchet-wheel to impart a step-by-step movement to said pattern-chain; a pawl engaging said fast ratchet to give a step-by-step movement to the time-shaft; a lifter engaging said fast-ratchet pawl to normally hold it out of coöperation with said fast ratchet and adapted to drop when a variation in the pattern-chain coöperates therewith, thereby permitting said pawl to engage its fast ratchet-wheel, substantially as set forth.

37. A knitting-machine having, in combination, a time-shaft; a ratchet loose on said shaft; a chain-wheel movable with said ratchet; a pattern-chain engaging said wheel; a ratchet-wheel fast to the time-shaft; a movable pawl-carrier; automatic means for moving said pawl-carrier; a stop for limiting the stroke of said pawl-carrier; a pawl carried by said carrier and engaging said loose ratchet-wheel to impart a step-by-step movement to said pattern-chain; a pawl carried by said carrier and engaging said fast ratchet to give a step-by-step movement to the time-shaft; means engaging said fast-ratchet pawl to hold it normally out of coöperation with said fast ratchet; means controlled by a variation in the pattern-chain for permitting said fast-ratchet pawl to engage its ratchet-wheel; and automatic means for lifting said stop out of the path of said pawl-carrier thereby permitting said carrier to move through a long stroke, substantially as set forth.

38. A knitting-machine having, in combination, a time-shaft; a ratchet loose on said shaft; a chain-wheel movable with said ratchet; a pattern-chain engaging said wheel; a ratchet-wheel fast to the time-shaft; a movable pawl-carrier; automatic means for moving said pawl-carrier; a stop for limiting the stroke of said pawl-carrier; a pawl carried by said carrier and engaging said loose ratchet-wheel to impart a step-by-step movement to said pattern-chain; a pawl carried by said carrier and engaging said fast ratchet to give a step-by-step movement to the time-shaft; means engaging said fast-ratchet pawl to hold it normally out of coöperation with said fast ratchet; means controlled by a variation in the pattern-chain for permitting said fast-ratchet pawl to engage its ratchet-wheel; au-

tomatic means for lifting said stop out of the path of said pawl-carrier thereby permitting said carrier to move through a long stroke; and a lifter in the path of a part of the loose-ratchet pawl for rendering inoperative said pawl during the portion of said long stroke of the carrier which is in addition to its customary length of stroke, so that said pattern-chain is advanced only its usual step when the long stroke is taken, substantially as set forth.

39. An automatic power-operated knitting-machine having, in combination, needles; a knitting cam-ring; automatic means for reciprocating said cam-ring; a movable narrower carried by said cam-ring, said narrower being automatically moved back and forth by the needles during reciprocating knitting; a movable widener carried by said cam-ring, said widener being automatically moved back and forth by the needles during reciprocating knitting; a widener-operator which is inoperative during widening and which operates during narrowing to move said widener back and forth in advance of the presentation of needles thereto so that said widener is then rendered inoperative; a narrower-operator which is inoperative during narrowing and which operates during widening to move said narrower back and forth in advance of the presentation of needles thereto so that said narrower is then rendered inoperative; time mechanism; and automatic devices controlled by said time mechanism for automatically controlling the action of said narrower and widener operators and bringing them into and out of action in alternation, substantially as set forth.

40. A knitting-machine having, in combination, a sinker comb-ring, a sinker cam-ring formed at a point remote from the sinker-cams to permit the outward movement of the sinkers, radially-sliding sinkers having butts, and a radially-movable sinker-shifter remote from the sinker-cams which acts upon the sinker-butts so as to move the sinkers radially outwardly and out of coöperative relation with the needles, substantially as set forth.

41. A knitting-machine having, in combination, a time-shaft; automatic means for moving said time-shaft; a plurality of pattern-wheels moved by said time-shaft and each capable of an independent movement on said shaft; independent means for automatically moving each of said pattern-wheels independently of the time-shaft, said means being brought into operation by the movement of the time-shaft; and mechanism controlled by each of said pattern-wheels for effecting a variation in the knitting, substantially as set forth.

42. A knitting-machine having, in combination, a yarn-twister operating upon both an idle and a working yarn for twisting them together; means for slackening the working yarn before the idle yarn reaches the needles; and connected mechanisms for automatically operating the same so that the working yarn is slackened during the twisting operation, substantially as set forth.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

CHARLES J. A. WARDWELL.

Witnesses:
JOHN ALDRICH,
W. L. WOODWORTH.