

Sept. 19, 1933.

A. A. ADLER ET AL

1,927,016

KNITTING MACHINE

Original Filed Aug. 1, 1922 3 Sheets-Sheet 1

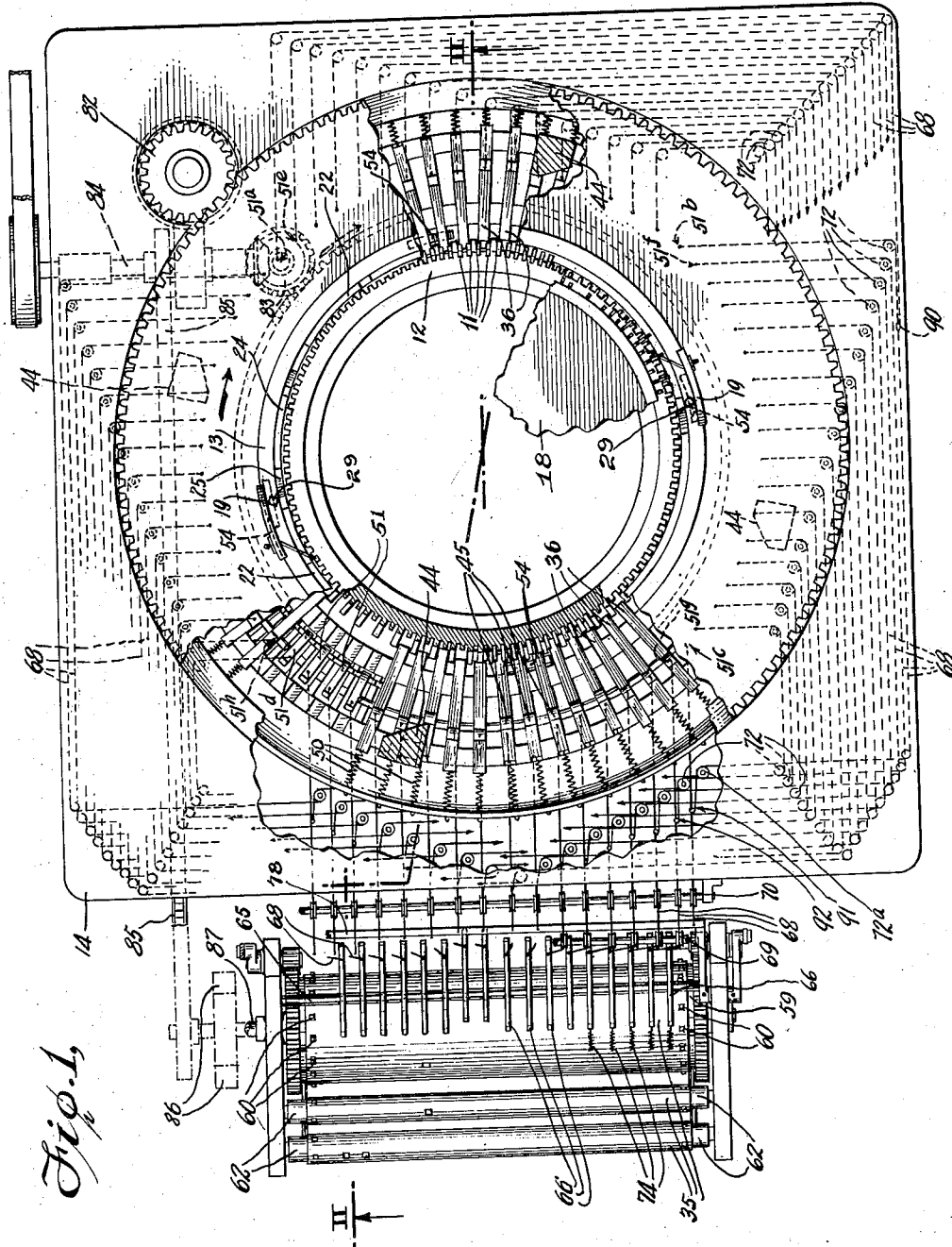


Fig. 1,

Alfred A. Adler
Harry Altmann
BY Jeffrey Kimball
ATTORNEYS

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A. A. ADLER ET AL

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Fig. 2,

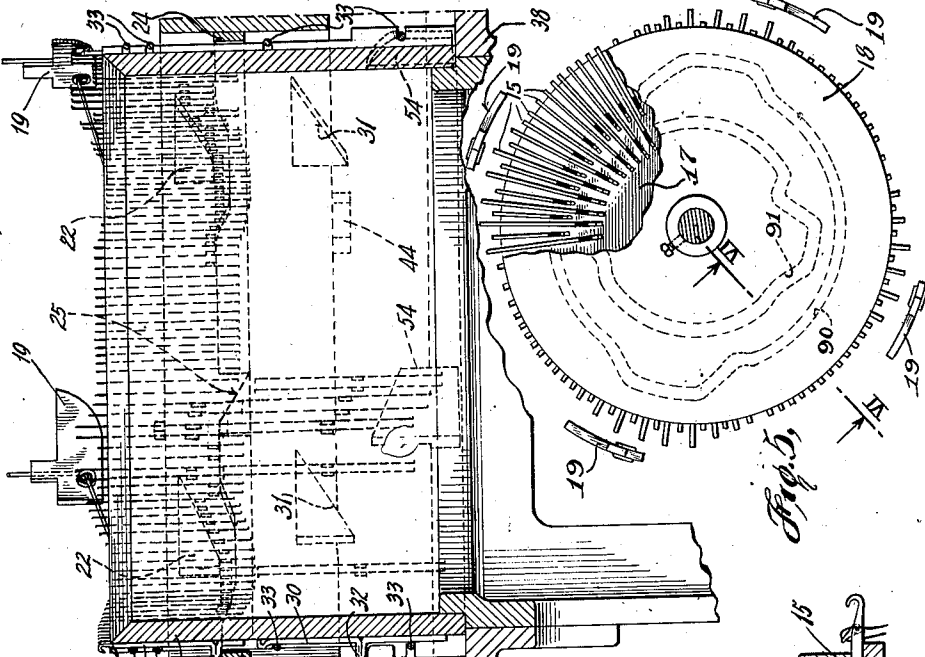


Fig. 5,

Fig. 4,

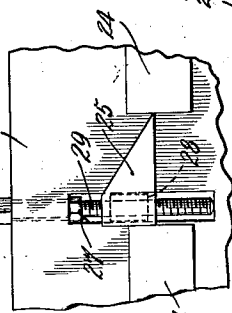


Fig. 6,

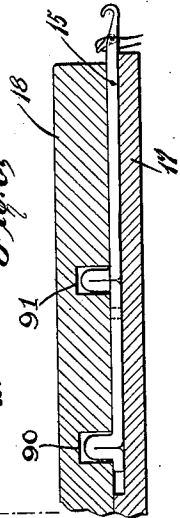
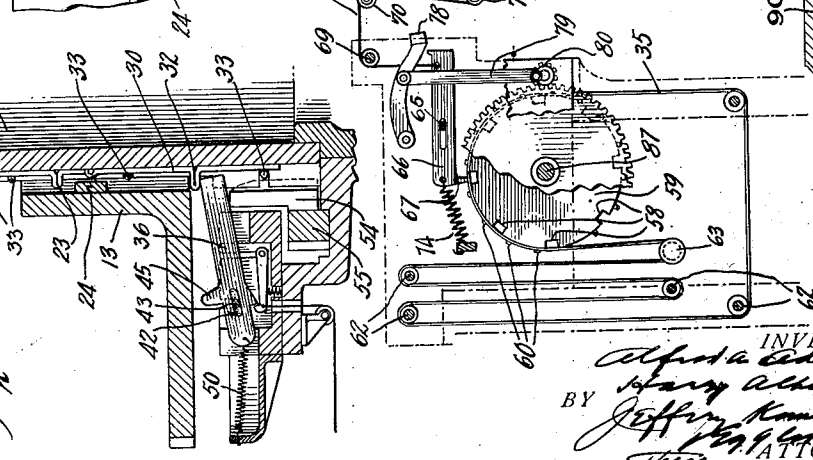


Fig. 3,



INVENTOR'S
Alfred Adler
Harry Alchutman
BY *Jeffrey Kambach*
169 1/2 East...
ATTORNEYS

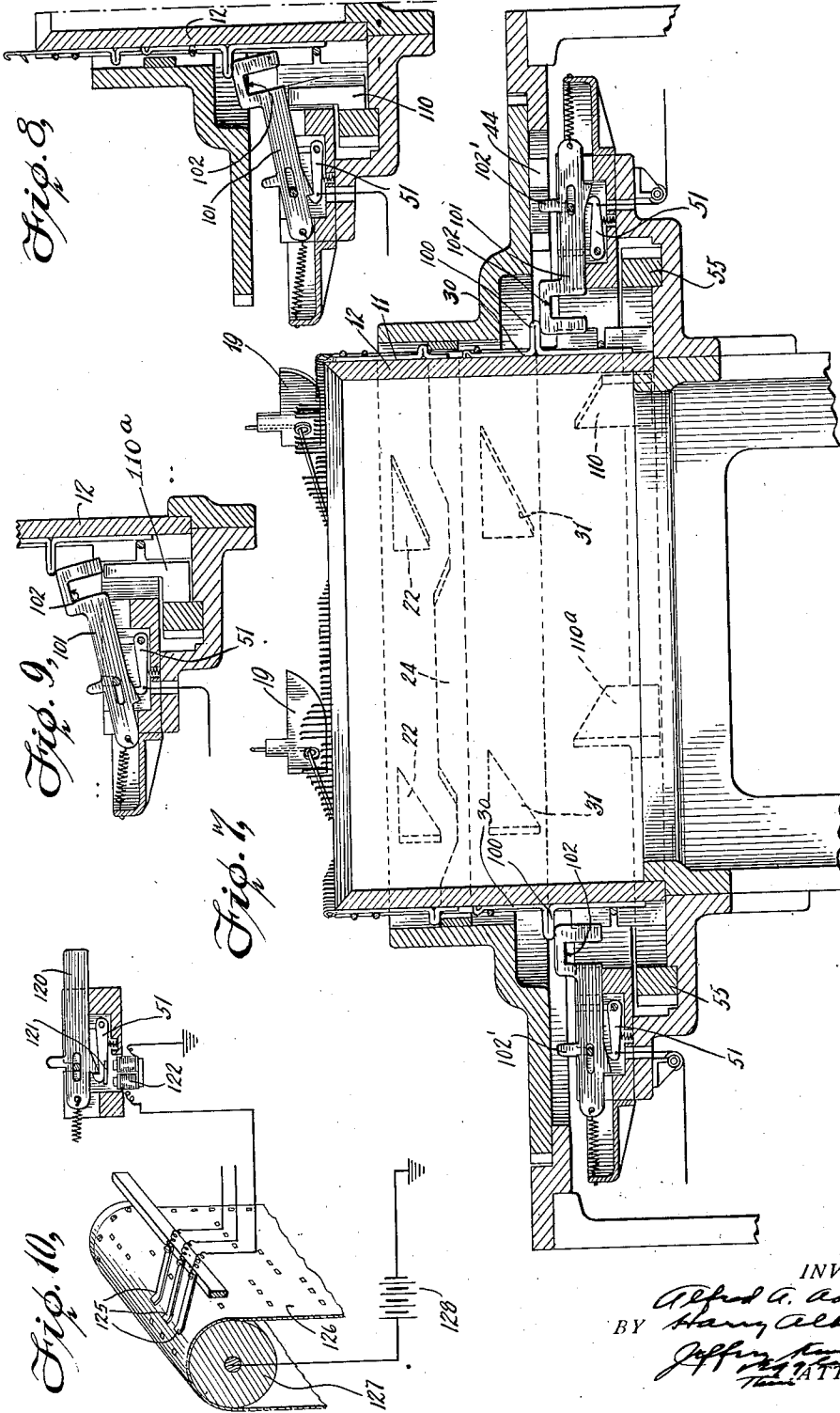
Sept. 19, 1933.

A. A. ADLER ET AL

1,927,016

KNITTING MACHINE

Original Filed Aug. 1, 1922 3 Sheets-Sheet 3



INVENTOR =
Alfred A. Adler
 BY *Harry Albertson*
Jeffrey, Kunkel
 ATTORNEYS

UNITED STATES PATENT OFFICE

1,927,016

KNITTING MACHINE

Alfred A. Adler, New York, N. Y., and Harry Albertman, Philadelphia, Pa., assignors to Jacquard Knitting Machine Co., Inc., a corporation of New York

Application August 1, 1922, Serial No. 578,887
Renewed September 4, 1931

30 Claims. (Cl. 66—25)

Our invention relates to knitting machines for the production of figured fabric and in some respects is an improvement on that new type of knitting machines set forth in our co-pending application, Serial No. 409,201, filed September 9, 1920, Patent No. 1,662,627.

The present invention permits the use of a single pattern to control an entire machine, provides for the positive functioning of the stitch-forming elements in the event of failure of the pattern controller to act, thereby eliminating a source of waste of cloth and breakage of needles, eliminates the breakage of needles or needle lifting jacks in the event of the failure of the parts of the pattern mechanism to move the full distance contemplated for perfect operation, and provides for a superior method of operation of the needles in machines having two needle banks cooperating in the same manner as the dial and cylinder needles of the well-known circular machine, whereby a figured cloth is produced that is thin and possesses other desirable features. These and various other objects of our invention will be apparent to those skilled in this art, from the disclosure of the preferred form of the invention shown in the accompanying drawings, wherein Figure 1 is a plan view, partly in section, of a circular knitting machine embodying our invention;

Figure 2 is a section thereof on the broken section line II—II of Fig. 1;

Figure 3 is a section of a portion of Fig. 2 with the parts of the machine in a different position;

Figure 4 is an elevation of a detail of a needle lifting cam;

Figure 5 is a detail of the dial and dial needles of the machine in Fig. 1;

Figure 6 is a section on the line VI—VI of Fig. 5;

Figure 7 is a section of a circular machine embodying a modification;

Figures 8 and 9 are sectional details of the machine of Fig. 7, showing the parts in different positions; and

Figure 10 illustrates a modified form of pattern controller and connections therefrom to the knitting machine.

In the knitting machine shown in Figures 1 to 6, a bank of needles 11 representative of stitch-forming elements is laid in individual slots in the outer surface of the stationary needle cylinder 12 for operation by cams located on the inner face of a cam cylinder 13 which is mounted as usual to turn in a circular trackway on the bed plate 14. A second bank of needles 15 is laid in radial slots in the stationary dial 17; their hook

ends alternate with the cylinder needles 11, and they are operated by the cam or cams in the lower face of the dial cap 18 which is rotated synchronously with the cam cylinder 13. The yarn guides or carriers 19 move with the cam cylinder 13 and dial cap 18 and may be mounted on the outer edge of the latter in the usual manner. In general, these constructions are similar to those commonly found in circular knitting machines, the points in which they distinguish from former machines appearing hereinafter. For clearness, the supports for the dial and the yarn guides have been omitted from the illustrations and likewise the supports for the yarn cones and other mechanisms common in circular knitting machines, the application of which to the present machine will be understood by those skilled in the art.

Four yarn carriers and sets of cams are shown in the drawings, but any number may be employed, as will be apparent. The cams on the inner face of the cylinder 13 include the usual stitch cams 22 and resting cam 24, the first of which rides over the needle butts 23 to retract or pull down the cylinder needles below the top of the needle cylinder 12 after they have been raised to take on yarn to form a new stitch; the resting cam 24 is recessed below each stitch cam to permit this complete retraction of the needles while the trailing end-walls of its recesses provide cam surfaces which immediately raise the needles slightly to the rest positions in which they are held until later raised still farther to take on further yarn. In the production of figured fabrics this raising of the needles to take on yarn may be controlled solely by a pattern mechanism later described. However, at times the usual needle raising cam will be found useful, as later appears, and we have therefore retained the usual needle raising cams 25, one for each feed, but these are here made manually adjustable into and out of operating position, for example as shown in Fig. 4. As there shown, the cam cylinder 13 is slotted axially at 27 back of each raising cam 25 and the latter is provided with a rectangular lug 28 to ride in the slot; a bolt 29 bearing on the lower end of the slot and threaded in the lug, provides for the elevation of the cam into operation or its depression into the wholly inoperative position of Figure 2. When held at their highest operating positions these raising cams as usual raise every needle to such a position that the preceding stitch or loop is dropped behind the open needle latch and hence produce knit cloth without figures and without

the assistance or operation of the pattern mechanism. For selectively raising the needles under the control of the pattern mechanism (the raising cams 25 being depressed from this high position), other raising cams 54 are employed to act on the needles when individual interposable members 36, located around and outside the needle bed 12, are interposed between these cams and the respective needles. Preferably each cylinder needle is provided with a jack 30 positioned in an extension of the needle slot so as to extend the needles in effect, so that this pattern-controlled needle-raising mechanism may be located out of the way of the cams 22, 24 and 25 previously mentioned; jack lowering cams 31 on the cam cylinder are used to act on the jack butts 32 to retract the jacks simultaneously with or just in advance of the retraction of the needles by the cams 22 and thus relieve the needles and the needle butts of the additional work of depressing the needle extensions. The usual resilient bands 33 hold both the needles and the jacks in these slots. In the machine illustrated, the interposable members 36 are interposed directly between the raising cams 54 and the jacks 30 and in such a construction the members 36 are preferably sliding levers laid in individual radial slots in the annular ring 37 which is attached to the frame of the machine by brackets 38 in such a position that the inner ends of the levers lie in the path of the raising cams 54 and the cams 44 on the underside of the horizontal flange of the cam cylinder 13 may engage the vertical butts 45 on the levers to slide the latter underneath the jack butts 32. Pivot pins 43 extending through the slots 42 hold the levers in their slots in the supporting ring 37. An interposable member or lever 36 may be provided for every jack, and hence for every needle, but we have found that sufficiently clear designs may be produced if the stitch-forming elements are operated in groups of a few adjacent elements, and especially if operated so that two adjacent stitches are drawn alike as by operating the needles in pairs; in the present machine a single lever 36 is provided for each two adjacent jacks. One of the positioning cams 44 is provided for each feed in the machine of Figs. 1 to 6, that is to say, four in all, and each is placed angularly in the rear of a jack retracting cam 31 so as to push in under the jack butts any and all members 36 that may have been held out from under the butts during the passage of the preceding feed. In opposition to the positioning cams 44, individual springs 50 tend to pull the members 36 out from under the jack butts 32 and thus remove them from their interposed positions; these springs are normally prevented from acting by individual spring pressed latches 51 located in recesses in the bottoms of the lever slots, each of which automatically engages a shoulder on its lever (Figs. 2 and 3) as the latter is pushed under its jack butts by the cams 44 and thus holds the lever under these butts unless pulled down into releasing position by the action of the pattern controller. The raising cams 54, one for each feed, are carried on a second cam cylinder 55 that is turned synchronously with the main cam cylinder 13 and these cams are respectively disposed in advance, angularly, of the retracting cams 22 and 31 and in substantially the same angular positions as the usual raising cams 25. The cams 54 are capable of raising the inner ends of the levers 36 so high that when the levers are held underneath the jack butts by the latches 51, the corresponding needles are raised at each pass of a cam 54 (as shown in Figure 3) to a position in which the preceding loop slips behind the needle latch and the needle takes on thread from the passing yarn guide. It follows from this construction that every pass of a yarn guide 19 in front of a needle is preceded by a pass of a lever positioning cam 44 over the lever 36 corresponding to that needle, and the lever is then retained in its jack-and-needle raising position by its latch 51 so that the succeeding raising cam 54 will raise the needle to form a new loop unless the pattern controller acts to pull down the latch and permit the spring 50 to pull out the lever from under its jack butts before the raising cam reaches it; in this latter case, that is to say when the lever 36 is released by the pattern control and retracted by its spring 50, the pass of the lever raising cam 54 raises the lever but the retracted lever now passes the end of the butt 32 of its jack without engaging it and the corresponding needles remain down and do not take on yarn. The succeeding positioning cam 44 again returns all the released levers 36 inwardly under the jack butts and thus returns all the levers to needle raising position. As to the whole bank of stitch-forming elements 11, the selection of the elements to be raised (or otherwise actuated in a particular way) for a pass of any feed, is timed with respect to that feed pass, and to that end, in the present instance, the relation is intended to be progressive, that is to say, the retraction of called or selected levers is a continuous progressive operation with respect to each yarn guide, being carried on simultaneously with the turning of the cam cylinder, so that the movement of the cams is not interrupted by the action of the pattern mechanism; and the action and manifestation of the control by the pattern mechanism is not interfered with by the continuous movement of the cams; in progression or succession the called levers are retracted while they and their needles and the respective jacks as progressively left at rest between each pass of a positioning cam 44 and the pass of the raising cam 54 immediately behind it. The levers may be retracted literally seriatim, one at a time, or a number may be retracted together between each two of the cams 44 and 54; the number that may be retracted simultaneously obviously depends on the spacing between the cams and the speed of the cam cylinder. In order to provide ample time for the retraction movement and also the simultaneous retraction of as many levers as possible, the cams 44 are located as close as practicable behind the lowering cams 31, and hence as far ahead of the following raising cam 54 as possible.

It may be noted at this point that the function of the pattern controller (regardless of its nature and location) is solely to release the stitch-forming elements from the action of the cams; it simply withdraws or causes the withdrawal of the interposed members 36 from between the needles and the raising cams 54, so that should the pattern controller fail to exercise control of any needle or needles at any time when it is intended that the control should be exercised, the needle or needles in question are caused to knit regularly and the only, or substantially only, result is imperfect figuring and possibly additional stitches in the fabric. No holes are produced in the fabric however by the failure of certain needles to rise; neither are uncast off stitches permitted to pile up on any needle until the latter is bent or broken and the operation of the machine interrupted.

until repaired. This is an important feature of our invention and is independent of the nature and location of the pattern controller and may be embodied in numerous ways. Another important feature of our invention involves the manner in which the interposable members 36 are moved into and out of acting position, that is to say, the manner in which we interpose the members which transmit to the stitch-forming elements the control, or the power which actuates them. Preferably each of these members is moved on a line that is at an angle to the direction of the action of the force that it transmits, and preferably at right angles thereto; this is illustrated in the machine described where the levers 36 slide at right angles or radially to the needle cylinder when being interposed or withdrawn, and where the line of action of the raising cams 54 is parallel to the cylinder axis. The advantage of interposing and withdrawing these members by movements at an angle to the action on them, is that this prevents damage to the machine if the interposed member is left at any time in an intermediate position, that is to say, for example, if the member 36 fails to move to either its extreme right hand or left hand position in Fig. 2 but stops somewhere between these two positions and is struck by a raising cam 54 while in this intermediate position. By way of contrast, in those prior devices in which the needle jack is the interposable member and is shifted lengthwise in its slot into and out of the path of a raising cam on the cam cylinder, if a jack is accidentally left with its butt in the path of the forward end of the cam instead of well above or well below it, the end of the cam strikes the butt and bends it against the face of the needle cylinder, and the machine must be stopped and repaired. Such an accident cannot occur when the interposable member is interposed by movement at a liberal angle to the line of the needle-raising action on it as will be apparent, and this feature is applicable to other stitch-forming mechanisms than that illustrated, and regardless of whether the interposable member is interposed directly between a raising cam and a needle jack, as shown, or not, as will be obvious to those skilled.

The pattern controller preferred is located remote from the needle bed, and while there may be more than one for the machine, a single controller will usually be sufficient since a remotely located controller can control a relatively large number of stitching elements. By locating the controller or controllers away from the machine ample space can be provided for the pattern 35 which, therefore, may be of any size desired; also in this manner at least one side of the needle bed and the fabric may be left accessible to the operator although the controlled elements are distributed on all sides of or all around the needle bed. This will become apparent from the following description of the controller and the controller connections illustrated. The moving pattern-controlling member 35 of the controller shown (which determines the operation of the lever latches 51) is a long sheet or belt of a thin flexible material, a heavy paper for example, and is marked in accordance with the figures or design desired in the fabric by means of perforations which are so placed in the sheet as to fall upon the longitudinal grooves 58 in the surface of the pattern drum 59 as the latter is turned. This drum is turned continuously (clockwise in Fig. 2) at a fixed rate with respect to the speed of the cam cylinders

13 and 55, and is provided with pins 60 to enter holes in the edges of the pattern sheet to draw the pattern sheet along with it. When the pattern sheet is of great length it is looped over and under loosely journalled rolls 62, another roll 63 running loose in one of the loops of the sheet so that its weight maintains the sheet under a little tension. A series of selector bars or feelers 66, hung on pivots 65 extending through slots, rest with their feeler fingers 67 in contact with the pattern sheet in the paths of the pattern perforations and at their opposite ends are connected by filamentary connecting members, such as flexible connections like the cords or wires 68, extending around the machine, to the respective latches 51 of the jack levers as shown for example in Figs. 1 and 2. Each cord or wire 68 is carried over such pulleys 69, 70, 71, 72, or other supports, as may be necessary. Individual springs 74 pull the feelers to the left (Fig. 2) and down lightly against the pattern sheet so that the latter may pass freely underneath the feelers until a perforation reaches one of the feelers when its finger is pulled through the same and into that slot 58 in the drum which happens to be beneath that perforation. The continued turning of the drum 59 brings the rear wall of the drum slot against the feeler finger or feeler fingers which have fallen into this slot and pushes such feeler or feelers lengthwise underneath the ram 78 which is connected by a link 79 to a crank pin 80 that is geared to the drum 59, so that the ram descends on the projected feelers to cause them to pull their cords 68 and depress the attached latches 51, thereby permitting the respective members 36 to be pulled back from under their jack butts as before described. The ram 78 passes the unprojected feelers 66 without striking them. The depression of the cord end of the projected selector feelers also withdraws the fingers from the drum slot and pattern perforation as will be apparent, and the ram holds them lifted momentarily while the pattern sheet continues to move, so that when the ram 78 rises and the fingers are again pulled down by the springs 74, the fingers strike against an unperforated portion of the sheet and the feelers slide back to the rest position shown in Figure 2. A shoulder may be provided on the ram end of each feeler, as shown in Fig. 2, back of which the ram engages, to keep the springs 74 from pulling the feelers from underneath the ram until the latter rises. This operation of depressing the feelers by the ram, releasing them again, and returning them to their rest positions, is made to occur within the time that the continuous turning of the drum brings the succeeding slot 58 of the drum, and possibly another perforation or row of perforations, under the row of selector fingers, and the pattern sheet is so perforated and the drum is driven at such a speed as to bring about directly the successive progressive retraction of the selected levers 36 that is required. That is to say, the pattern is so perforated as to select the feelers progressively, acting on one or a few at a time (the number from which a selection is made at any one time depending on the spacing between the positioning and raising cams 44 and 54 and corresponding to the number of levers 36 that it is possible to release simultaneously), and furthermore the pattern is so timed and so driven with respect to the cam cylinder that its selections are made at such times that the selected levers 36 are retracted intermediate

the positioning and raising cams. The progressive retraction of the levers 36 that is needed to preserve the continuity of rotation of the cam cylinder is brought about therefore, directly by the progressive pulling of the cords 68, which is preferred for the sake of simplicity, and the latter is here shown as brought about directly by the progressive selection from the plurality of feelers related to the single pattern, altho it may be brought about in other ways. As before pointed out, the number of levers 36 that may be retracted simultaneously, determines the maximum number of feelers from which the pattern 35 may make a simultaneous selection; obviously therefore, the greater the distance between each positioning cam 44 and its following raising cam 54, the shorter may be the length of the pattern sheet 35 for a given figuring of the fabric.

The main cam cylinder 13 and the second cam cylinder 55 are turned synchronously in the fixed relation shown in the drawings by means of the gears 82 and 83 respectively which are driven from the main shaft 84 and which at the same time drives the drum 59 at the desired speed proportionally to the speed of the cam cylinders, through the agency of the chain 85 and the intermediate gears 86 terminating in the shaft 87 of the drum 59.

Each selector finger of a remote pattern controller may be connected to and hence control an individual stitch-forming element or pair of adjacent elements; in the alternative, two or more such elements (or pairs of adjacent elements) in different parts of the bed but that are always to be operated together, may be connected to the same selector bar, thus reducing the number of selector bars, simplifying the preparation of the pattern, etc. In the machine shown, the pattern is to be repeated four times around the machine, that is to say, the four quarters of the tubular fabric are to be knitted with the same design, and hence each selector 66 is connected to four latches 51 spaced ninety degrees apart. For example (Fig. 1), the cord from the latch at 51a is tied at 90 to the cord from the latch at 51b, and the latter is tied at 91 to the cord from the latch at 51c, while the cord from the latch 51d is carried completely around the pulley 72a and is also tied at 91 to the cord from the latch at 51c; in a similar manner the cord from the latch at 51e is tied to the cord from the latch at 51f and the latter cord and the cord from the latch 51h are tied at 92 to the cord leading from the latch 51g. The remaining needles are similarly interconnected in fours in regular order, the interconnections being only partly completed in the drawings in order to avoid confusion of the lines. Obviously, when any lever 36 of any set of four needles is released and retracted from needle operating position, the other levers 36 of the same set are similarly released and the four quadrants are knitted with the same design. Not less than four yarn guides 19 are needed with this arrangement in order to supply yarn to every needle every time it is raised high enough to drop its preceding loop back of its latch; otherwise loops would be cast off prematurely and holes formed in the cloth.

Machines embodying the invention as thus described may be operated in various ways; for example, and first assuming that the dial is omitted: If any considerable length of unfigured fabric is to be formed of simple "knit" stitches,

either of a single solid color or striped by courses, the needle raising cams 25 may be used to advantage; for this purpose they are raised so high manually, by means of the bolts 29, that as the main cam cylinder 13 is turned about the needle bank 11 these cams raise the needles to a "knit stitch" height; that is to say, as each thread guide passes any needle the latter is raised so high while taking on the thread of the passing guide that the preceding loop is dropped back of the needle latch so as to be cast off when the succeeding stitch cam 22 retracts the needle again. Yarn is supplied by the yarn guides 19, and in each rotation of the cam cylinder as many courses or rows of stitches are added to the fabric as there are thread guides, four in the machine shown. If yarns of different colors are supplied to the different guides the fabric is striped horizontally by courses or rows. The driving connections of the pattern drum 59 may be interrupted so that the drum does not turn when the cams 25 are employed in this manner, thus making it unnecessary to provide a length of pattern sheet 35 corresponding to the unfigured portion of fabric. The levers 36 and lever raising cams 54 also perform no function during this operation and the driving connections of the second cam cylinder 55 may also be discontinued if desired and if a disconnecting means is provided. If the driving connections of the second cam cylinder 55 are not interrupted, the same result may be accomplished by the jacks, levers 36 and lever raising cams 54 without the assistance of the needle raising cams 25. In this mode of operation the cams 25 are depressed to the level of the ring 24 and the driving connections of the pattern drum 59 are interrupted to reduce the length of the pattern sheet as before or, in the alternative, the pattern sheet 35 is left unperforated for a corresponding length. All the levers 36 are permanently held under the jack butts 32 by the inaction of the feelers 66, this inaction permitting the latches 51 to retain their hold on the levers, and accordingly all the needles are raised to knit at every pass of every jack raising cam 54 and every needle casts off the previous loop and forms a stitch on the passage of every thread guide. Since in both of these operations the needles are raised at every pass of every yarn guide, both these modes of operation require that yarn be supplied by every guide 19. The same result may however be accomplished with the assistance of the pattern sheet (without the aid of cams 25) when yarn is supplied to only a part of the thread guides 19. In this operation the pattern sheet 35 is so perforated that all the latches 51 are pulled down and correspondingly all the levers 36 retracted out of jack elevating position, in advance of such lever raising cams 54 as correspond to the unthreaded yarn guides 19; on the other hand, none of the latches 51 are actuated and none of the levers 36 retracted in advance of the passage of the raising cams 54 corresponding to the yarn guides 19 that are supplying yarn. Accordingly every needle is made to knit at every pass of yarn, but is held inoperative at the passes of the unthreaded guides in order that the loops may not be cast off as incomplete stitches and the continuity of the cloth interrupted. This last method of producing unfigured cloth is particularly useful where shorter lengths of unfigured cloth of a solid color (or striped by rows) are desired, such as intermediate figured portions of the same

fabric, since this method requires only the unthreading of certain of the thread guides, the proper perforations of the pattern sheet 35 being provided for at the time the sheet is perforated for the figuring of the fabric which occurs before or after, or both before and after, the unfigured portion. For the production of figuring in colors, yarns of the different colors (or in the case of cross dyeing, yarns of different materials or previously subjected to different treatments) are placed in successive guides 19 and the needles are raised to take on the different yarns as the desired figuring of the fabric may require and as the operation of the needles is directed by the pattern sheet 35; when a needle is not raised to take on yarn from any one of the yarn passes, the yarn of that pass reaches straight across behind the space occupied by that needle, and hence does not appear on the face of the fabric at that point. Thus in the machine illustrated, each course or row of stitches may be made up in part of stitches of one color and in part of stitches of the other color, the yarn of the first color floating or lying loosely behind the stitches of the second color and the second color lying loosely behind the stitches of the first. White yarn for example may be supplied to two diametrically opposite yarn guides 19 and red yarn supplied to the two intermediate guides. As the cam cylinder is turned and the white yarn is passing any lot of adjacent needles, the pattern 35 being drawn under the feelers 66 presents perforations to such of the feelers of the needles of that lot as it is desired should skip the white yarn and knit the red yarn carried in the following guide. Accordingly those needles (of the lot in question) which are to knit the red yarn in that course are not raised when white yarn guide passes them but remain retracted and the white yarn reaches straight across the spaces occupied by them; all the other needles of the lot are raised however and so take on and form stitches from the white yarn from the passing guide because their feelers find no perforations in the pattern sheet and hence their lever latches 51 hold the corresponding levers 36 in jack raising position during the time the corresponding cam 54 raises them. Immediately after the white guide passes each needle however, a positioning cam 44 follows it and replaces all the retracted levers under the jack butts again. When the next raising cam 54 (which corresponds to and cooperates with a red yarn) approaches the same lot of needles the pattern mechanism has advanced to exercise further control of the same needles and now the feelers which found no perforations while the white yarn was passing and hence permitted the making of stitches of the white yarn, are presented with perforations in advance of the passage of the red yarn guide and accordingly their needles remain down as the red yarn passes them. On the other hand the needles that remained down and made no stitches during the passage of the white yarn now have no perforations presented to their feelers and hence knit the red yarn. These two yarn guides, one white and the succeeding red yarn, thus lay a single complete course or row of stitches with each complete rotation of cam cylinder, some of the stitches being red and the others white as required by the figuring desired; obviously the red yarn might be laid before the white, and the operation may be continued through additional courses with such changes in the arrangement

of the red and white stitches as the design may call for. The second pair of thread guides lay another single course simultaneously with the first pair and in a similar manner and under the simultaneous control of the pattern mechanism, and thus as many courses of stitches are added to the fabric at each turn of the cam cylinder as there are sets of colored yarns. Since each feeler controls four needles (or pairs of adjacent needles) and four sets of raising and stitching cams are employed in the manner illustrated, the second set of yarn guides is needed not only to increase the rate at which the fabric is produced but also to prevent the casting off of incomplete stitches and to preserve the continuity of the fabric as before indicated and as will be apparent to those skilled in the art. It may be noted at this point that while the same design is worked into all the quadrants of the tubular fabric by this operation, the coloring is reversed in some of the quadrants; that is to say, with the operation exactly as described, in two opposite quadrants of the fabric the figure may appear as red on a white background but in the other two quadrants the figuring will appear as white on a red background. This is due to the fact that as many needles 11 (or rather pairs of adjacent needles) have been coupled together into a group by the cords 68 as there are yarn guides, the (pairs of) needles being tied and operating together in groups of fours and four yarn guides being employed. Accordingly every time any group of four needles is raised to take on yarn, two opposite needles take on white yarn and simultaneously the other two needles take on red yarn, with the result that opposite quadrants of the fabric are constructed exactly alike, but the other two quadrants are alike in design but reversed in coloring. The reversing of the coloring among the quadrants may be varied, and other variations secured by other relative distributions of the colors among the yarn guides 19. All quadrants may be made alike by coupling together by the cords 68, into each group, as many needles (or pairs of adjacent needles) as there are sets of colors, and other arrangements may be devised to obtain other effects. Designs may also be worked out in knit and tuck stitches with the assistance of the needleraising cams 25. For this purpose the cams 25 are manually raised sufficiently high above the ring 24 to raise all the needles high enough to take on the thread of the passing guides, but not high enough to drop the preceding loops behind the needle latches. Accordingly, when the stitch cams 22 retract the needles that are raised solely by the cams 25, each needle holds two loops in the manner well understood in the production of tuck stitches, but casts off none. By suitably perforating the pattern sheet 35 any lever 36 may be retracted at any time to withdraw its needle or needles from the action of the lower cams 54 and permit the same to be lifted solely by one of the cams 25 and take on this double loop, all the other needles, the levers 36 for which are not retracted, making full "knit" stitches. These examples are representative of the operation of the cylinder needles of the machine.

Referring now to the dial and the dial needles that may be laid alternately with the cylinder needles as usual: While fabrics may be formed by the cylinder needles alone, as appears above, omission of the dial from the machine illustrated permits the yarns to float loosely behind the

fabric wherever they are required to pass needles without being knit into it; the addition of a dial to the cylinder interknits or anchors these threads where they would otherwise float, and thus provides a more compact and serviceable fabric. The stitching of the dial is not necessarily controlled by the pattern mechanism and the ordinary form of dial may be employed, in which all the needles are operated by a single cam race which causes every needle to knit at all the passes of all the yarn guides. Such a dial, however, causes its needles to lay a course or row of stitches from every thread guide, whereas in the operation producing figures in colors above described, completion of a single course of stitches by the cylinder needles may require as many passes of yarn guides as there are colors, as there pointed out. That is to say, if the above-described method of two-color figuring is followed when the usual type of dial is employed, the dial needles lay two courses of stitches for every course laid by the cylinder needles. This non-uniformity may be taken care of by causing the cylinder needles to draw longer stitches than the dial needles as will be understood. However, the dial construction illustrated (particularly in Figs. 5 and 6), causes the dial needles to lay a single course for every course laid by the cylinder needles, thus permitting the two banks of needles to draw stitches of the same length and the production of a fabric of a uniform construction. As shown in Figs. 5 and 6, the dial needles 15 are divided into as many groups as there are colors used in the figuring (two, white and red, having been assumed) and the needles of different groups are distinguished by having their butts at different distances from the center of the cam dial. The needles of the groups are intermixed and each group is provided with its own cam race 90 and 91. Preferably the needles are long or short, depending on the distance of their butts from the dial center, and the needle slots are only long enough to accommodate their respective needles. This preserves strength in the walls forming the slots and permits the use of a number of needle groups. The cam races are identical (except for such changes as are due to one being radially nearer the center than the other) but the needle-raising-and-stitch-cam portions of the races are so provided and so angularly displaced or set apart from each other that the different groups take on yarn from different yarn guides; when a long needle is being projected and retracted to knit a stitch from one of the thread guides the shorter needles at the sides of the long needle are held inactive; conversely, when a short needle is knitting on some portion of the dial the longer needles of the same portion of the dial are held inactive. Thus each of the races 90 and 91 is arranged to project and retract its needles twice, the two projecting and retracting portions of each race being 180° apart and the four projecting and retracting portions being set 90° apart as appears in Fig. 5. As a result of this construction each needle group knits from two of the yarn guides and it requires the pass of as many yarn guides to complete a course of stitches by the dial needles as it requires passes of the yarn guides to complete a course of stitches by the cylinder needles, and the dial lays one complete row of stitches while the cylinder needles are laying one complete row. Referring again to the pattern controller in the machine above described, it will be observed that the pattern mechanism is required to operate once for each color. That is to say, in the case of the two-color figuring before described a portion of the pattern sheet 35 must be brought under a feeler or selector bar 66 prior to the pass of a white yarn over the corresponding needle, and then prior to the passage of the succeeding red yarn over the same needle another portion of the pattern sheet must be brought under the same feeler. In effect, in order to bring about the knitting of the desired yarn, there must be as many set-ups of each selector as there are colors. The length of the pattern sheet may be reduced by so arranging the construction that a single set-up of each selector is sufficient to bring about the knitting of the desired yarn. Such a modification is illustrated in Figs. 7, 8 and 9. A jack-raising cam is employed for each of the colors as before, but the interposable levers and jack butts are so related that the levers remain under the butts in all positions of the levers and the cams and levers are so arranged that only one cam (of each set of colors) operates to raise the lever in any position of the latter. Figs. 7, 8 and 9 are adapted to two-color work. As in Figs. 1 and 2, there is the same needle cylinder 12 carrying the cylinder needles 11 with their jacks 30, stitch cams 22, resting cam 24, jack retracting cams 31, four yarn guides 19, and, it may be assumed, the pattern sheet 35 and feelers controlling the needles in groups of four as in the earlier figures. The jack butts 100 are however longer than the jack butts of the preceding figures as appears, so that the interposable levers 101 remain underneath the butts 100 and hence in jack lifting position regardless of whether the levers are in their innermost position or retracted. The levers 101 are provided with vertical butts 102' and like the levers 36 of the preceding figures are pushed inward by the positioning cams 44 and held or released for retraction by the cord controlled latches 51 as before. The forward ends of the levers 101 are provided with notches 102, however, and the lower lifting cams 110 and 110a for each set of colors are carried by the second cam cylinder 55 at different distances from the axis of the cylinder; for example, the lever lifting cam 110 co-acting with the right hand yarn guide 19 in Fig. 6, is placed close to the inside of the cam cylinder 55, whereas the lever raising cam 110a which cooperates with the other yarn guide appearing in the figure, is displaced radially inward from the cam cylinder 55 (see Figs. 8 and 9). As a result, any lever 101 retained in its innermost position by its latch 51 is acted upon by the cam 110, but is passed (without being lifted) by the following cam 110a which passes through the notch 102 (Fig. 8). On the other hand, when a perforation is presented to the feeler of any needle and its lever 101 permitted to retract, cam 110 passes through the notch 102 in the lever without lifting it, but the following lifting cam 110a engages the forward end of the lever and lifts it and its needle (Fig. 9). One positioning cam 44 is used for each set of colors, that is, as shown one cam is used to reset the levers 101 inwardly after the pass of a white and a red yarn, but none is used to reset the levers after the passage of the white yarn and before the passage of the succeeding red yarn. It will now be apparent that one space on the pattern sheet 35 is all that is needed to provide for the proper stitching of two yarns. If no perforation is presented to a feeler subsequent to the passage of a cam 44 over the corresponding jack lever and

prior to the passage of the cam 110 under the same lever, the lever raising cam 110 causes the corresponding needle to knit from the first thread guide, but the raising cam 110a of the succeeding thread guide passes through the notch 102 without raising the lever; in the alternative, if a perforation is presented to the feeler, the cam 110a causes the needle to knit, but the cam 110 passes the lever without lifting it.

Figure 10 illustrates filamentary connections from the pattern controller to the stitch-forming elements of an electrical type. In this case, the latches 51 which retain the jack-lifting levers 120, are provided with iron armatures 121 held thereby over individual electro-magnets 122. One side of the magnets is grounded and the other side is connected to one of the feelers 125, which in this case are spring contacts resting on the insulating fabric 126 of the pattern sheet which runs over a metallic drum 127. The drum is connected to one side of the battery 128 and the opposite side of the latter is grounded. It will be apparent that when an unperforated portion of the sheet 126 lies underneath a feeler 125, the circuit to the corresponding electro-magnet 122 is interrupted and hence the corresponding jack lever 120 is retained inwardly underneath the jack butt. On the other hand, when a perforation appears below one of the feelers 125, the feeler is allowed to come into contact with the metal drum 127 and complete a circuit to its electro-magnet 122, thus drawing down the corresponding latch 51 and permitting its jack lever 120 to retract.

It will be understood by those skilled in the art that the embodiments of our invention herein described are merely representative of our invention and that the latter is not limited thereto.

We claim:

1. In a knitting machine, the combination of a circular bank of stitch-forming elements, a yarn guide, a pattern-controlling element having its pattern-calling agencies arranged in rows substantially crosswise of itself, a plurality of couplings subject to the same single pattern-controlling element and connecting the same to a plurality of said stitch-forming elements, and means for actuating progressively, while stitches are being formed, those of said couplings which are selected for the control of said stitch-forming elements in individual passes of the yarn guide.

2. In a knitting machine for the production of figured fabric, the combination of a bank of stitch-forming elements, and a pattern mechanism including a pattern member, a plurality of feelers, all of which are simultaneously subject to the marking of the same pattern member and are connected to the stitch-forming elements to control their operation in accordance with said marking, and means for advancing the pattern, the said means advancing the said pattern member at such a rate during the knitting of fabric and the markings of the pattern being so arranged that such of the said feelers as are to be selected for the knitting of a single course of the fabric are selected progressively during the knitting of that course.

3. In a knitting machine, the combination of a cylindrical bank of needles, a cam cylinder for continuous rotation about the needle bank provided with a cam for raising the needles, and a pattern mechanism including a pattern member, a plurality of feelers, all of which are simultaneously subject to the markings of the same pattern member and are connected to the needles to con-

trol their operation, and means for advancing the said pattern member during the knitting whereby the pattern member advances simultaneously with the rotation of the cam cylinder, the markings of the pattern being so arranged that such of the said feelers as are to be selected for the knitting of a single course are selected progressively in advance of the moving raising cam.

4. In a knitting machine, the combination of a cylindrical bank of stitch-forming elements, a cam cylinder for continuous rotation about said bank and provided with a stitch cam for drawing the stitches, and a pattern mechanism including a pattern member, a plurality of feelers all of which are simultaneously subject to the markings of the same pattern member and are connected to the stitch-forming elements to control their operation, and means for advancing the said pattern continually while the cam cylinder is rotating, the marking of the said pattern member being such that the feelers to be selected thereby for the production of the desired fabric are selected progressively at such times that their control of the needles is effected on the needles progressively in advance of the moving stitch cam.

5. In a knitting machine, the combination of a cylindrical bank of needles, a cam cylinder means for continuous rotation about the needle bed and provided with needle raising and stitch cams, and a pattern mechanism including a pattern member, a plurality of feelers all simultaneously subject to the markings of the same pattern member and connected to the needles to control their raising, and means for advancing the said pattern member during the knitting whereby the pattern member advances during the rotation of the cam cylinder, the markings of the said pattern member being so arranged that such of its feelers as are to be selected for the knitting of a single course are selected progressively intermediate the passage of a stitch cam and the passage of a raising cam following it.

6. In a knitting machine for the production of figured fabric, the combination of a cylindrical bank of stitch-forming elements, cam cylinder means rotating thereabout and provided with actuating cams for the stitch-forming elements, a remotely located pattern member, a plurality of feelers subject to the marking of said member, means for advancing the pattern member while the said cam cylinder means is rotating, connections subject to the feelers extending toward the needles to control the operation thereof, means for operating said connections the marking of the pattern means being such that such of its feelers as are to be selected in the knitting of each course are selected by the pattern member progressively and at such times as to effect their control on the stitch-forming elements intermediate the passage of cams thereover.

7. In a knitting machine for the production of figured fabrics, the combination of a cylindrical bank of stitch-forming elements, cam cylinder means rotating thereabout and provided with cams for effecting the actuation of the stitch-forming elements, a pattern drum provided with a plurality of recesses around its circumference, a pattern sheet passing over the drum as the latter rotates and provided with perforations in accordance with the figuring desired, the perforations being so located as to fall above the recesses in the drum, feelers engaging with the pattern sheet and arranged to fall through its perforations into the drum recesses, a ram acting on such feelers as are differentiated from other feelers by the mo-

mentary presence or absence of perforations therefor in the pattern sheet, and a cord or wire connection from each feeler to the bank of stitch-forming elements through which the action of the ram controls the operation of said elements, the drum being turned at such a rate and the pattern perforations being so arranged that the differentiation of feelers required for any course, occurs progressively.

8. The combination with a knitting machine including a circular bank of stitch-forming elements, a yarn guide and means for actuating said elements to cause the formation of stitches, of a pattern mechanism including a pattern-controlling element and means for operating the hereinafter mentioned filamentary connections in accordance with the call thereof by the pattern controlling element, said pattern mechanism being located remote from the knitting machine, and filamentary connections connecting said pattern mechanism to the respective stitch-forming elements of the knitting machine to control the actuation of those elements, a plurality of said filamentary connections being subject to the call of the same single pattern-controlling element and said connection operating means operating progressively, while the knitting machine is forming stitches, those of said plurality of filamentary connections which are selected for the control of stitch-forming elements in any single pass of the yarn guide.

9. In a knitting machine, the combination of a stationary cylindrical bank of needles, cam cylinder means turning about the needle bank and provided with a stitch cam and a needle-raising cam, a yarn guide turning about the same axis, synchronously with the cam cylinder means, to furnish yarn to the needles actuated by said cams, levers mounted on a stationary support and extending radially to the needle bank axis, said levers being slidable radially of the needle bank axis to and from a position underneath respective needles and in the path of the raising cam, whereby the passing raising cam engages the levers and thereby raises the respective needles, and a pattern mechanism controlling the interposition of the levers between the respective needles and the raising cam, exercising its control on the levers successively in advance of the raising cam.

10. In a circular knitting machine, the combination of a circular bed for stitch-forming elements, a cam revolving about the axis of said bed to actuate the stitch-forming elements therein, levers pivoted outside said bed and interposable into the path of said cam by movement in a direction at an angle to the path of the cam to complete operative connections between said cam and stitch-forming elements, means to so move the levers, and mechanism, including a pattern, controlling progressively, while said cam is repeatedly revolving around the machine axis and during individual revolutions of the cam and in advance of the cam, the placement of the levers in the path of the cam.

11. In a circular knitting machine, the combination of a circular bed for stitch-forming elements, a cam revolving about the axis of said bed to actuate the stitch-forming elements therein, levers pivoted outside said bed and slidable substantially longitudinally in the path of the cam and in a direction substantially at right angles to the element-actuating force of the cam which the levers transmit, to provide operative connections between said cam and said stitch-forming

elements, means to so slide said levers, and mechanism including a pattern, controlling progressively, while said cam is making repeated revolutions around the machine axis and during individual revolutions of the cam and in advance of the cam, the longitudinal placement of the levers with respect to the path of the cam.

12. In a knitting machine, a slotted bed, movable elements carried in slots of said bed and respectively including stitch-forming elements, cams to project and retract said elements, movable members carried outside said bed and normally interposed between said elements and one of said cams so that said cam may actuate the respective elements, and a pattern controller governing the release of said members from such interposition and thereby governing the action of said elements.

13. In a circular knitting machine, the combination of a circular bed for stitch-forming elements, a cam revolving about the axis of said bed to actuate stitch-forming elements to substantially the limit of their movements in one direction, levers pivoted outside said bed and individually related to stitch-forming elements in said bed and actuable by said cam to actuate said stitch-forming elements, and mechanism, including a pattern, controlling progressively, while said cam is making repeated revolutions in one direction around the machine axis and during individual revolutions of the cam and in advance of the cam, the operative correlation between the respective levers and said cam, whereby selective actuation of said stitch-forming elements, under the control of said pattern, is obtained.

14. In a circular knitting machine, the combination of a circular bed for stitch-forming elements, a cam revolving about the axis of said bed to actuate stitch-forming elements to substantially the limit of their movements in one direction, levers pivoted outside said bed and individually related to stitch-forming elements in said bed and actuable by said cam to actuate said stitch-forming elements, a plurality of mechanisms, individually allocated to said levers respectively for selectively relating said levers to said cam for actuation thereby, and a pattern mechanism actuating said mechanisms progressively while said cam is making repeated complete revolutions around the machine axis in one direction and during individual revolutions of the cam and in advance of the cam.

15. In a circular knitting machine, the combination of a circular bed for stitch-forming elements, a cam revolving about the axis of said bed to actuate stitch-forming elements therein, a plurality of levers extending generally away from said bed, and lying in the path of said cam for actuation by the latter in a direction around their fulcrums to actuate said stitch-forming elements, and individually slidable substantially longitudinally of themselves into and out of position with respect to stitch-forming elements in said bed to actuate the latter under the force exerted by said cam, and mechanism, including a pattern, controlling progressively, while said cam is making repeated revolutions around the machine axis in one direction and during individual revolutions of the cam and in advance of the cam, the longitudinal placement of the individual levers, whereby said stitch-forming elements are actuated selectively under the control of said pattern.

16. The subject matter of claim 14, characterized by the fact that said pattern mechanism includes a pattern and means additional to the

pattern for actuating said plurality of mechanisms as called by the pattern.

17. The subject matter of claim 15 characterized by the fact that said mechanism which includes the pattern also includes means additional to said pattern for causing the placement of the levers as called for by the pattern.

18. In a knitting machine, the combination of a bank of needles, stitch and needle raising cams, a yarn guide moving with said cams to supply yarn to the needles successively actuated thereby, members for interposition between the needles and the raising cam through which the raising cam acts to raise the respective needles, means moving with said cams and in advance of the raising cam for moving all said members into interposed positions, and a pattern controller acting to withdraw selected members progressively intermediate the passage of said means and the passage of the raising cam.

19. In a knitting machine, the combination of a bank of needles, a stitch cam and a cam for raising the needles, a yarn guide moving with said cams to supply yarn to the needles actuated thereby, levers for various needles, a lever positioning cam moving with and in advance of the needle raising cam to slide the levers to interpose the same between the raising cam and the needles so that the raising cam may raise the needles, springs tending to retract the respective levers from their interposed positions, latches holding the levers interposed against the pull of said springs, and a pattern controller for withdrawing selected latches to permit their respective levers to be retracted from interposed position by their springs.

20. In a knitting machine for the production of figured fabrics, the combination of a stationary cylindrical bank of needles, cam cylinder means turning about the same and provided with a stitch cam and a cam for raising the needles, a yarn guide turning with the cam cylinder about the needle bank to supply yarn to the needles as the latter are actuated by said cams, a plurality of levers laid radially to the axis of the needle bank, a lever positioning cam also carried by the cam cylinder means to slide the levers radially to interpose the same in and to complete the connections between the raising cam and the needles, said lever positioning cam being located in advance of the said raising cam, springs tending to retract the respective levers from their interposed positions, latches holding the levers interposed against the pull of said springs, a pattern controller located remote from the needle bank, and filamentary connections extending from said controller to the latches through which the pattern controller withdraws selected latches progressively and permits the successive withdrawal of the levers of selected needles intermediate the passage of the lever positioning cam and the passage of the raising cam.

21. In a knitting machine, the combination with a bank of stitch-forming elements, projecting and retracting cams for said elements, members for interposition in the connections between one of the cams and said elements, said members normally tending to assume the interposed positions, and a pattern controller governing the withdrawal of the interposed members from the connections.

22. In a knitting machine for the production of figured fabric, the combination of a stationary cylindrical bank of needles, butts being provided for the needles, cam cylinder means turning about

the needle bank and provided with a stitch cam and a needle raising cam, a yarn guide turning about the needle bank with the cam cylinder to supply yarn to the needles as the latter are actuated by the said cams, a plurality of levers laid radially to the axis of the needle bank, a lever positioning cam also carried by the cam cylinder means and in advance of the raising cam, said positioning cam sliding the levers to positions underneath butts of respective needles whereby the raising cam acting on the levers so located may raise the respective needles, and pattern mechanism to withdraw levers from underneath the said butts progressively and intermediate the passage of the lever positioning cam and the raising cam, in accordance with the figuring desired.

23. In a knitting machine, the combination of a circular bank of stitch-forming elements, revolving projecting and retracting cams for said elements, members for interposition between the elements and one of said cams through which said cam actuates the respective stitch-forming elements, means moving with and in advance of said cam for moving all said members into interposed positions, and a pattern controller acting to withdraw selected members progressively intermediate the passage of said means and the passage of the said one of the cams.

24. In a knitting machine, the combination of a bank of stitch-forming elements and a pattern mechanism acting on the stitch-forming elements by groups of a small number of adjacent elements, the elements of each group being always acted on as a unit and thereby acted on alike.

25. In a knitting machine for the production of figured fabric, the combination of a bank of stitch-forming elements and a pattern mechanism acting on pairs of adjacent elements as units, so that the two elements of each pair are always actuated alike.

26. In a knitting machine, the combination of a plurality of banks of needles, a plurality of yarn guides, and a pattern mechanism so controlling the needles of one bank that yarn must be taken from all of said plurality of yarn guides to complete the formation of a course of the stitches of said bank, cams being arranged to actuate the needles of the other bank in groups, the needles of which are intermixed and the number of groups corresponding to the number of said yarn guides, one group taking yarn from each guide, whereby said other bank of needles completes the formation of only a single course of its stitches while the first bank is forming a course of stitches.

27. In a knitting machine for the production of figured fabric, the combination of a cylinder bank of needles, a bank of dial needles, a plurality of yarn guides, and a pattern mechanism so controlling the cylinder needles that yarn must be taken thereby from all of said plurality of yarn guides to complete the formation of one course of cylinder needle stitches, the dial bank comprising as many groups of needles as there are of said yarn guides, the butts of each group being at a different distance from the center of the dial and the needles of the groups being intermixed, and the dial having as many cams as there are groups of needles, the cams being so angularly related that each group of needles takes yarn from only one of said yarn guides and the dial needles form only one complete row of dial stitches while the cylinder needles are forming one row of cylinder stitches.

28. In a circular knitting machine, a plurality of banks of needles, a plurality of yarn guides

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capable of supplying yarn for all the needles, a pattern mechanism so controlling the knitting on the needles of one of said banks that yarn is taken from each of said plurality of yarn guides to complete the formation of individual courses of the stitches formed on the said bank, and means so controlling the knitting on the needles of the remainder of said needle banks that, in individual courses, stitches of the yarn from one of said plurality of yarn guides are formed on one group, less than the whole, of those needles, and stitches of the yarn from another of said plurality of yarn-guides are formed on another group of those needles, the needles being inter-mixed, whereby, in individual courses, the number of stitches formed on the needles of said remainder of the needle banks is less than the number of the needles in said remainder of the needle banks multiplied by the number of said plurality of yarn guides.

29. In a circular knitting machine having two banks of sliding needles, a plurality of yarn guides, said needle banks and the yarn guides being revolvable, one with respect to the other, around the axis of the machine, a pattern mechanism so controlling the actuation of the needles of one bank that individual rows of the stitches

formed thereon are formed in part from yarn from each of said yarn guides, and means for so sliding the needles of the other needle bank, regularly selectively, that substantially the same number of rows of stitches are formed on the two needle banks and individual rows of the stitches formed on said other bank are formed in part from yarn from each of said yarn guides.

30. In a circular knitting machine, a circular bank of stitch-forming elements, a plurality of yarn guides, the needle bank and yarn guides being revolvable, one with respect to the other, around the machine axis, a stitch-forming-element-actuating cam related to each of said yarn guides, a plurality of levers individually related to the stitch-forming elements to actuate the same under the thrust of said cams, said levers being individually slidable longitudinally to and from positions wherein they can be actuated by different ones of said cams, and a pattern mechanism controlling the longitudinal placement of said levers with respect to the cams, said pattern mechanism making one call on said levers in each revolution of the said group of cams.

ALFRED A. ADLER.
HARRY ALBERTMAN.

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