(No Model.) 4 Sheets—Sheet 1.

W. H. PEPPER & A. T. L. DAVIS.

STRAIGHT KNITTING MACHINE.

No. 542,653. Patented July 16, 1895.

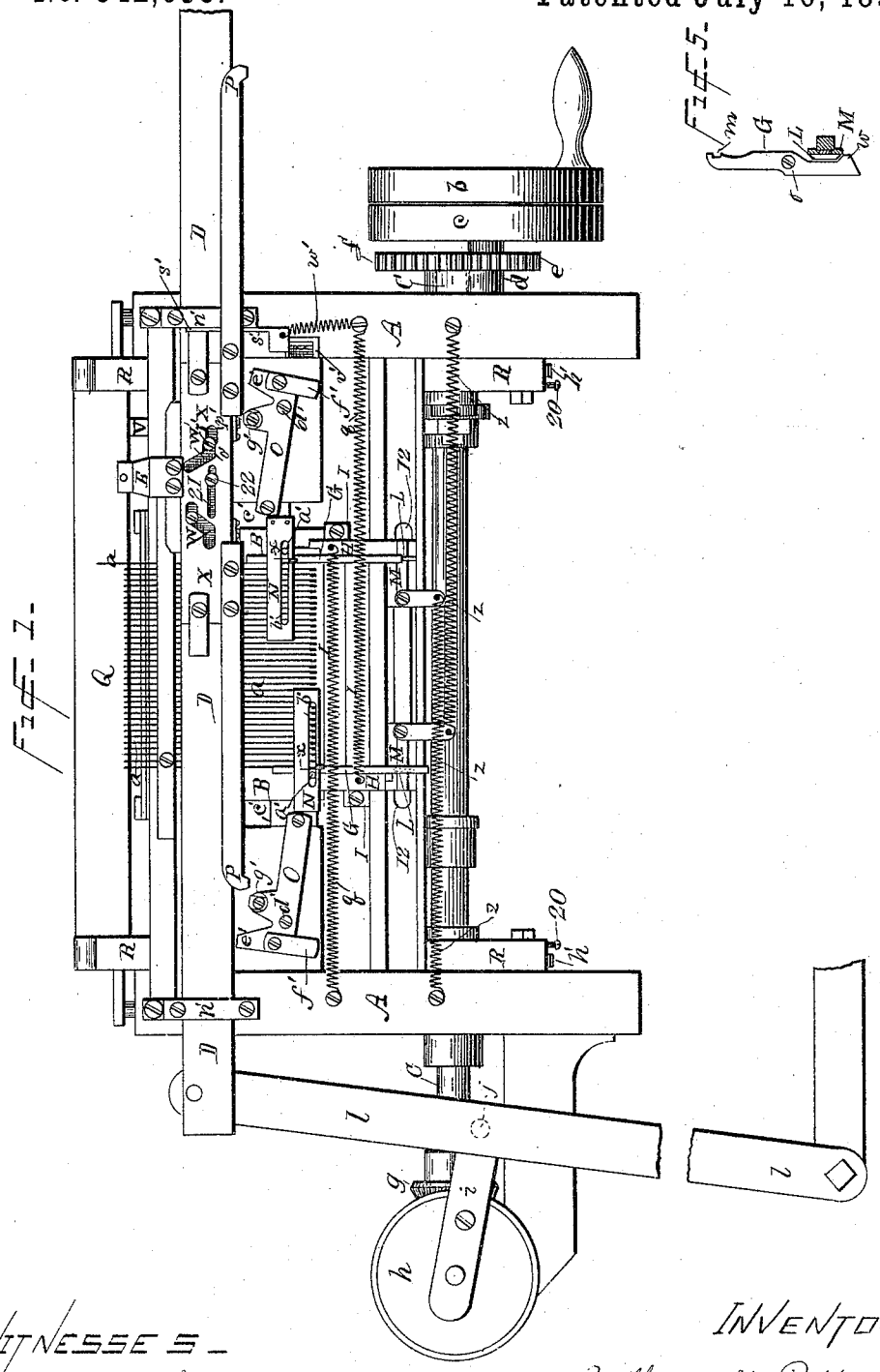

Fig. 1.

Fig. 5.

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Fig. 2.

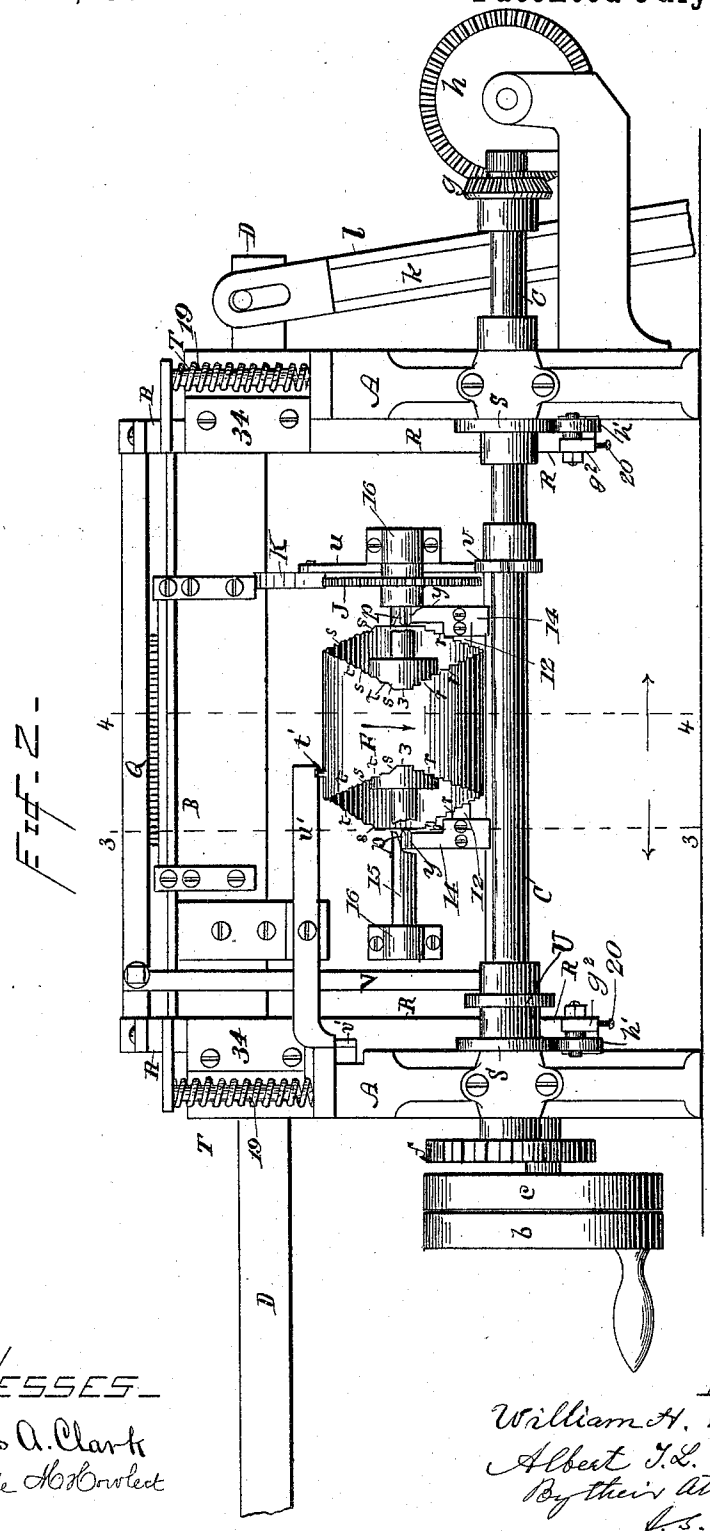

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Fig. 3.

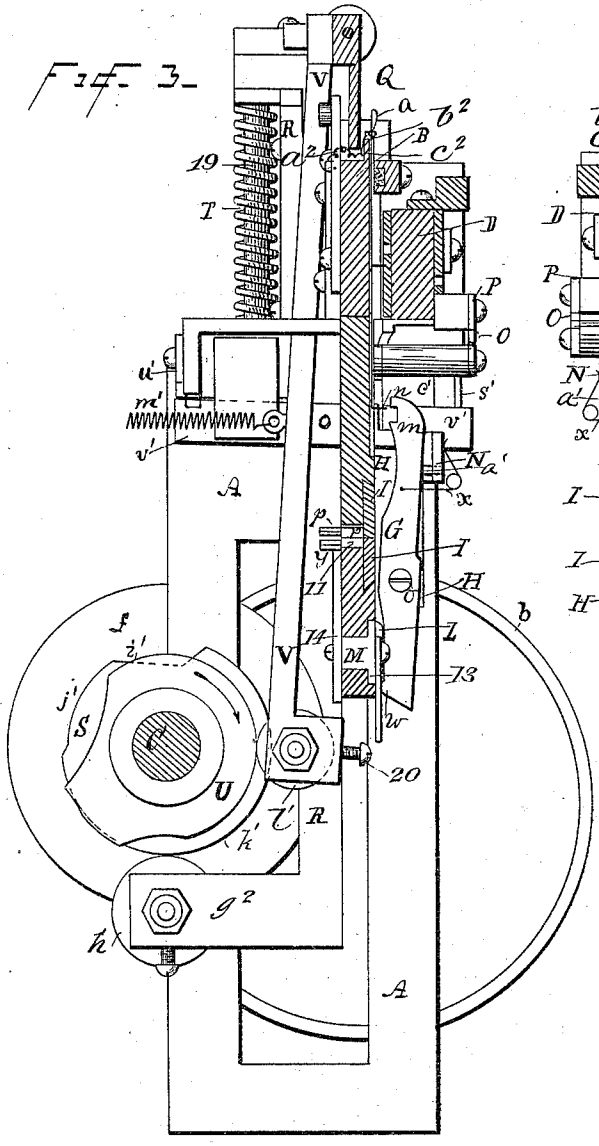

Fig. 4.

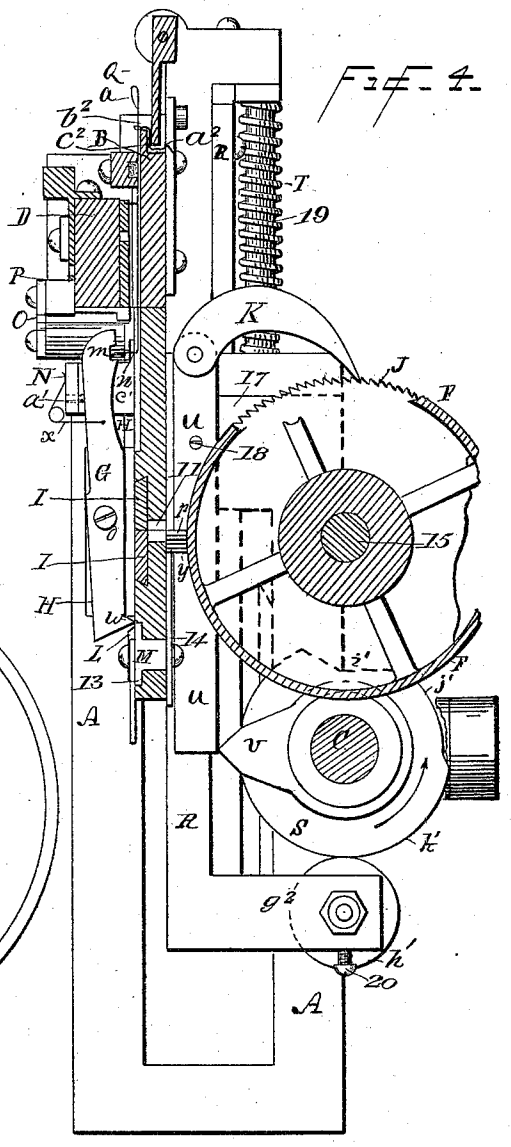

Fig. 6.

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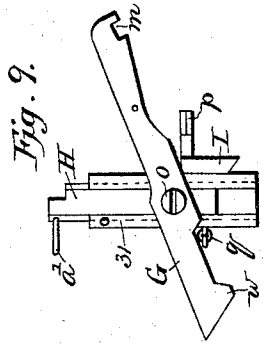

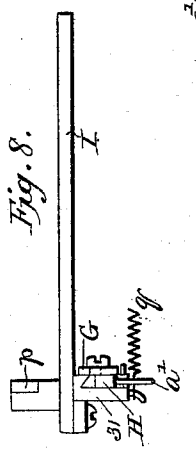

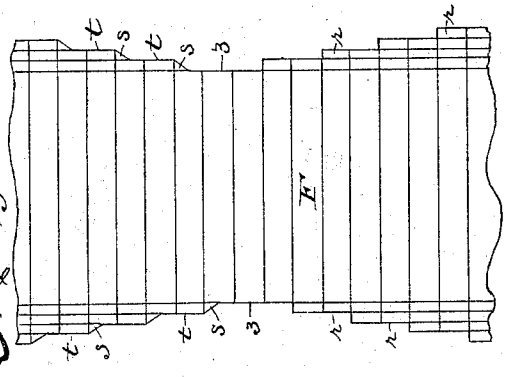

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UNITED STATES PATENT OFFICE.

WILLIAM H. PEPPER AND ALBERT T. L. DAVIS, OF LAKE VILLAGE, ASSIGNORS TO EDGAR C. COVELL, OF LACONIA, NEW HAMPSHIRE.

STRAIGHT-KNITTING MACHINE.

SPECIFICATION forming part of Letters Patent No. 542,653, dated July 16, 1895.

Application filed November 8, 1888. Renewed May 23, 1895. Serial No. 550,410. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM H. PEPPER and ALBERT T. L. DAVIS, of Lake Village, in the county of Belknap and State of New Hampshire, have invented certain new and useful Improvements in Straight-Knitting Machines, of which the following is a specification.

The present improvements relate to straight-knitting machines having latch-needles; and it consists in means for narrowing and widening the web, in means for feeding down the knitted web and applying the necessary tension thereto, and in means for knitting a course of loose stitches in the web as a guide for cutting the same.

The present improvements are applicable to all classes of straight-knitting machines, but for convenience in illustration and description will be described as applied to a straight-knitting machine for the purpose of knitting the toes and heels of stockings in separate parts to be subsequently applied in knitting complete stockings.

In the accompanying drawings, Figure 1 represents a front view of a straight-knitting machine provided with the present improvements. Fig. 2 is a broken rear view of the same. Fig. 3 is a transverse vertical section, on a larger scale, of the machine in a plane indicated by the line 3 3 in Fig. 2. Fig. 4 is a transverse vertical section thereof, also on a larger scale, in a plane indicated by the line 4 4 in Fig. 2, the view looking in a direction opposite to that in which Fig. 3 looks. Fig. 5 is a separate side view of one of the needle-shifters and a cross-section of its carrying-slide. Fig. 6 is a view of one of the needles used in the machine. Fig. 7 is a perspective view of the lower section of the needle-bar. Fig. 8 is a plan view, and Fig. 9 a side view, of one of the needle-shifters and its carrier. Fig. 10 is a perspective view of the needle-shifter coupling-cam and its carrier. Fig. 11 shows a fragment of the pattern-drum on an enlarged scale.

Between two supporting-standards A A is mounted the needle-guide bar B, ordinarily in a vertical position, the needles *a a* running in the usual vertical grooves of the needle-bar next to the upper edge thereof, and this bar B also serves as the support for various other parts of the machine, which are mounted thereupon, as shown, in any suitable manner.

The bar B is substantially rectangular and extends entirely across between the standards A A. Its top edge is just below the latches of the needles when in their normal position and its lower edge is about in line with the top of the drive-shaft C, as shown in Figs. 3 and 4. This bar may be composed of several sections, (two such sections being shown,) and in addition to containing the needle-grooves it also contains the guide grooves and slots of the parts constituting the widening and narrowing devices and affords the support for the operating mechanism thereof, all as will hereinafter appear.

The driving-belt (not shown) runs upon ordinary fast and loose pulleys *b c*, which, from their shaft *d* through gear-wheels *e f*, transmit rotary motion to a driving-shaft C. At the other end of this driving-shaft rotary motion is communicated therefrom by a bevel-pinion *g* thereon to a bevel-wheel *h*, which carries a crank-bar *i*, having a crank-pin *j*, which works in a groove *k* of a lever *l* pivoted at its lower end, whereby a lateral reciprocating movement is communicated to its upper end and a corresponding longitudinal reciprocating movement is communicated to the needle-actuating cam-bar D, pivoted to the upper end of the lever. The thread-guide E is carried by the said cam-bar.

It will be noted that the diameter of the bevel-wheel *h* is just double that of the bevel-pinion *g*, so that two rotations of the driving-shaft C are necessary to effect a complete reciprocation of the needle-actuating cam-bar D.

The above are ordinary parts and movements, and are here set forth simply to give a complete specification of the essential parts of the whole machine.

We will first describe the improved means for effecting the narrowing and widening of the web. As is usual in these machines, the narrowing is effected by raising the needles and consequently throwing them out of action, and the widening is effected by lowering the needles and thus bringing them again into action. In accordance with the present

improvements (assuming that all of the needles are in use) the narrowing is effected by alternately raising out of action the outermost needles at opposite ends of the row of needles, the alternate throwing out of action continuing until the web has been narrowed sufficiently. The narrowing is thus effected along both edges of the web. The widening of the web is effected in the reverse manner by bringing successively into action first one needle at one end of the row of needles and then one needle at the other end of the row of needles. In order to carry out this method of widening and narrowing at both edges of the web, the machine is provided with duplicate widening and narrowing mechanism.

Each of the needles *a*, for the purpose of co-operation with the widening and narrowing mechanism, is provided with an auxiliary nib or butt *n* (see Fig. 6) in addition to the usual nib or butt which co-operates with the knitting-cams on the cam-bar D. The butts *n* of the various needles are at the lower ends of the needles and a sufficient distance below the cam-bar to allow for the proper elevation of the needles by the action of the narrowing and widening mechanism.

The primary and fundamental features of the narrowing and widening mechanism consist of two needle-shifters G G, one at each end of the machine, one of the needle-shifters acting upon the needles at one end of the machine and the other acting upon the needles at the other end of the machine. Each of these needle-shifters G is of a thickness approximating that of one of the needles, so that it can act upon only one needle at a time.

Each needle-shifter has for the purpose of narrowing three movements—an oscillating movement to and from the needle-butts *n*, a vertically-reciprocating movement, and a step-by-step horizontal movement. Before entering into a description of the specific construction and operating mechanism of the needle-shifters it will aid in the understanding thereof to first refer to the objects of these three movements of the needle-shifter. The object of the movement of the needle-shifter G to and from the needle-butt *n* of the needle at one end of the row of needles is to couple and uncouple the needle-shifter to and from the needle. After the needle-shifter has been coupled to the needle-butt of the end needle it is raised vertically in a plane parallel with that of the vertical movement of the needle, thereby lifting the needle out of co-operation with the knitting-cams. After the needle has thus been lifted the needle-shifter moves away from the needle, thus uncoupling from the needle-butt. The needle-shifter then moves down to its lowest position, leaving the needle raised. After the needle-shifter has thus resumed its lowest normal position it is given its third movement in a horizontal direction. It is moved sufficiently far in a horizontal direction toward the center of the machine to bring it into co-operation with the next needle adjacent to the one which has just been elevated—that is, the extent of each horizontal movement or step of the needle-shifter is just equal to the horizontal distance between the centers of two adjacent needles. The movements of the two needle-shifters at opposite ends of the machine alternate with each other, so that the needles at opposite ends of the machine are raised in succession; also, during the operation of widening the web each of the needle-shifters G has three movements, but the sequence of these movements is slightly varied. When widening the needle-shifter is first moved upward and is then moved inward toward the needles, so as to couple when at the upward limit of its movement with the butt *n* of one of the elevated needles on one side of the machine nearest the center. After coupling the needle-shifter then moves downward, carrying the needle with it, and when it reaches its lowermost position it then moves outward away from the needle, so as to become uncoupled from the needle-butt. The needle is thus left in its lowered position ready for co-operation with the knitting-cams. The needle-shifter is then moved horizontally one step toward one end of the machine the proper distance to enable it to co-operate with the next raised needle. The two needle-shifters alternate in action at the two ends of the machine during the widening operation as well as during the narrowing operation.

It becomes necessary, therefore, to describe the specific construction of the needle-shifters G and the means for imparting the three movements to the needle-shifters. For convenience of description we will first describe the mechanism for imparting the horizontal movements, then the mechanism for imparting the vertical movements, and lastly the mechanism for imparting to the needle-shifters their motions to and from the needles.

Each needle-shifter G is centrally pivoted, so as to swing in a vertical plane to a vertically-movable holder H, which in turn moves in vertical guides or ways on and is carried by a horizontally-movable carrying-slide I. Each carrying-slide I slides back and forth in suitable guides or ways formed in some fixed portion of the knitting-machine. The two slides I I are preferably located in a dovetailed guide recess or groove 30 on the front face of the bar B, as shown in Figs. 3 and 4, whereby the slides are held in place on the bar B, and are permitted longitudinal movement. From each carrying-slide a tappet *p* projects backward through a slot 11 in the bar B in contact with a pattern-cylinder F, one tappet *p* being at one end of the cylinder and the other tappet at the other end of the said pattern-cylinder. (See Fig. 2.) The two carrying-slides are at all times drawn or pressed inward to or against the pattern-cylinder by counter-springs *q q* or their equivalents. The pattern-cylinder F extends horizontally and is mounted so as to rotate parallel with the driving-shaft C, and it has a step-by-

step rotary movement, each step being through a comparatively-small arc. The shaft 15 of the pattern-cylinder F is mounted in bearings 16 at the ends of brackets 17, secured to the bar B. Upon each end or edge of the pattern-cylinder is a series of receding steps *r r*, each of a depth equal to the distance between adjacent needles from center to center and of a length corresponding to two spaces of the intermittent movement given to the pattern-cylinder. The intermittent movement of the pattern-wheel is effected by a ratchet-wheel J on the shaft of the pattern-wheel, which is actuated once for each course of stitches knit by the machine—that is, the pattern-cylinder is moved one step for the movement of the cam-bar D in one direction and twice for each complete reciprocation of the cam-bar. The pawl K is mounted on a vibratory lever *u*, pivoted at 18 to one of the brackets 17 and moved by a cam *v* on the driving-shaft C, which, as before stated, makes two rotations while the crank bevel-wheel *h* makes one rotation, the said bevel-wheel being twice as great in diameter as the bevel-pinion *g* on the driving-shaft, and therefore the pattern-wheel is moved at each movement of the needle-cam bar and at each knitting of a course of stitches. It consequently follows that one inward step is made by each of the tappets *p* on the pattern-wheel at each complete reciprocation of the needle-cam bar D and at the knitting of two courses of stitches. At every inward step of each tappet *p*, each tappet being moved inwardly by its spring *q*, (see Fig. 1,) the corresponding slide I, and consequently its needle-shifter G, is moved horizontally toward the center of the row of needles a distance equal to the distance between the centers of two adjacent needles. In this manner, therefore, the proper horizontal step-by-step movement of the needle-shifters during the narrowing operation is effected. The steps *r r*, at opposite ends or edges of the pattern-cylinder, should alternate with each other, so that at one movement of the pattern-cylinder one needle-shifter will move toward the center and at the next step the other needle-shifter will move toward the center. The number of the steps *r r* on the pattern-cylinder necessarily determines the number of the needles which can be thrown out of action, and the circumferential length of the several steps determines the frequency of the elevation of the needles as compared with the number of courses of stitches knit. It is hence evident that any desired variations in these respects can be adopted by using a pattern-cylinder of the necessary diameter provided with steps of the desired circumferential lengths. In order, however, that the same pattern-cylinder may be used for the widening operation and may be rotated constantly in the same direction, the steps *r r* at each edge of the cylinder occupy somewhat less than one-half of the circumference of the cylinder. For the purpose of widening, somewhat less than the other half of each of the two edges of the pattern-cylinder is provided with a series of alternating cams *s* and dwells *t*. The dwells *t* correspond in location and function to the circumferential portions of the steps *r*. The distance between adjacent dwells *t* (in a line parallel to the axis of the cylinder F) is equal to the distance between the steps *r r*, and consequently equal to the distance between the centers of two adjacent needles. Instead, however, as in the case of the steps *r*, being connected by a perpendicular shoulder, adjacent dwells *t* are connected by an incline or cam *s*. The combined circumferential length of a dwell *t* and a connecting-cam *s* is equal to the circumferential length of one of the steps *r*, and consequently equal to the distance advanced by the pattern-cylinder in two of its intermittent movements. Considering only the cams *s* and dwells *t* on one edge of the pattern-cylinder, the effect upon one of the tappets *p* and the corresponding needle-shifter G will be described. Assuming the tappet *p* to be in contact with one of the dwells *t*, the pattern-wheel is given one movement by the pawl K. The effect of this is to bring the adjacent cam *s* in contact with the tappet *p*, and thus to lift the tappet *p* out of the dwell *t*. This movement advances the corresponding needle-shifter G one space outwardly. At the next movement of the pattern-wheel the tappet simply slides along the dwell *t* without affecting the position of the needle-shifter G. Consequently the needle-shifter G under consideration moves outwardly once with each two movements of the pattern-wheel and with each complete reciprocation of the cam-bar D, by reason of the timing of the parts already referred to. The movements of the two needle-shifters G are identical, except that they alternate with each other, the alternation being effected by placing the dwells *t* at one edge of the pattern-cylinder opposite to the cams *s* on the other edge of the pattern-cylinder. The number of the cams *s* being equal in number to the steps *r r*, it follows that the needle-shifters will be moved outwardly by the cams *s s* as far as they were moved inwardly when co-operating with the steps *r r*.

Between the meeting ends of the series of steps *r* and of the series of cams *s* and dwells *t*, at each end of the pattern-cylinder, are two dwelling-spaces, as shown, of sufficient length to produce the proper movements in changing from narrowing to widening at one meeting end and to knit the proper number of even courses of stitches between the different toes and heels of the web at the other meeting end. The pattern-cylinder and the intermediate devices thus operate to move each needle-shifter G step by step into successive co-operation with the needles at one end of the machine during both the widening and narrowing operations.

The second movement given to each needle-shifter G is a vertical reciprocating movement.

Each needle-shifter makes a complete vertical reciprocation for each step made in a horzontal direction. It is consequently necessary that each needle-shifter should make a complete vertical reciprocation for each complete horizontal reciprocation of the cam-bar D. Accordingly the movement of the cam-bar is utilized for operating the needle-shifters in a vertical direction. The mechanisms for effecting the vertical reciprocation of the two needle-shifters are identical, and consequently a description of one will suffice for both.

Each vertically-movable holder H slides vertically upon and is carried by a post 31 on one of the slides I. Reciprocal guiding and holding provisions upon the holder H and post 31 are furnished for this purpose—as, for example, a vertical dove-tailed groove on one and a correspondingly-shaped projecting rib on the other. To each of the holders H one of the needle-shifters G is pivoted, and each holder is provided at its upper end with a rigidly-attached outwardly-projecting pin a', which enters into and engages with a longitudinal horizontal slot b' formed in a lifter-bar N. (See Fig. 1.) The length of the slot b' is sufficient to accommodate the horizontal movement of the holder H. Each lifter-bar N is mounted on a vertically-movable slide c', which fits and moves in a vertical guide or way 33 in the bar B. It is evident from the connections between the several parts that any vertical movement of slide c' will effect a similar movement in the corresponding needle-shifter G. Each slide is pivotally connected to one end of a cam-lever O, which is pivoted at d' to a fixed support, as to the bar B. Each cam-lever is vibrated by means of a stud P carried by the cam-bar, which is brought successively into contact with striking-tappets e' g' on the lever O. The tappets e' g' are located on opposite sides of the point d', so that when the stud strikes the tappet g' the cam-bar O will be vibrated and the slide c' will move down, the tappet e' at the same time being moved upward into the return path of the stud P. On the contrary, when the stud next strikes the tappet e', the lever O will be turned in the opposite direction, the slide c' will be raised, and the tappet g' will be raised again into the path of the stud P. Each lever O and the parts operated thereby are maintained in any position in which they may be left by a friction-spring f', which is carried by the lever and bears frictionally against a fixed part of the machine. The studs P are so located on the cam-bar that the shifting of the slides c' (and therefore of the needles a) takes place at the beginning and completion of each course of stitches and when the needles are out of co-operation with the knitting-cams.

The third movement of each needle-shifter G is its oscillatory movement on its axis, whereby it is alternately coupled with and uncoupled from the needle-butts n. The coupling itself is effected by simply providing each shifter near its upper end on its inner edge with a notch m, (see Figs. 3, 4, and 5,) which when the upper end of the shifter is swung inwardly engages one of the needle-butts n. The normal position of each needle-shifter G is its uncoupled position—that is, when its notch m is away from the needle-butts. Each needle-shifter is maintained in this normal position and restored thereto when displaced by a spring x. Now, as has been before set forth, the coupling action of the needle-shifter G is different in widening from what it is in narrowing. In narrowing the coupling must be effected when the needle-shifter is at its lowest position, it must remain coupled during its upward movement, the uncoupling must be effected at its upper position, and it must remain uncoupled during its downward movement, so as to pass clear from the needle-butts; but in the widening operation these movements are different. The needle-shifter must be coupled at its upper position, remain so during the downward movement, be uncoupled at its lower position, and remain so during the upward movement. In order that the mechanism for accomplishing these several results may be clearly understood without confusion we will describe the mechanism first with sole reference to the narrowing operation, and subsequently with reference to the widening operation, premising the description with the remark that the operating mechanisms for the two needle-shifters are identical.

Co-operating with each needle-shifter G is a cam L, which is mounted on a slide M, having a horizontal step-by-step movement, said slide moving in suitable ways or guides on the bar B or other fixed part of the machine. As shown in the drawings, each slide M is located in a slot 12 in the bar B, being of the same width as the said bar, and the slide M is maintained in position in said slot by a head 13, fitting in a communicating groove 32, and by a plate 14 screwed to the slide M and lying against the rear face of the bar B. Each cam L is incapable of vertical movement, and it is located so as to be encountered by a stud w (see Fig. 5) on the lower tail end of the co-acting needle-shifter G as the needle-shifter moves upwardly. (Note that only the narrowing operation is referred to.) Assuming that the normal relative position of the cam L and the needle-shifter G is that shown in Figs. 3 and 5, and at the left side in Fig. 1, (where the cam L is immediately behind the needle-shifter, as shown in dotted lines,) it will be evident that as the needle-shifter rises its stud w will encounter the lower edge of the cam L, and thereby the notched end of the shifter will be swung inwardly to couple with the adjacent needle-butt n. During the upward movement of the needle-shifter its stud w travels on the outer vertical face of the cam L, so that the shifter is maintained in its coupled position.

The vertical height of the cam L, however, is less than the upward travel of the needle-shifter, so that when the needle-shifter reaches the limit of its upward movement its stud *w* is carried above the cam L, as shown in Fig. 4, and the coiled spring *x* throws the needle-shifter out from its coupled position with the needle-butt *n*. Now, in order that the needle-shifter may not, during its downward movement, be again coupled with the needle-butt, (the effect of which would be to restore the needle to its normal position,) it is essential that the cam L should be moved out of the path of the stud *w*. It is for this purpose, primarily, that the cam L is mounted on the slide M, having a step-by-step movement in a horizontal direction parallel to the horizontal movement of the slide I. The step-by-step movement of the two slides M is effected by the steps *r r* on the pattern-drum F, which co-operate with the tappets *y y*, carried by the plates 14 of the slides M, said tappets being held in contact with the respective steps *r r* by counter-springs *z z*. The effect of the action of the pattern-drum F on the tappets *y* and slides M is exactly the same as the effect upon the slides already described, so that further description is deemed unnecessary. The timing, however, of the action upon the slides M as compared with the slides I is of importance. The step movement of the slide I takes place when the needle-shifter G is at its lowest position, while the step movement of the slide M is taken when the needle-shifter is at its highest position. The movement of the slide M therefore precedes the movement of the slide I, and this result is accomplished by placing the tappet *y* in advance of the tappet *p*—that is, (referring to Fig. 2 and considering the direction of rotation of the pattern-drum F,) the tappet *y* is so placed that it is advanced from step *r* to the next step *r* ahead of the tappet *p*. As already set forth, two intermittent movements of the pattern-cylinder F are necessary to advance one tappet *p* or *y* from one step *r* to the next. Accordingly, the arrangement of the tappets *y* and *p* is such that when the needle-shifter (note that narrowing is now alone referred to) is moving upward both tappets are in contact with the same step *r*. When, however, the needle-shifter G reaches its upward limit of movement, the pattern-cylinder makes one of its intermittent movements and the tappet *y* drops onto the next step *r* under the influence of its spring *z*, (thus moving the cam L out of the downward path of the needle-shifter,) while the tappet *p* still remains on the first step *r*, and consequently the horizontal position of the slide I and of the needle-shifter is not affected. When, however, the needle-shifter G reaches its downward limit of motion, the pattern-cylinder advances another of its intermittent movements. The horizontal position of the tappet *y* is not affected, since it remains on the second step *r*, but the tappet *p*, under the influence of its spring *q*, drops onto the second step, and as a consequence the needle-shifter G advances one step and again assumes its normal position in reference to the cam L. These alternate step movements of first the cam L and then of the shifter G continue in succession during the entire narrowing operation.

It need hardly be said that the foregoing description has referred to only one of the cams L and that the other cam L moves in exactly the same way, one cam L at one end of the pattern-cylinder moving a step simultaneously with the needle-shifter G at the other end of the pattern-cylinder. During the widening operation, however, it is evident that if the same cams L are used (as is the case) to effect the oscillation of the needle-shifters G the studs *w* must encounter the cams L as they move downward and the cams L must be moved out of the way while the needle-shifters move upward, so that the action upon the needles may be reversed. It is consequently necessary (referring now to each shifter G) that the tappet *y* should encounter the cams *s* when the needle-shifter is at its lowest position, and that the tappet *p* should encounter the cams *s* when the needle-shifter is at its highest position. This is easily and simply effected by simply making of a proper length the dwell 3 (see Fig. 2) on the pattern-cylinder F between the meeting ends of the series of steps *r* and of the series of cams *s* and dwells *t*. The length of this dwell 3 should be such that it will be traversed by the tappets during an uneven number of the intermittent movements of the pattern-cylinder. This, it is evident, will reverse the timing of the movements of the cams L and shifters G.

To enable the same cams L to be used for both narrowing and widening, the thickness of each cam should be less than the length of its step, and both its upper and lower edges should be inclined, as shown in Fig. 5.

The second part of the present invention consists in the means for feeding down the web and applying the necessary tension thereto. In knitting toes and heels of stockings fashioned by narrowing and widening, since they have a bulged form, it is impracticable to apply a weight to hold the knit web properly in tension.

A most important part of our invention consists in means by which we not only dispense with a weight for the purpose, but whereby we produce a perfectly-uniform tension on all the stitches of the web whatever may be its form, and this tension is made positive and fixed. For this purpose the machine is provided with an oscillating and reciprocating web-feed and tension bar Q, the lower edge of which extends in a horizontal plane parallel with the upper edge b^2 of the needle-carrying bar B. This web-feed and tension bar Q is journaled at its opposite end in and between two vertically-sliding bars R

R, which form therewith a vertical frame. The bars R R are mounted in place on the standards A, fitting in guideways 34 thereon, and are permitted a vertical movement both by said guideways and by means of rods 19 19, which either may be connected with the bars R R and slide in ways formed in the standards A, or may be fixed to the standards A and co-operate with ways in the bars R R. At the lower end of each of these bars R is a horizontal arm g^2, carrying a friction-roller h', which co-operates with a cam S on the driving-shaft C, said shaft rotating in the direction indicated by the arrows in Figs. 3 and 4. Each friction-roller h' is located directly under its cam S, so that the action of the cams is to depress the rollers and consequently the feed and tension bar Q. The rollers are held in contact with the cams, and the feed and tension bar Q is raised by means of coiled springs T T, which bear against shoulders on the bars R R. Each of the cams S has three cam-faces i' j' k', of different extents of thrust. When the rollers h' bear against the cam-surfaces k' having the greatest radii, the feed and tension bar Q occupies its lowest position, as shown in Figs. 3 and 4 when the rollers h' bear against the next cam-surfaces i' having the least radii, the feed and tension bar Q occupies its highest position, and when the rollers h' bear against the third cam-surfaces j' having intermediate radii, the feed and tension bar Q occupies an intermediate position. The effect of the cams S upon the feed and tension bar is thus to cause the same to successively occupy these different vertical positions. When in its lowest position, the lower edge of the feed and tension bar occupies a position slightly above the horizontal shoulder a^2 on the needle-bar B, which is below the plane of the upper edge b^2 of the bar B and on the side of the bar opposite the needle-grooves. When at its highest position the lower operative edge of the feed and tension bar is above the upper edge b^2 of the needle-bar B and above the plane of the loops on the needles, and when in its intermediate position the lower edge of the tension-bar Q occupies a position just above the upper edge b^2 of the needle-bar B.

The oscillating movements of the feed and tension bar Q are effected by the following means. To the bar Q is rigidly attached a downwardly-hanging arm V. At its lower free end this arm V carries an antifriction-roller l', which is held in contact with a cam U on the driving-shaft C by means of a spring m'. (See Fig. 3.) This cam has two circular parts of different radii connected by cam-surfaces, as shown, so that the feed and tension bar is oscillated between two positions. When the friction roller l' bears against the circular part of the cam U having the lesser radius, as shown in Fig. 3, the operative edge of the feed and tension bar occupies its outermost position—that is, its position farthest from the latch-needles a. When in this position, as shown in Fig. 3, the tension-bar is some little distance from the vertical shoulder c^2 on the bar B; but when the roller l' bears against the circular part of the cam U having the greater radius then the operative edge of the feed and tension bar occupies its innermost position in close proximity to the cast-off sides of the latch-needles—that is, on the side of the needles opposite to their latches.

The combined effect of the cams S S U on the feed and tension bar produces the following results: Assuming the normal position of the feed and tension bar to be that shown in Fig. 3, the bar is first raised to its highest position above the loops on the needles; secondly, it is swung inwardly until it bears against the needles, or is brought close to them, above the newly-formed loops; thirdly, it is moved down nearly to the upper edge b^2 of the needle-bar, thus feeding down the loops; fourthly, it is swung outwardly so as to swing clear of the upper edge b^2 of the needle-bar, and, fifthly, it is moved downwardly toward the shoulder a^2, and since the knitted web lies between it and the shoulder a^2 it presses against the web and applies the necessary tension thereto. This fifth movement also restores the feed and tension bar to its normal position.

It will be noted that the cam-surfaces on the cams S U are so located that the feed and tension bar occupies what has been termed its "normal" position during the greater part of one rotation of the driving-shaft C, and consequently, owing to the timing of the parts, during the greater part of the movement of the cam-bar D in one direction, and the parts are in addition so timed that the feed and tension bar Q presses on the web and holds the same down during the entire loop or stitch forming operations, and the release of the web by the feed and tension bar the feeding down of the newly-formed course of loops or stitches and the resumption of the normal position of the feed and tension bar take place during the time that the cam-bar D is reversing its movement and while the knitting-cams are inoperative.

It will be evident that the pressure of the tension-bar upon the web and the needles can be regulated by making the bearings of the rollers h' l' adjustable. Adjusting-screws 20 20 are shown (see Figs. 3 and 4) for effecting the adjustment of the bearings of these rollers.

The third portion of the improvements relates to the means for knitting a course of loose stitches in the web as a guide where the toes and heels are to be cut apart. We effect this by lowering the needle-cam W below its usual position at the proper time and thus making longer stitches. The grooved plate X which effects this has a sliding movement on the cam-bar effected by striking guide-stops n' n' near the terminations of the reciprocating movement of the cam-bar D.

This plate X is the cam-shifting plate for shifting the knitting-cams so as to enable the knitting to be accomplished during the movement of the cam-bar in both directions, such as is almost universally used in ordinary straight-knitting machines. It is guided on the cam-bar D in any of the usual well-known ways, as by a slot 21 and screw 22. The cam-groove o' at one end of the grooved plate has an extension p beyond the lower end of its ordinary movement sufficient to lower the needle-cam as far as required for this purpose, and the grooved-plate is moved at the proper time far enough to bring the cam-stud r' into this extension by interposing a movable loose-course finger s' between the grooved plate and the guide-stop n' at one end of the machine. This is done automatically by means of a cam t', Fig. 2, on the periphery of the pattern-cylinder, adapted to strike a vibratory lever u, which is connected with the movable finger s' by another vibratory lever v', Fig. 3, or equivalent means. A counter-spring w' withdraws the movable finger s' from position after the loose course of stitches has been knit.

The finger s' is held and guided on the adjacent standard A by any suitable means, as by providing the standard with a dove-tailed groove, the plate s' being correspondingly shaped.

Where a second loose course is desired for running on by, a second cam t' can be located on the pattern-cylinder for this purpose.

It will be noted in the foregoing description that the words "horizontally," "vertically," and similar expressions are used relatively only, on the assumption that the needles are arranged vertically. Should the needles be arranged in other than a vertical plane, the planes of the other parts would necessarily be altered accordingly.

We claim as our invention—

1. The needles of a knitting machine, the reciprocating cam-bar which actuates said needles, a laterally-movable slide, a vertically-movable holder mounted on said laterally-movable slide, and a swinging needle shifter mounted on said holder, in combination with a laterally-movable shifter cam L, which effects the swinging movement of said needle shifter, a pattern drum which co-operates with said laterally-movable slide and said cam L, to move the same laterally, means for maintaining the laterally-movable slide and the cam L, in co-operative relation with the pattern cylinder and means carried by the needle-actuating cam-bar and between said cam-bar and said vertically-movable holder for effecting the vertical movements of said vertically movable holder, substantially as set forth.

2. The needles of a straight knitting machine, the reciprocating cam bar which actuates said needles, two laterally-movable slides I, I, two vertically-movable holders mounted on and carried by said slides respectively, and two swinging, needle shifters, each pivoted to one of said vertically-movable holders, said slides, holders, and shifters, being located at opposite ends of the machine so as to co-operate with the needles at both ends of the machine, in combination with means for effecting the vertical movements of said holders, two shifter cams which co-operate with said needle shifters respectively to swing said shifters, two laterally-movable slides M, M, by which said shifter cams are respectively carried, and a rotating pattern cylinder or wheel for effecting the lateral movements of said slides I, and said cam-slides M, said pattern cylinder or wheel having at each end a series of receding steps r, r, which co-operate with one of said slides I, and one of said slides M, during the narrowing operation to allow said slides to move inward step by step, and having also at each end a series of cams s, and dwells t, which co-operate with one of said slides L, and one of said slides M, during the widening operation to move said slides outward step by step, and means, such as springs, for maintaining the laterally-movable slides I, and M, in co-operative relation with the pattern cylinder substantially as set forth.

3. The latch needles of a latch needle knitting machine, and the reciprocating needle-actuating cam-bar thereof, in combination with a vertically-movable and laterally-swinging feed and tension bar, which rises, swings in toward the needles, feeds down a fresh course of stitches, swings back from the needles, and then bears down upon the knitted web, and means for moving said feed and tension bar vertically and for swinging the same to and from the needles, substantially as set forth.

4. The latch needles of a latch needle knitting machine, and the reciprocating needle-actuating cam-bar thereof, in combination with a vertically-movable and laterally-swinging feed and tension bar which bears upon the knitted web during the stitch-forming operations, and which during the change of motion of said cam-bar rises, swings in toward the needles, feeds down the fresh course of stitches, swings back from the needles and then bears down upon the knitted web, and means for moving said feed and tension bar vertically and for swinging the same to and from the needles, substantially as set forth.

5. In combination with the needle cam of a knitting machine, the means specified for knitting a loose course of stitches, consisting essentially of the sliding grooved plate having the groove extension, the stop bar, the interposed movable finger, the pattern mechanism provided with a cam projection, and connecting mechanism between the pattern mechanism cam and the said movable finger, substantially as and for the purpose herein set forth.

6. The reciprocating needles of a knitting machine, and a needle shifter characterized

by the following movements, (*a*) a movement to and from the needle adjacent thereto whereby said needle shifter is coupled to said needle and is uncoupled therefrom, (*b*) a reciprocating movement parallel with the reciprocating movement of the needle whereby the needle is moved in and out of action, and (*c*) a step-by-step lateral movement whereby said needle shifter is brought successively into co-operation with a plurality of the knitting needles, in combination with means for imparting to said needle shifter its several specified movements, substantially as set forth.

7. The vertically-reciprocating needles of a knitting machine, a vertically-movable holder, and means for moving said holder vertically, in combination with a needle shifter pivoted to said holder whereby said needle shifter partakes of the vertical movement of said holder, said needle shifter being adapted at one end to be coupled to the adjacent one of said needles when moved thereto, and said needle shifter having at its other end a projecting stud or tappet, and a cam L, having no vertical movement and located in the path of the stud or tappet on said needle shifter, whereby the coupling end of said lever is moved toward the adjacent one of said needles, substantially as set forth.

8. The laterally-movable slide I, having tappet *p*, in combination with a pattern cylinder having an intermittent rotary movement, said pattern cylinder having on one edge a series of receding steps *r*, *r*, with which said tappet *p*, engages and whereby said slide is allowed to move step by step in one direction, and a series of alternating cams *s*, and dwells *t*, on the same edge, with which said tappet *p*, engages, whereby said slide is moved step by step in the opposite direction, and means for maintaining said slide in co-operative relation with the pattern cylinder substantially as set forth.

9. The laterally-movable slide I, having tappet *p*, and the laterally-movable slide M, having tappet *y*, in combination with a pattern cylinder having an intermittent step-by-step rotary movement, said cylinder having on one edge a series of steps *r*, *r*, a series of alternating cams *s* and dwells *t*, and a dwell 3, between said two series of steps, said tappets *p*, and *y*, being located side by side and engaging said steps, cams and dwells, and means for maintaining said slides I, and M, in co-operative relation with said steps, cams and dwells the relations between said steps, cams and dwells, and the rotation of the pattern cylinder being as follows, (*a*) the circumferential extent of each of said steps *r*, being equivalent to two of the intermittent movements of the cylinder, whereby the cylinder must move twice before a tappet resting on one step will be advanced to the following step, (*b*) the circumferential extent of one cam *s*, and one dwell *t*, being equal to the circumferential extent of one of the steps *r*, and (*c*) the circumferential extent of the intermediate dwell 3, being equivalent to an uneven number of the intermittent movements of the pattern cylinder, substantially as set forth.

10. The reciprocating latch needles of a latch needle knitting machine, and the needle bar in which said needles are mounted, in combination with a web feed and tension bar characterized by the following movements, first a vertical movement to a position above the loops or stitches on the needles, second an inward movement toward the needles and into close proximity thereto, third a downward movement parallel with the needles whereby the loops are fed down, fourth an outward movement to enable it to swing clear of the upper edge of the needle bar, and fifth a downward movement onto the web, whereby the web is pressed and held down, and means for effecting said movements, substantially as set forth.

11. The combination of the movable cam-bar, the needle-cam thereon, a plate upon said cam-bar and movable thereon, said plate having means for moving said needle-cam to form a loose course, a loose-course finger movable into the path of said plate to move the same so as to form the loose course, a pattern mechanism, and means between said pattern mechanism and said finger for effecting the movement thereof, substantially as set forth.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

WILLIAM H. PEPPER.
ALBERT T. L. DAVIS.

Witnesses:
GEO. N. PIPER,
THOMAS HAM.