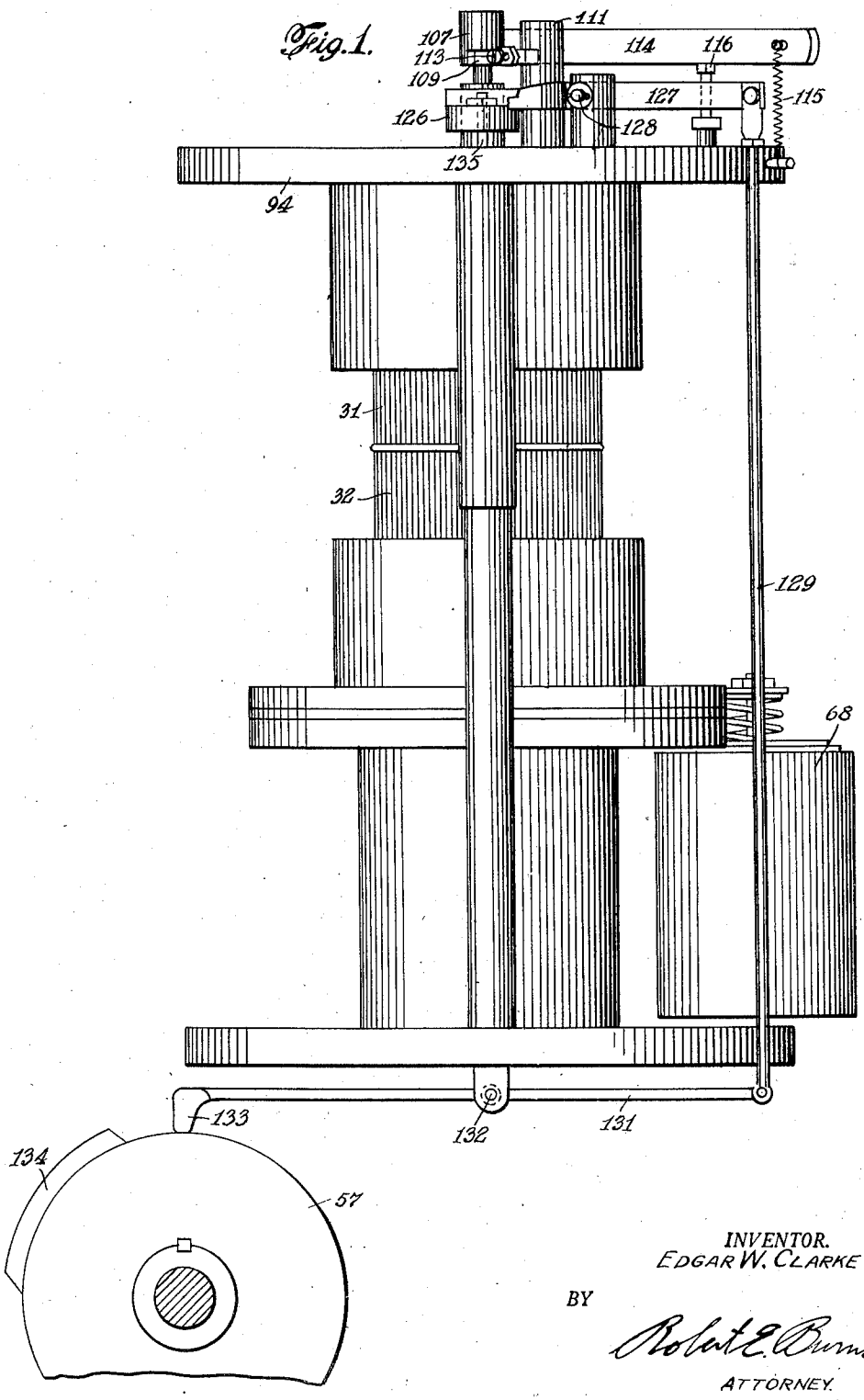
Feb. 10, 1948. E. W. CLARKE 2,435,770

CIRCULAR KNIT HOSIERY

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Fig. 1.



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Fig. 2.

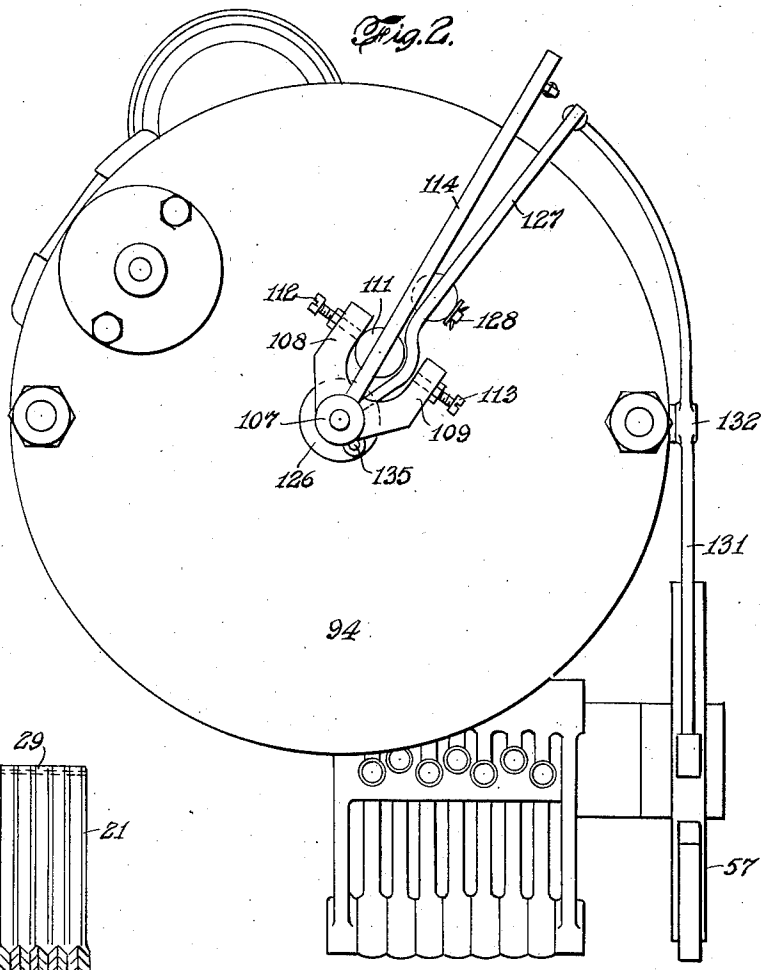


Fig. 3.

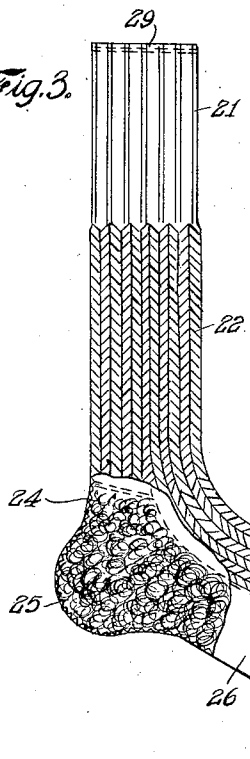
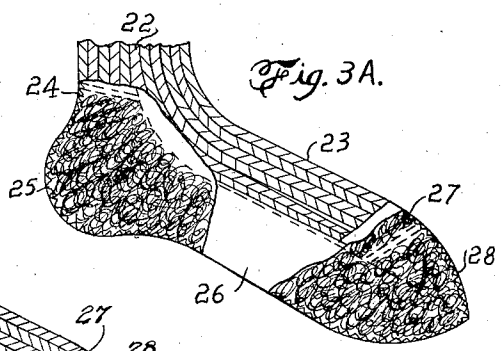


Fig. 3A.



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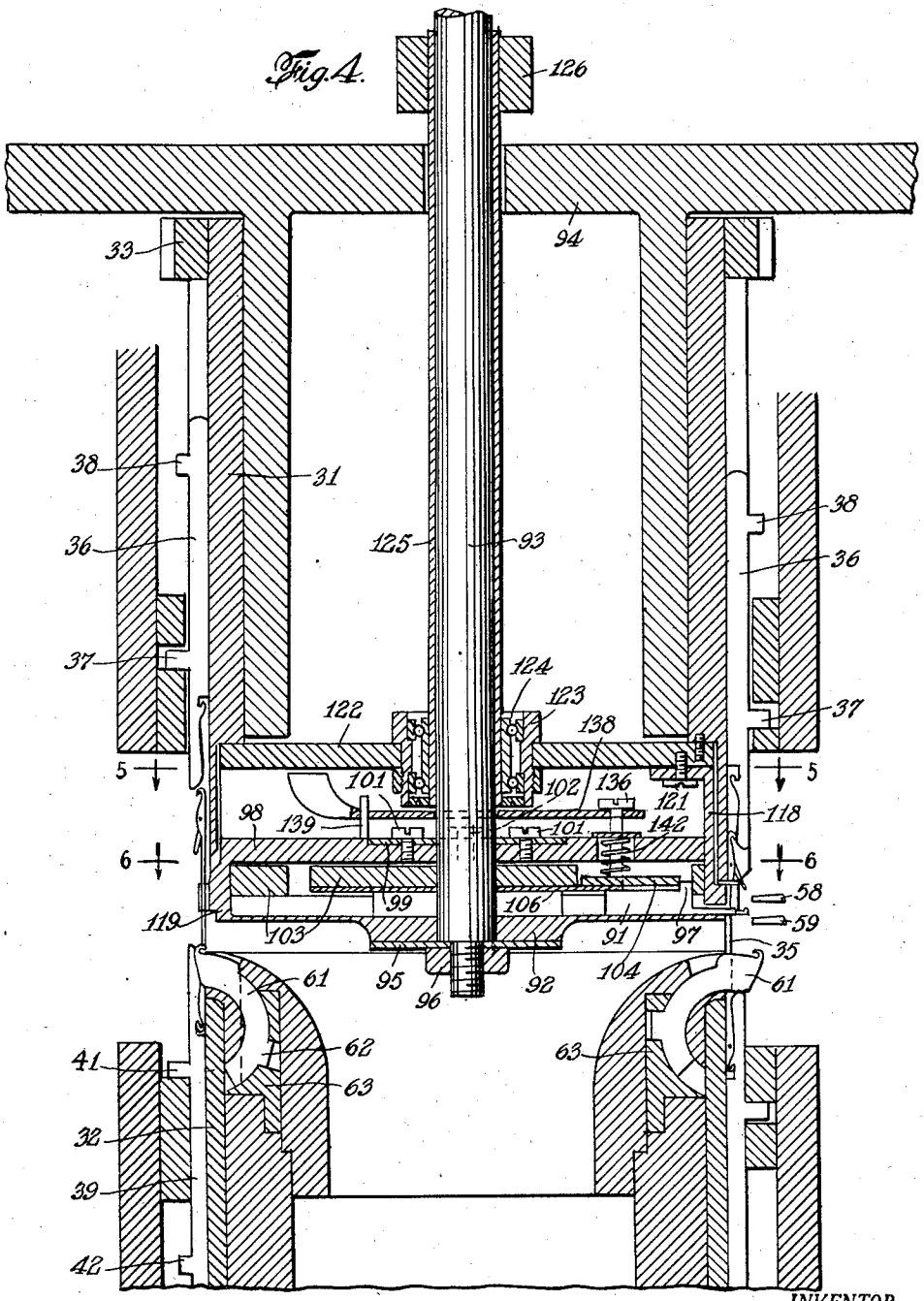
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CIRCULAR KNIT HOSIERY

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Fig. 4.



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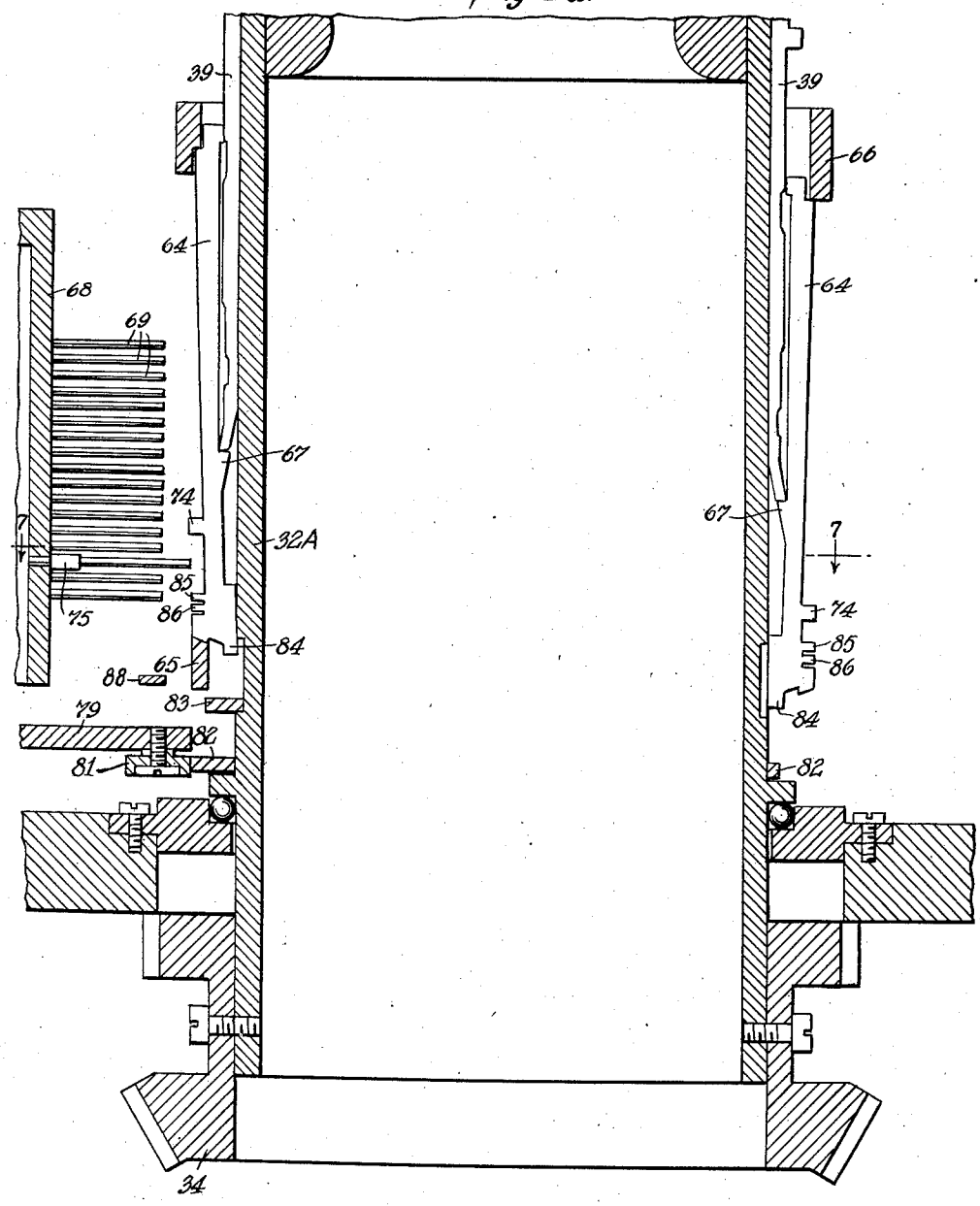
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Fig. 4a.



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Fig.5.

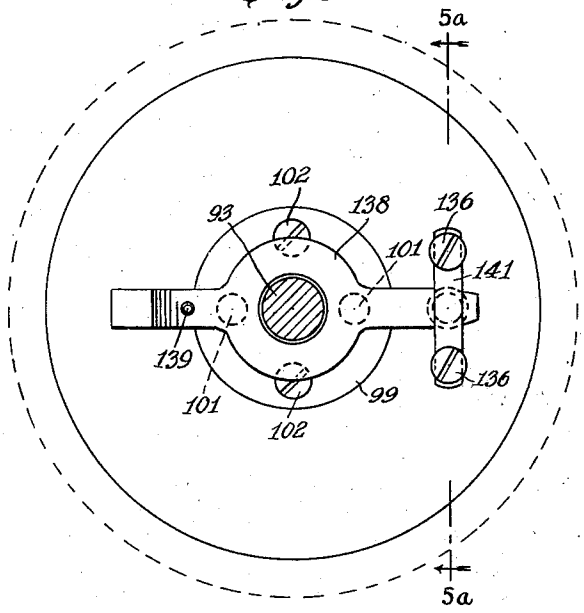


Fig.6.

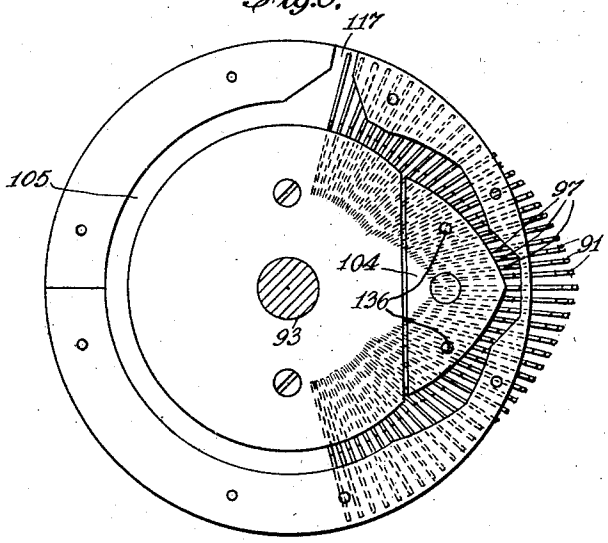
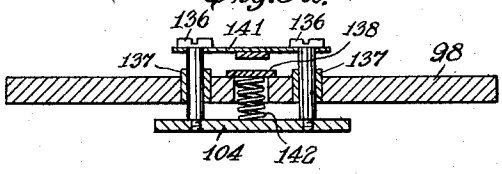


Fig.5a.



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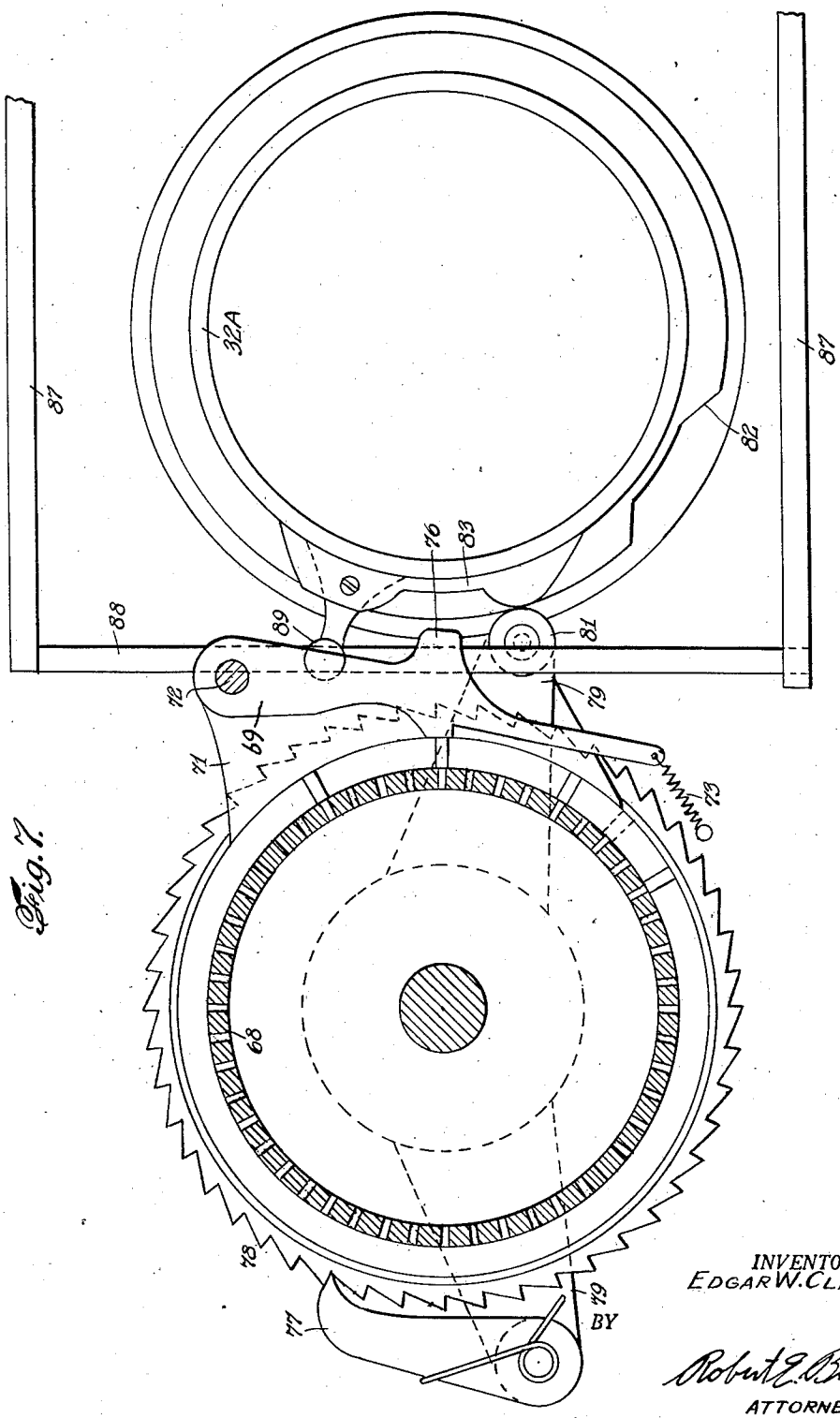


Fig. 7.

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CIRCULAR KNIT HOSIERY

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Fig. 9.

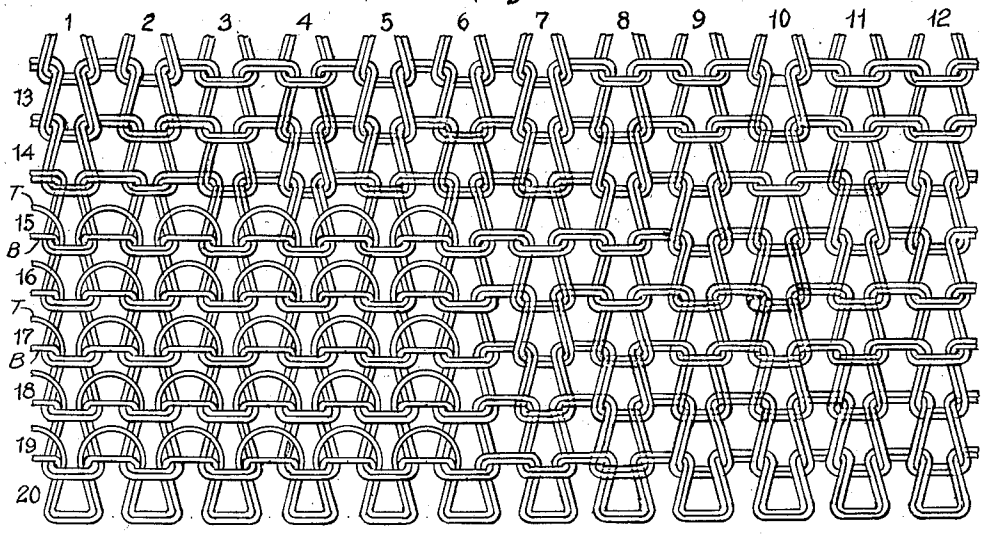
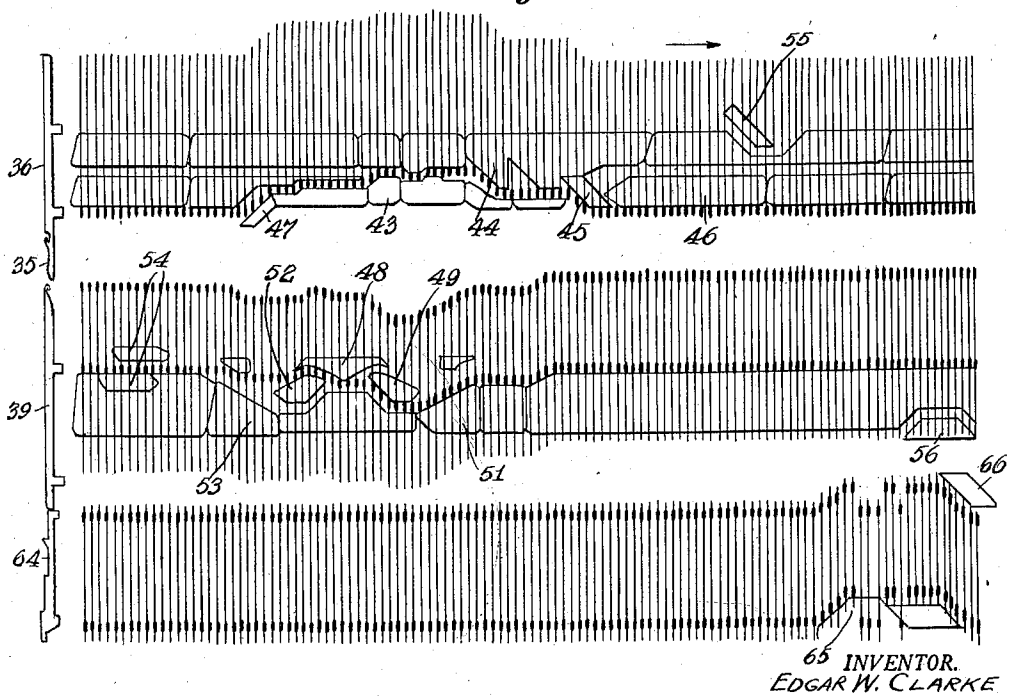


Fig. 8.



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Patented Feb. 10, 1948

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UNITED STATES PATENT OFFICE

2,435,770

CIRCULAR KNIT HOSIERY

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Application July 14, 1945, Serial No. 605,020

14 Claims. (Cl. 66—178)

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The present invention relates to knitted articles composed at least in part of terry fabric and to the knitting of such articles on a circular knitting machine having superposed coaxial needle cylinders and needles operative selectively in either cylinder.

A characteristic feature of terry fabric is that it has long loops of thread, hereinafter referred to as terry loops, which protrude on at least one face of the fabric and provide a soft cushioning effect. It has heretofore been proposed to produce terry fabric on a circular knitting machine by feeding two threads to the needles and drawing longer loops of one thread than of the other. For example, the two threads may be fed to the needles and knitted together but with the sinker loops of one thread longer than the corresponding sinker loops of the other thread so as to form the terry loops of the fabric. The terry loops may or may not be combed or brushed to provide a soft matted fabric surface.

My invention is particularly directed to producing knitted articles, for example articles of hosiery, composed in part of terry fabric and in part of Links-Links fabric. The term Links-Links fabric is herein used to designate a patterned fabric formed of inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected needle wales. In knitting on a coaxial cylinder knitting machine, an outwardly facing stitch—sometimes called a "plain" stitch—is produced by a needle operating in the lower cylinder and is drawn to the outer face of the fabric, while an inwardly facing stitch—sometimes called a "rib" stitch—is produced by a needle operating in the upper cylinder and is drawn to the inner face of the fabric. By transferring selected needles back and forth from one cylinder to the other in predetermined sequence during the knitting operation, a fabric is produced in which the inwardly facing stitches and outwardly facing stitches are arranged in predetermined order both coursewise and walewise to form a design or pattern in the fabric as desired. Such a pattern is herein referred to as a Links-Links pattern and depends for its distinctive appearance on the predetermined arrangement of inwardly facing stitches and outwardly facing stitches.

Terry fabric has heretofore been produced on machines which apart from the complications introduced to form the terry loops were of relatively simple construction. Machines for producing Links-Links fabric, on the contrary, are relatively complex requiring superposed coaxial needle cylinders, needles operable in either cylinder and pattern controlled mechanism for selectively transferring needles from one cylinder to the other during the knitting operation. To enable a single Links-Links pattern drum to control the needle selection, all needles are transferred to one of the cylinders at one point of the needle circle in each revolution of the machine and selected needles are then transferred back to the other cylinder to provide the selection required by the pattern for the particular course of fabric being knitted. As selected needles are thus continually being transferred back and forth between the needle cylinders during the knitting of the Links-Links fabric, accurate alignment of the needle cylinders is essential to avoid needle breakage and the cylinders of a Links-Links machine are spaced close together to facilitate the needle transfer. The close spacing of the needle cylinders and the necessity of avoiding interference with the continual transfer of needles from one cylinder to the other during knitting has prevented performing on a Links-Links machine any operation requiring mechanism or instrumentalities interposed between the needle cylinders. Moreover, the needle selection for producing Links-Links fabric is customarily obtained by means of selectors or jacks having butts at a plurality of different levels making it necessary to extend the needle cylinder to such length that the operation of any mechanism inside the needle cylinder at the level where knitting occurs is rendered difficult. The provision of instrumentalities capable of operating to produce terry fabric concurrently with the operation of the Links-Links mechanism, for example to produce fabric which is Links-Links fabric throughout a portion of its coursewise extent and terry fabric throughout another portion of its coursewise extent, presents a still more difficult problem.

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These difficulties and obstacles are overcome by the present invention which provides for the first time a knitted article, for example an article of hosiery, having both the advantageous characteristics of terry fabric and the desirable appearance and extensibility provided by Links-Links patterning. Moreover, in accordance with my invention there is provided a new article of hosiery having leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected needle wales, and heel, sole and toe portions comprising a plurality of threads knit to form body stitches and terry loops of greater length than

said body stitches. In such an article the leg portion is composed of Links-Links fabric throughout its coursewise extent while the instep portion and sole portion together comprise an integral section composed of Links-Links fabric throughout a portion of its coursewise extent and of terry fabric throughout another portion of its coursewise extent. A high splice portion of terry fabric extending upwardly above the heel can be provided as desired. In a preferred embodiment of my invention the sole and instep portion of the article is knit of a plurality of threads extending continuously around the fabric, the threads being knit to form longer loops of one thread than of another to form terry loops in the sole portion and the same thread being knit in plating relation with loops of substantially the same length in the Links-Links fabric of the instep portion.

My invention further provides a method and apparatus for producing fabric structures of the kind described above, the apparatus being described and claimed in divisional application Serial No. 645,862, filed February 6, 1946. In accordance with my invention a knitting machine having coaxial needle cylinders with needles operable in either cylinder, means for feeding a plurality of threads to the needles and means for operating the needles to receive and knit the threads is provided with pattern controlled mechanism for transferring selected needles from one cylinder to the other during the knitting operation to form inwardly facing stitches and outwardly facing stitches in predetermined sequences in selected needle wales and coordinated mechanism for forming terry fabric. The terry mechanism comprises instrumentalities cooperating with the needles to draw longer loops of one thread, herein referred to as a terry thread, than of another thread which forms the body stitches of the fabric. The operation of the instrumentalities for forming terry loops is coordinated with the operation of the mechanism for producing Links-Links fabric in such manner as to prevent interference between the two. Moreover, the coordination of the Links-Links mechanism and the terry mechanism makes it possible to knit Links-Links fabric on certain needles of the needle circle while concurrently knitting terry fabric on other needles.

In the embodiment herein particularly described, the terry forming instrumentalities are associated with the upper needle cylinder. The upper cylinder is also provided with elements which cooperate with the needles in the upper cylinder to draw inwardly facing stitches of the Links-Links fabric. These elements are herein referred to generically as "verge bits" or a "verge." To prevent interference between the terry forming instrumentalities and the verge bits, the latter are movable vertically and their upward movement is coordinated with the operation of the terry instrumentalities so that the latter instrumentalities are operated only when the verge bits are raised. In order to produce terry fabric for part of a course and Links-Links fabric for another part of the same course, I provide a group of terry instrumentalities extending part way around the needle circle and a series of verge bits of corresponding circumferential extent that can be raised or lowered independently of other verge bits in the needle circle. The actuation of this group of terry instrumentalities is coordinated with the raising and lowering of the verge bits located in the same portion of needle circle so that when the terry instrumentalities are operated, the verge bits in the corresponding portion of the needle circle are raised out of the way while other verge bits in other portions of the needle circle remain down in position to cooperate with upper cylinder needles to form inwardly facing stitches of the fabric. Preferably, the terry instrumentalities are actuated by a cam or other operating element which is moved into and out of operative position by the movement of corresponding verge bits.

Still other features, characteristics and advantages of my invention will appear from the following description and the appended claims in conjunction with the accompanying drawings which show by way of example a knitted article selected to illustrate the invention and a knitting machine selected to illustrate the knitting of such article.

In the drawings,

Fig. 1 is a partial side elevation of a knitting machine for carrying out my invention.

Fig. 2 is a partial plan view of the machine.

Fig. 3 is a conventional illustration of an article of hosiery embodying my invention, portions of the heel, sole and toe being broken away to show internal construction.

Fig. 3*a* is a similar illustration of the foot portion of an article of hosiery having a modified toe band construction, the article being otherwise the same as that of Fig. 3.

Figs. 4 and 4*a* are together a composite vertical sectional view through the needle cylinders of the machine, the upper portion of the machine being shown in Fig. 4 and the lower portion in Fig. 4*a*. Certain parts have for convenience been shown in these views although they are not in the same plane.

Fig. 5 is a transverse section taken on the line 5—5 in Fig. 4.

Fig. 5*a* is a partial vertical section taken on the line 5*a*—5*a* in Fig. 5.

Fig. 6 is a transverse section taken on the line 6—6 in Fig. 4.

Fig. 7 is a horizontal section through the lower needle circle and the Links-Links pattern drum taken approximately on the line 7—7 in Fig. 4*a*.

Fig. 8 is a developed view of the cam blocks of the machine and includes at the left-hand end of the figure a diagrammatic side view of the needles, sliders and jacks.

Fig. 9 is a diagrammatic inside view showing the stitch structure of a representative section of fabric of a knitted article such as that shown in Fig. 3 or 3*a*.

The embodiment of my invention shown by way of example in Figs. 3, 3*a* and 9 is a men's half hose or sock having a top portion **21**, leg portion **22**, instep portion **23**, high splice portion **24**, heel **25**, sole **26**, toe-band **27** and toe **28**. The top portion **21** is provided at its upper edge with a selvage, welt or other antiravel structure **29** and is formed of fabric having suitable extensibility and recoverability to pass over the heel when the sock is being put on and yet fit the leg snugly when being worn. For example, the top can be formed of 1x1 or other rib knit fabric or of fabric having elastic thread incorporated therein. In the particular embodiment illustrated in the drawings, the top portion of the sock is formed of thread knit to form selected groups of consecutive wales of outwardly facing stitches and other wales of inwardly facing stitches to provide vertically extending ribs that are more than one wale in width.

The leg portion **22** and instep portion **23** of the article shown in Fig. 3 are formed by Links-

Links fabric, i. e., fabric in which the thread or yarn is knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected needle wales. Referring for example to Fig. 9 which shows diagrammatically the stitch structure of a small portion of fabric at the junction of the leg portion, the instep portion and the high splice, it will be seen that in wale 7 there are inwardly facing stitches in courses 13 and 14, outwardly facing stitches in courses 15 and 16, inwardly facing stitches in courses 17 and 18, an outwardly facing stitch in course 19 and an outwardly facing stitch in course 20. In wale 8 there is an outwardly facing stitch in course 13, inwardly facing stitches in courses 14 and 15, outwardly facing stitches in courses 16 and 17, inwardly facing stitches in courses 18 and 19 and an outwardly facing stitch in course 20. The inwardly facing stitches and outwardly facing stitches likewise occur in predetermined sequences in selected courses of the fabric. For example, in course 13 there are inwardly facing stitches at wales 1 and 2, outwardly facing stitches at wales 3 and 4, inwardly facing stitches at wales 5, 6 and 7, outwardly facing stitches at wales 8 and 9, an inwardly facing stitch at wale 10, and outwardly facing stitches at wales 11 and 12. The sequence of stitches is different in succeeding courses. However, the Links-Links pattern will ordinarily repeat itself in a predetermined number of courses of the fabric. It will be noted that both walewise and coursewise, the inwardly facing stitches may occur in groups of two or more consecutive stitches drawn to the same face of the fabric as well as singly. The same is true of outwardly facing stitches. The number of different combinations of inwardly facing stitches and outwardly facing stitches that can be used to produce different Links-Links patterns is virtually unlimited.

The high splice portion 24, heel 25, sole 26, at least the lower part of toe-band 27 and toe 28 are formed of terry fabric composed of body thread B and terry thread T (Fig. 9) knit together in such manner as to form loops of terry thread that are longer than the corresponding loops of the body thread stitches so as to project on a face of the fabric in the form of terry loops. As illustrated in the lower left-hand portion of Fig. 9, all the stitches of the terry fabric are drawn to the same face of the fabric, being shown as outwardly facing stitches. The body thread B and terry thread T are knitted together, preferably in plated relation with the needle loops of the two threads substantially coextensive. However, the sinker loops of terry thread T are substantially longer than the sinker loops of the body thread B—preferably at least twice as long—and form terry loops on the inner face of the fabric. It will be seen that the terry loops occur at successive wales in successive courses to provide a soft cushion fabric. The terry thread T can, if desired, be an extra or splice thread extending across only the terry portions of the fabric. However, it is shown as a continuous thread extending all the way around the fabric. In the Links-Links portion of the fabric forming the instep 23, the two threads B and T are knit together preferably in plated relation with loops of substantially the same length, while in the terry fabric forming the sole the threads are knit with loops of different lengths to provide terry loops as described above. Thus the threads B and T both extend continuously throughout the coursewise extent of the fabric so that there are no loose ends. The leg portion 22 is also preferably knit of the same thread as the instep portion 23 and sole 26.

As illustrated in Figs. 3 and 9, the leg portion 22 of the article is formed of Links-Links fabric throughout its circumferential or coursewise extent. It will be understood that the Links-Links pattern may be an "all over" pattern or may be confined to selected areas such as the sides of the sock so that the stitches in considerable areas are drawn to the same face of the fabric. However, regardless of the particular pattern used, the fabric of the leg portion of the sock is considered as being Links-Links fabric throughout its circumferential extent.

Following the leg portion there is an integral tubular seamless section composed of Links-Links fabric throughout a portion of its circumferential extent to form the instep portion 23 and composed of terry fabric throughout another portion of its circumferential extent to form the high splice portion 24 and sole portion 26. Each of the individual courses of this section is formed partly as terry fabric and partly as Links-Links fabric. Referring to Fig. 9 it will be seen, for example that each of courses 16 to 20 is knit to form terry loops in wales 1 to 5 and is knit to form Links-Links fabric in wales 6 to 12. It will be understood that Fig. 9 shows only a very small section of the fabric and that both the terry portions and Links-Links portions of the fabric are much more extensive than shown in this figure. The toe-band 27 is knit as a further integral section of tubular seamless fabric which may be formed of terry fabric through its circumferential or coursewise extent as illustrated in Fig. 3*a*. Alternatively, the fabric of the toe band may have terry loops on the lower side only as illustrated in Fig. 3, the upper portion being knit as non-terry, for example plain knit, fabric. The heel pocket 25 and toe pocket 28 are formed of partial courses knit by reciprocation of the machine and are composed of terry fabric throughout.

It will be understood that the Links-Links pattern shown in Figs. 3, 3*a* and 9 is for the purpose of illustration only and that an infinite number of different patterns can be produced by varying the selection of needles transferred from one cylinder to another during the knitting of the fabric.

In Figs. 1, 2 and 4 to 8 there is shown so much of a knitting machine as is necessary to illustrate my invention. The invention is shown by way of example embodied in a coaxial knitting machine of the general type manufactured by Wildt & Co. Ltd., of Leicester, England, and certain standard parts which are not necessary to an understanding of the invention have been omitted for the sake of clearness.

The machine illustrated in the drawings has an upper needle cylinder 31 and a lower needle cylinder 32 (Figs. 4 and 4*a*). The lower cylinder is substantially longer than the upper cylinder, being provided with a downward extension 32A of greater outside diameter than the upper portion of the cylinder. The upper and lower cylinders are rotated in synchronism with one another, for example by suitable gears 33 and 34, and have aligned grooves or tricks in their peripheries. A circular series of needles 35 having a hook and latch at each end are operable in either cylinder and transferrable from one cylinder to the other. When in the upper cylinder the needles are operated by sliders 36 having knit-

ting butts 37 and transfer butts 38. When in the lower cylinder the needles are operated by sliders 39 having knitting butts 41 and transfer butts 42.

Cams for operating the needles by engagement with the slider butts are shown by way of example in Fig. 8 where the direction of movement of the needles and sliders relative to the cams, when the machine is operated by continuous rotation, is from left to right as indicated by the arrow. The cams for operating needles in the upper cylinder comprise a stitch cam 43 and a clearing cam 44. There are also provided a welt cam 45 which is withdrawn to allow the knitting butts of the sliders to pass through an idle track 46 so that the upper cylinder needles will hold their stitches without knitting during the knitting of welt courses on the lower cylinder needles and a switch cam 47 operable in conjunction with lower cylinder switch cams to render the needles on the instep side of the cylinder inactive during the knitting of the heel and toe.

Cams for operating needles in the lower cylinder include a center cam 48, stitch cam 49 and clearing cam 51. When the cylinder is rotated in the opposite direction as when it is oscillated during the knitting of the heel and toe, the needles are actuated by a stitch cam 52 and clearing cam 53. The lower cam block is also provided with vertically movable switch cams 54 which cooperate with the switch cam 47 of the upper cylinder cam block to render needles on the instep side of the needle cylinder inactive during the knitting of the heel and toe.

The transfer of needles from one cylinder to the other is effected by an upper transfer cam 55 (Fig. 8) acting on the transfer butts of the upper cylinder sliders 36 to transfer needles from the upper to the lower cylinder, and by a lower transfer cam 56 acting on the transfer butts of the lower cylinder sliders to transfer needles from the lower to the upper cylinder. The lower transfer cam is so positioned that the transfer butts of the lower cylinder sliders normally pass beneath it unless the sliders have been raised or conditioned by the selecting mechanism hereinafter described which controls the transfer of needles during the knitting operation to produce Links-Links fabric. Hence the cam 56 transfers to the upper cylinder only those needles that have been selected by the selecting mechanism. It will be noted that the upper transfer cam 55 is located ahead of the lower transfer cam 56 so that needles transferred to the lower cylinder by the upper transfer cam may be transferred back to the upper cylinder by the lower transfer cam 56.

The movable cams such as the transfer cams, welt cam and switch cams are operable by suitable mechanism under the control of the main pattern drum 57 (Fig. 1) which is intermittently racked around during the knitting of the article being produced by the machine. As the control of such cams is well known in the art, it will be readily understood without further description.

Adjacent the point at which the needles are actuated to draw stitches, there is provided a feeding station for feeding thread to the needles. The feeding station includes means for feeding the body thread B and terry thread T in spaced relation so that instrumentalities which cooperate with the needles to form terry loops can come between the two threads and separate them. In Fig. 4 a feed finger for the terry thread is indicated schematically at 58 and a feed finger for the body thread at 59. It will be understood that additional feed fingers may be provided at the feeding station and that the feed fingers can be moved into and out of feeding position, for example under control of the main pattern drum.

The lower cylinder is provided with a series of sinkers 61 or equivalent instrumentalities disposed between successive needles and cooperating with needles in the lower cylinder to form stitches. The sinkers are shown as having butts 62 which are acted on by sinker cams 63 to move the sinkers between an inner position as illustrated at the left-hand side of Fig. 4 and an outer position as shown at the right-hand side of the same figure.

Mechanism for controlling the selective transfer of needles from one cylinder to the other to produce a Links-Links pattern is associated with the lower needle cylinder in the embodiment of my invention illustrated in the drawings. The selection is effected by putting the upper transfer cam 55 (Fig. 8) into operation to transfer all upper cylinder needles to the lower cylinder each revolution of the machine and then transferring selected needles from the lower cylinder to the upper cylinder to provide the particular selection required for the course being knitted. The selecting mechanism comprises a series of selectors or jacks 64 associated with the lower cylinder sliders and means for selectively actuating the jacks to raise the sliders of selected needles sufficiently for the transfer butt of the slider to engage the lower transfer cam 56 by which the slider is further elevated to transfer the associated needle to the upper cylinder. The jacks 64 are slidable in grooves or tricks provided in the enlarged extension 32A of the lower cylinder 32 and partially overlie the sliders 39 as clearly shown in Fig. 4*a*. The jacks are movable vertically by suitable cams which are illustrated as a cam 65 (Figs. 4*a* and 8) for moving the jacks upwardly and a cam 66 for moving them down. The jacks are also capable of limited movement radially of the cylinder, the movement being more or less pivotal about the upper end of the jack. A shoulder 67 provided on the inner edge of the jack is adapted to engage the lower end of the corresponding slider 39 when the jack is in its inner position so that the slider is raised by the jack when the latter is moved upwardly by the cam 65. This lifts the slider high enough so that the transfer butt engages the lower transfer cam 56 (Fig. 8) to complete the transfer of the corresponding needle to the upper cylinder. When a jack is in its outer position, the shoulder 67 does not engage the slider and the slider is hence not lifted by the jack. The corresponding needle accordingly remains in the lower cylinder. The selective distribution of the needles between the upper and the lower cylinders during successive revolutions of the needle cylinders thus depends upon the actuation of the jacks 64.

The operation of the selectors or jacks 64 is controlled by a pattern drum 68 (Figs. 4*a* and 7) acting through presser levers 69 pivotally mounted one above the other in a suitable grid 71. The pivotal axis of the levers is indicated at 72. A spring 73 acting on each lever tends to swing it toward the pattern drum 68. The jacks 64 are provided with butts 74 at levels corresponding to the levels of the presser levers 69, each jack that is to be actuated being provided with a butt at one or more levels. The pattern drum 68 is provided with projecting pins 75 removably carried in selected ones of suitable

holes in the periphery of the drum and adapted to engage presser levers 69 to swing selected ones of the levers toward the needle cylinder. In Fig. 4a the third presser lever from the bottom of the series is shown in the position to which it is moved by a pin 75, the remaining levers being shown retracted. When a presser lever is pressed inwardly, a cam surface 76 on the lever engages all the jacks that have butts 74 at the same level as the lever to press the jacks inwardly into engagement with the corresponding slider 39. The jacks are then raised by cam 65 to initiate the transfer of the corresponding needles to the upper cylinder as described above. The jack shown at the left-hand side of Fig. 4a is in the position it would occupy after being pressed in by the third presser lever from the bottom and subsequently raised by the cam 65.

Means is provided for intermittently rotating or racking the Links-Links pattern drum 68 during the knitting operation. The racking mechanism is illustrated in the drawings as a pawl 77 engaging a ratchet 78 on the pattern drum and carried by an arm 79 which is swingable about an axis concentric with the drum. The other end of arm 79 carries a roller 81 engaging a cam 82 that is rotatable with the needle cylinder and actuates the arm to rack the pattern drum one step forward each revolution of the needle cylinder. As the pattern drum is racked, different ones of the pins 75 come into engagement with the presser levers 69 disposed at corresponding levels to actuate selected ones of the jacks 64 and thereby initiate the transfer of selected needles to the upper cylinder. By selecting the location of the pins 75 on the pattern drum 68 and the position of the butts 74 on the jacks 64, an infinite number of different Links-Links patterns can be produced.

Additional control of the actuation of the jacks 64 is provided by a neutralizing cam 83 (Figs. 4a and 7) acting on the tails 84 of the jacks and by cams acting on additional jack butts 85 and 86. Thus the jacks may be provided with tails of different lengths and the neutralizing cam 83 may be raised or lowered to engage all or certain of the jacks and move them back out to their outer position after they have been pressed inwardly by presser levers 69 but before they engage the "up" cam 65. For example the jacks on the sole side of the needle cylinder may be provided with long tails so that during the knitting of the instep and sole portions of an article such as that shown in Fig. 3, the action of the Links-Links pattern drum on the needles knitting the sole can be "neutralized" so that all of the needles on the sole side of the cylinder remain in the lower cylinder. Butts 85 and 86 are adapted to be engaged by movable cams acting on the jacks after they have been neutralized by the neutralizing cam 83 but before they are raised by the "up" cam 65. These butts are utilized when the same needle selection is desired for a number of successive courses. For example butts 85 may be provided on alternate jacks only to obtain a 1x1 selection for producing a selvage or a welt while butts 86 may be used for obtaining a 2x2 or other selection for producing vertical ribs in the top portion of a sock.

The neutralizing cam 83 is movable vertically under control of the main pattern drum acting through suitable linkage including arms 87, crossbar 88 and posts 89 (Fig. 7) so as to engage all, some or none of the jacks as desired. Cams for engaging jack butts 85 and 86 are likewise movable into and out of operative position under control of the main pattern drum, as will be readily understood.

The knitting machine in accordance with my invention is also provided with instrumentalities cooperating with the needles to form terry loops and operable concurrently with the mechanism described above for selectively transferring needles from one cylinder to another during the knitting operation to produce Links-Links fabric. In the embodiment illustrated in the drawings the terry instrumentalities are associated with the upper needle cylinder and cooperate with needles in the lower cylinder and with lower cylinder sinkers to form longer loops of one thread than of another. The terry instrumentalities are shown in the drawings (Figs. 4 and 6) in the form of a series of bits 91 which are located directly above the sinkers 61 so as to project out between successive needles when the needles are in position to receive thread fed at the feeding station. The relation of the bits to the thread feeds is such that the bits project between the terry thread T and the body thread B so that the terry thread is above the bits while the body thread is below the bits and between the bits and the sinkers. The needles operating in the lower cylinder are raised high enough to receive both threads. When the needles are drawn down by the stitch cam, loops of body thread are drawn over the sinkers to form the body stitches of the fabric while longer loops of the terry thread are drawn over the bits 91. The needle loops of the body thread B and the terry thread T are thus drawn in plating relation while the sinker loops are drawn separately with the sinker loops of the terry thread much longer than the sinker loops of the body thread because of the location of the terry bits 91 above the sinkers 61. The lengths of the terry loops can be adjusted by varying the distance between the terry bits and the sinkers. Preferably the terry loops are at least twice as long as the corresponding loops of body thread.

In the embodiment of my invention shown in the drawings, the terry bits 91 are moved cyclically between an inner retracted position and an outer position in which the bits project out beyond the needle circle to separate the terry thread and the body thread as described above. The bits are moved out as they reach or approach the thread feeding station and are retracted to release the terry loops after stitches of the body thread and terry thread have been drawn by the needles. While the bits 91 or equivalent instrumentalities may be supported in any desired manner, they are shown as being carried by a dial 92 located inside the needle circle adjacent the lower end of the upper cylinder and hence about the upper end of the lower cylinder. The dial is rotatably supported at the lower end of a shaft or spindle 93 which extends out through the top plate 94 of the machine and is concentric with the needle cylinder. A bearing plate 95 and nut 96 retains the dial on the shaft. The dial 92 is rotatable with the needle cylinder and is provided with radial grooves in which the bits 91 are slidable. The path traveled by the bits as the dial rotates is illustrated in Fig. 6, which shows the dial in plan. Terry bits may, if desired, be provided all the way around the dial. However, if it is desired to knit terry fabric only in the heel, sole and toe portions of a sock, the bits need be provided only on one side of the dial corresponding to the sole side of the needle cylinders.

The means for cyclically projecting and re-

tracting the terry bits 91 is shown by way of example in the drawings as cam surfaces engaging butts 97 provided on the terry bits 91. A cam plate 98 is secured to a flange 99 of the spindle 93 by means of a plurality of screws or bolts 101 and 102. On the lower surface of the cam plate there are mounted stationary cams 103 and a vertically movable cam section 104 which together form a cam track 105 (Fig. 6) the shape of which controls the inward and outward movement of the terry bits as the dial 92 rotates relative to the cam plate 98. A thin disc 106 interposed between the cam plate and the dial assists in retaining the bits 91 properly seated in the grooves of the dial.

The cam plate 98 is positioned in predetermined angular relationship with respect to the thread feeding station of the machine to project and retract the bits at the proper time to insure preparation of the body and terry threads and the formation of terry loops. When the cylinders are turned alternately in opposite directions as when knitting the heel and toe, the position at which the bits are projected is preferably shifted upon each reversal of the direction of rotation to assure proper operation. In the arrangement shown in the drawings this is accomplished quite simply by oscillating the cam plate 98. At its upper end, and above the top plate 94 of the machine, the spindle 93 is provided with a fitting 107 having angularly spaced arms 108, 109 which straddle a post 111 projecting up from the top plate 94 (Figs. 1 and 2). The angular spacing between the arms 108, 109 permits the spindle 93 and hence the cam plate 98 to oscillate through a predetermined angle which is preferably adjustable by means of abutment screws 112, 113. As the dial 92 is oscillated in synchronism with the needle cylinders the frictional drag between the dial, the bearing plate 95 and the cams causes the shaft 93 and cam plate 98 to oscillate within the limits determined by the arms 108 and 109, thereby properly positioning the cams for each direction of rotation.

The vertical position of the dial 92 is adjustable by vertical movement of the spindle 93. The fitting 107 at the upper end of the spindle 93 engages the inner end of a lever 114 (Figs. 1 and 2) which is pivoted on the post 111. A tension spring 115 pulls downwardly on the outer end of the lever 114 thereby tending to lift the spindle 93. The downward movement of the outer end of lever 114 is limited by an adjustable stop 116 (Fig. 1). By adjustment of the stop 116, the height of the bit dial and hence the length of terry loops formed by the bits can be readily adjusted. It will be noted that the spring 115 acting through the lever 114 and spindle 93 provides a resilient support for the dial so that the dial will not be damaged in the event the dial is adjusted too high or the upper needle cylinder is adjusted too low.

In order to be able to knit non-terry fabric all around the cylinder as, for example, in knitting the leg portion of a sock, provision is made for rendering the terry bits 91 inoperative. In the arrangement shown by way of example in the drawings this is done by raising the movable cam section 104 (Figs. 4 and 6) out of engagement with the butts 97 of the terry bits so that the bits are not projected. If it is desired separately to control different groups of terry bits, the bits may be provided with butts of different lengths. For example the bits on one side of the dial may be provided with longer butts than the bits on the other side. By vertical movement of the movable cam section 104, one or more groups of bits may be put into operation or rendered inoperative as desired.

The angular position of the cam plate 98 and the shape cam track 105 which governs the actuation of the terry bits may be utilized to control accurate plating of the body thread and terry thread during knitting. As the hook of the needle engages the terry thread first and draws a partial loop over the bits 91 before engaging the body thread, the position of the threads in the hooks of the needles and hence the plating of the threads may be controlled by properly timed inward or outward movement of the terry bits. To facilitate servicing the machines, a gate 117 (Fig. 6) is provided through which the terry bits may be inserted or removed without dismantling the machine.

When selected needles are operated in the upper cylinder, as occurs in knitting Links-Links fabric, there must be provided a series of verge bits which serve the same purpose as the sinkers in the lower cylinder to engage the previously drawn stitches and cause them to be cast off when new stitches are drawn by the needle. The lower edges of the fins or walls between the needle grooves of the upper cylinder ordinarily serve this function, the lower end portion of the upper cylinder commonly being referred to as a "verge." The verge has heretofore been integral with the cylinder or has been in the form of a separate ring secured to the lower end of the cylinder and having needle grooves aligned with the needle grooves of the cylinder. As the terry bits 91 preferably project at a level above the lower edge of the verge in order to form long terry loops, the problem arises as to how to prevent interference between the bits and the verge. The problem is complicated by the fact that during the knitting of the tubular seamless section forming the sole and instep portions of a sock such as that shown in Fig. 3, the terry bits must be in operation on one side of the needle cylinders to form the terry fabric of the sole while the verge must be in operative position on the other side of the cylinder to knit the Links-Links fabric of the instep portion.

In the embodiment of the invention shown in the drawings, this problem is solved by splitting the verge into two sections 118 and 119 and providing means for raising one section independently of another so that the verge section 118 corresponding in circumferential extent to the group of terry bits on the sole side of the needle cylinder can be raised up out of the way of these bits while the verge section 119 on the instep side of the cylinder remains at proper level to cooperate with the needles in producing Links-Links fabric. As shown in Fig. 4 the verge section 118 is carried by the upper needle cylinder, being secured by suitable screws 121 to a bearing plate 122 by which the upper cylinder is supported. The bearing plate 122 is carried by the outer race 123 of an anti-friction bearing 124 of which the inner race is fixed to a hollow shaft or sleeve 125 that surrounds the spindle 93 and extends up through the top plate 194 of the machine. The upper end of the sleeve 125 is provided with a collar or fitting 126 that engages the inner end of a lever 127 which is pivotally supported at 128 by a post projecting up from the top plate 94 (Fig. 1). The outer end of the lever 127 is connected by a link or riser 129 with

one end of a rocker arm 131 which is pivoted at 132 and is provided at the other end with a cam follower 133 adapted to engage a cam 134 on the main pattern drum 57. When the cam follower 133 rides up on cam 134, the upper needle cylinder is lifted and the verge section 118 which is carried by the upper cylinder is raised up out of the way of the bits 91 so that the latter can be operated to produce terry fabric, for example in the sole portion of a sock. During the knitting of the top portion and the leg portion of a sock where there is no terry, the upper needle cylinder and associated verge section 118 are lowered so that the two sections of the verge are at the same level thereby providing a properly positioned knocking-over edge for the upper cylinder needles knitting the vertical rib fabric of the top or the Links-Links fabric of the leg portion. An adjusting screw 135 (Fig. 1) extending through the collar 126 and adapted to engage the top plate 94 adjustably determines the lower position of the upper cylinder.

The other verge section 119 (Fig. 4) is carried by the bit dial 92 and normally remains at a constant level. As the ends of the verge section 119 carried by the dial abut the ends of the verge section 118 carried by the upper needle cylinder, the bit dial 92 is caused to rotate with the upper needle cylinder and the needle grooves of the verge section 119 are maintained in proper alignment with corresponding needle grooves of the upper and lower cylinders. The split verge in accordance with my invention thus forms a simple and effective means for driving the bit dial 92 in synchronism with the needle cylinders.

In accordance with my invention, the operation of the dial bit 91 is coordinated with the raising and lowering of the verge so that the bits are in operation only when the verge section corresponding in circumferential extent to the group of bits is raised up out of the way. In the embodiment of my invention shown in the drawings mechanism for raising and lowering the movable bit cam section 104 (Fig. 4) to put the bits into and out of operation is actuated by vertical movement of the upper needle cylinder and hence by the vertical movement of the verge section 118. As illustrated in Figs. 4, 5 and 5a, the movable cam section 104 is carried by two posts or pins 136 which extend up through bearing sleeves or holes 137 in the cam plate 98. A lever 138 for raising the cam section 104 straddles the spindle 93 and rests loosely on the heads of the diametrically opposite bolts 102 which provide a fulcrum for the lever to rock about a horizontal axis. A pin 139 projecting upwardly from the cam plate 98 through a hole in the lever 138 serves to locate the lever without interfering with its rocking movement. One end of the lever 138 lies under a crossbar 141 that extends across between the two pins 136 and is retained by the heads of the pins. The other end of the lever 138 projects upwardly and is adapted to engage the lower side of the bearing plate 122 of the upper needle cylinder. The upwardly projecting end is preferably hardened or provided with a roller to reduce friction and wear. A spring 142 acts between the movable cam section 104 and the cam plate 98 to press the cam section downwardly.

When the upper needle cylinder is lowered so that the verge section 118 is in its lower or operative position, the bearing plate 122 presses down on the left-hand end of the lever 138 as viewed in Fig. 4 and lifts the right-hand end of the lever thereby raising the movable cam section 104 and

rendering the bits 91 inactive. Interference between the bits and verge which would otherwise result in breakage of the bits is thereby positively prevented. When the verge section 118 is raised by moving the upper needle cylinder upwardly, the upward movement of the bearing plate 122 permits the movable cam section 104 to be lowered by spring 142 to operative position in which it engages the butts of the terry bits. It will thus be seen that the terry bits on the sole side of the needle cylinder can be put into operation only when the corresponding verge section 118 is raised.

An important feature of my invention from the point of view of construction and maintenance of the machine is that the dial 92, bits 91, cam plate 98 with its associated cams and the complete operating mechanism for the movable cam section 104 are all assembled as a unit on the spindle 93 and can be removed from the machine without disturbing the relation of the parts.

The operation of the machine will be more fully understood from the following description of the steps in making an article of hosiery such as those shown in Figs. 3 and 3a. The socks are preferably produced by string work with a number of ravel courses or a draw thread between successive socks in the string. To produce the welt or anti-ravel edge 29 alternate needles are transferred to the upper cylinder and at least one course of 1x1 rib is knit. The welt cam 45 (Fig. 8) is withdrawn to render the upper cylinder needles inoperative while a plurality of welt courses are knit on lower cylinder needles only. Thereupon the welt cam again goes in to close the welt. The 1x1 rib knitting may be continued to form the top portion 21 of the sock. However, if a broad rib top is desired, the needle selection is changed, for example by means of jack butts 86 (Fig. 4a), to position groups of needles in the lower cylinder and intervening needles or groups of needles in the upper cylinder.

Upon completion of the top portion 21 (Fig. 3), any cams acting on jack butts 85 or 86 (Fig. 4a) are withdrawn and the neutralizing cam 83, which has heretofore been raised to neutralize the jacks, is lowered to the position shown in Fig. 4a so that the Links-Links pattern drum becomes effective. During the knitting of the leg portion 22 all upper cylinder needles are transferred to the lower cylinder each revolution of the machine by the upper transfer cam 55 (Fig. 8) and selected needles are transferred back to the upper cylinder under control of the Links-Links pattern mechanism to provide the needle selection required for the course being knitted to produce the Links-Links pattern desired. It will be understood that during this phase of the knitting operation, selected needles throughout the circumference of the needle cylinder are subject to the control of the Links-Links pattern drum.

When the high splice portion 24 (Fig. 3) is reached, the neutralizing cam 83 (Fig. 4a) is raised sufficiently to engage the long tail jacks, i. e., all the jacks on the sole side of the needle cylinders so that the corresponding needles are all retained in the lower cylinder to produce the outwardly facing stitches of the terry fabric of the high splice. At approximately the same time the upper needle cylinder 31 is raised by the cam 134 acting through the linkage shown in Figs. 1 and 4. The upward movement of the upper needle cylinder raises the verge section 118 (Fig. 4) out of the way of the terry bits on the sole

side of the needle cylinder and simultaneously lowers the movable bit cam section 104 into operative position to engage the butts of the terry bits. The terry bits are thereby cyclically projected during rotation of the needle cylinder and cooperate with the needles to form the terry fabric of the high splice portion of the sock. The needles on the instep side of the needle cylinder continue under the control of the Links-Links pattern mechanism which transfers selected needles from one cylinder to another to produce a continuation of the Links-Links fabric of the leg. The Links-Links mechanism and the terry mechanism thus operate concurrently.

During the knitting of the heel, the machine is operated by reciprocation or oscillation of the needle cylinders and the needles on the instep side of the cylinders are rendered inactive under control of the switch cams 47 and 54 (Fig. 8). When the heel is completed, circular knitting is resumed to knit the sole portion 26 and integral instep portion 23 by the concurrent operation of the terry mechanism and the Links-Links mechanism as described above for the high splice and the initial part of the instep portion.

If it is desired to form the toe-band portion 27 of terry fabric throughout its coursewise extent the knitting of Links-Links fabric on the instep side of the needle cylinders is discontinued when the toe-band is reached and terry bits provided on the instep side of the bit dial 92 are put into operation. The verge section 119 on the instep side of the dial is in this event provided with suitable openings to permit projection of the bits. The toe portion 28 is knit in the same manner as the heel and is preferably followed by one or more courses of plain knitting to provide a loopers edge. Upon completion of the toe, the upper needle cylinder is lowered, thereby bringing the two sections of the verge to the same level and lifting the movable bit cam section 104 by engagement of the bearing plate 122 (Fig. 4) of the upper cylinder with the upwardly projecting end of the lever 138. The terry bits are thereby rendered inactive and interference between the bits and the lowered verge section 118 is positively prevented.

While the operation of the machine has been described for producing articles of hosiery such as shown in Figs. 3 and 3a it will be understood that the machine is not limited to such articles. Moreover, my invention is not limited to the structural details herein described by way of example, as modifications may be made both in the knitted article and the machine. For example in the terry portions of the fabric, terry loops may be provided in spaced wales or spaced courses instead of in consecutive wales and courses. The machine may, if desired, be provided with two or more feeding stations and corresponding knitting waves to produce a plurality of courses simultaneously. A multi-feed machine can, for example, be advantageously used to produce terry loops in spaced courses by actuating the terry-forming instrumentalities at one feed but not at another. While in the particular arrangement shown in the drawings a section of the verge is raised by raising the upper needle cylinder, it will be understood that the verge section may be raised independently of the cylinder, for example by being slidably mounted on the cylinder or on the dial carrying the terry instrumentalities. It will be apparent to those skilled in the art that still other modifications may be made within the scope of the appended claims.

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

1. An article of hosiery comprising leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected needle wales, and heel, sole and toe portions comprising a plurality of threads knit to form body stitches and terry loops of greater length than said body stitches.

2. In an article of hosiery, the combination of a top portion comprising thread knit to form selected wales of inwardly facing stitches and other wales of outwardly facing stitches, leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales, and heel and toe portions comprising thread knit to form terry fabric.

3. In an article of hosiery, the combination of a top portion comprising thread knit to form selected groups of consecutive wales of outwardly facing stitches and other wales of inwardly facing stitches, leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales, and heel and toe portions comprising thread knit to form terry fabric.

4. In an article of hosiery, the combination of leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales, groups of successive stitches of selected courses being drawn to the same face of the fabric, and heel, sole and toe portions comprising thread knit to form terry fabric.

5. In an article of hosiery, the combination of leg and instep portions comprising thread knit to form inwardly facing stitches and outwardly facing stitches recurring in predetermined sequences in each of selected wales to provide a repeating Links-Links pattern and heel, sole and toe portions comprising thread knit to form terry fabric.

6. A knitted article comprising a section formed throughout its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a Links-Links pattern, and an integral section formed throughout a portion only of its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a continuation of the Links-Links pattern of said first mentioned section and formed throughout another portion of its coursewise extent of thread knit to form terry fabric.

7. A knitted article comprising a section formed throughout its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a Links-Links pattern, and an integral section formed throughout a portion only of its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a continuation of the Links-Links pat-

tern of said first mentioned section and formed throughout another portion of its coursewise extent of the same thread knit to form terry fabric.

8. An article of hosiery comprising leg and instep portions of Links-Links fabric and integral heel, sole and toe portions of terry fabric.

9. An article of hosiery comprising leg and instep portions of Links-Links fabric and integral high splice, heel, sole and toe portions of terry fabric.

10. An article of hosiery comprising a top portion of vertical rib fabric, leg and instep portions of Links-Links fabric and integral heel, sole and toe portions of terry fabric.

11. A method of knitting which comprises knitting a plurality of threads together while drawing longer loops of one of said threads than of another to form terry fabric and concurrently producing an integral portion of fabric by drawing selected stitches of a course to the outer face of the fabric and other stitches of said course to the inner face of the fabric and varying the selection in successive courses so that inwardly facing stitches and outwardly facing stitches occur in predetermined sequences in each of selected wales.

12. Knitted fabric comprising a plurality of threads knit to form in each of a plurality of selected wales a series of inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences and a succession of stitches in which loops of one thread are substantially longer than corresponding loops of another thread.

13. Knitted fabric comprising a plurality of threads knit to form in each of a plurality of courses a succession of stitches in which loops of one thread are substantially longer than corresponding loops of another thread and a series of inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences, the arrangement of inwardly facing stitches and outwardly facing stitches being varied in successive courses.

14. A knitted article comprising a section formed throughout its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a Links-Links pattern, an integral section formed throughout a portion only of its coursewise extent of thread knit to form inwardly facing stitches and outwardly facing stitches occurring in predetermined sequences in each of a plurality of selected wales to provide a continuation of the Links-Links pattern of said first mentioned section and formed throughout another portion of its coursewise extent of thread to form terry fabric, and a further integral section formed throughout its coursewise extent of thread knit to form terry fabric.

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