April 23, 1935. S. A. WELCH ET AL 1,998,473

KNITTING MACHINE

Filed April 22, 1930 5 Sheets-Sheet 1

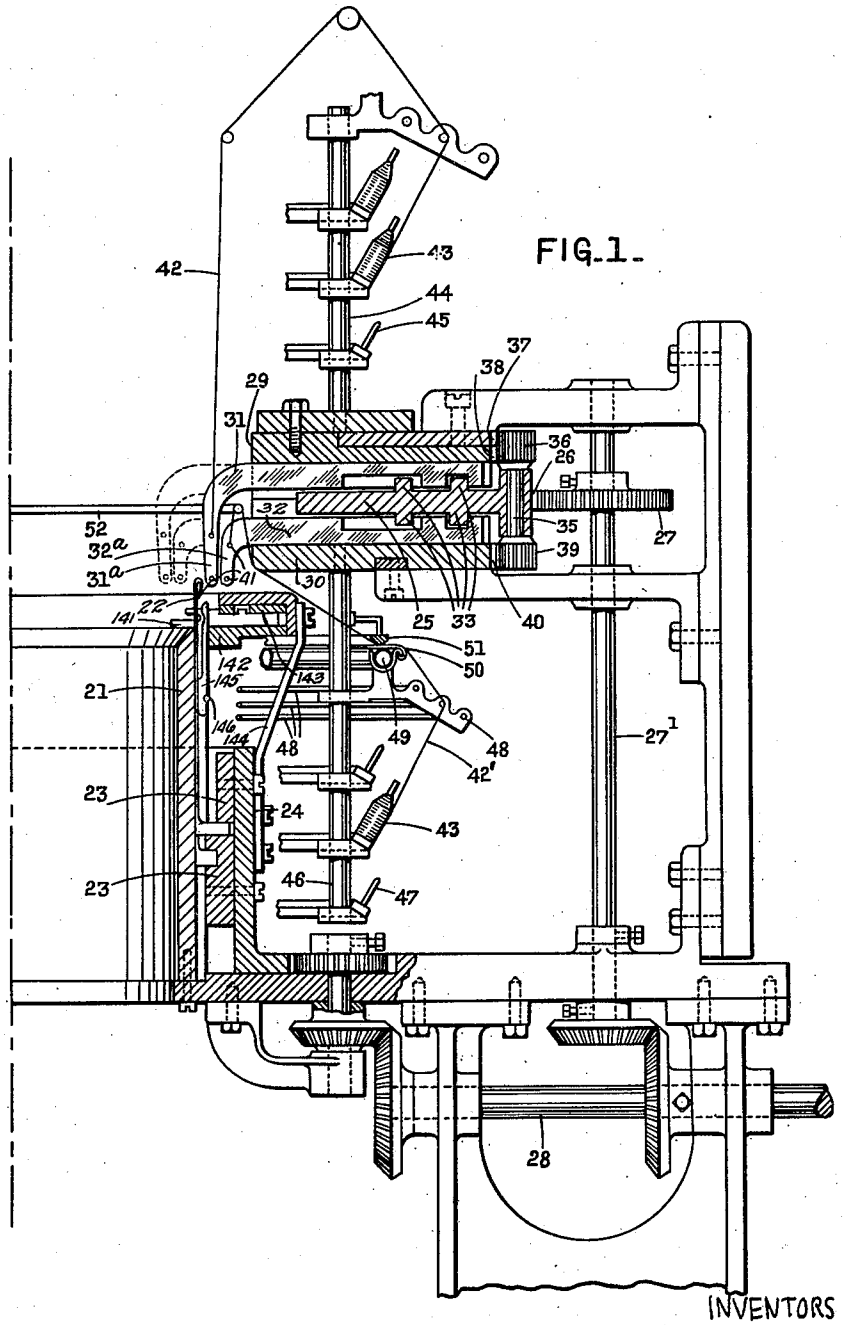


FIG. 1.

INVENTORS
SIDNEY ARTHUR WELSH
ALBERT FAIRHOLME GUYLER
JOHN THOMAS ASHBY
WILLIAM HENRY BOALER
by
J. Seltzer and Wilkinson
ATTORNEYS

April 23, 1935. S. A. WELCH ET AL 1,998,473

KNITTING MACHINE

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FIG. 2a

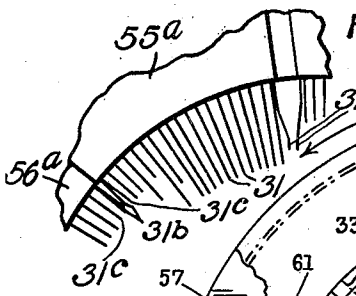


FIG. 2.

FIG. 3.

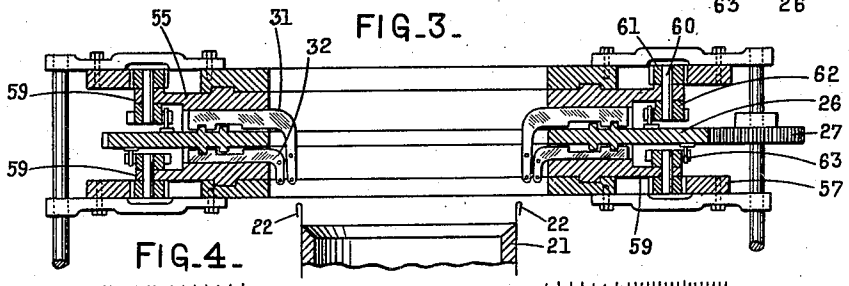


FIG. 4.

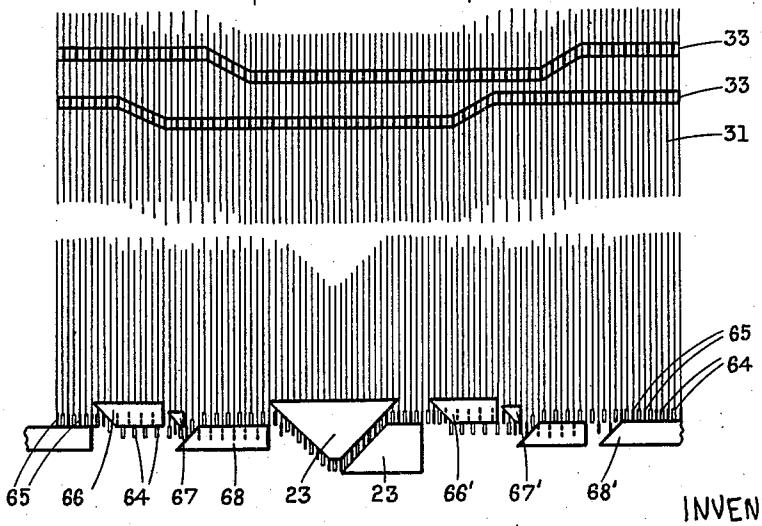
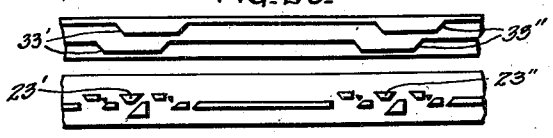


FIG. 2b.



INVENTORS

SIDNEY ARTHUR WELSH
ALBERT FAIRHOLME GUYLER
JOHN THOMAS ASHBY
WILLIAM HENRY BOALER

by

J. Seltzer and Silverman

ATTORNEYS

April 23, 1935. S. A. WELCH ET AL 1,998,473

KNITTING MACHINE

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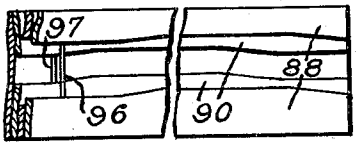


FIG. 5a

FIG. 5.

INVENTORS
SIDNEY ARTHUR WELSH
ALBERT FAIRHOLME GUYLER
JOHN THOMAS ASHBY
WILLIAM HENRY BOALER
by
J. Seltzer and Silverman
ATTORNEYS

April 23, 1935. S. A. WELCH ET AL 1,998,473

KNITTING MACHINE

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FIG. 6.

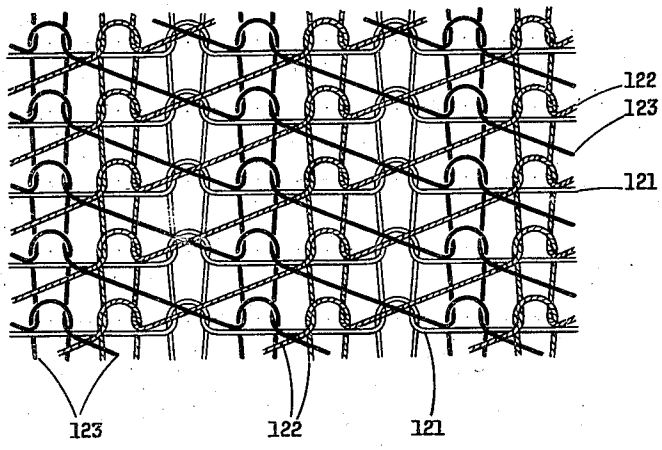
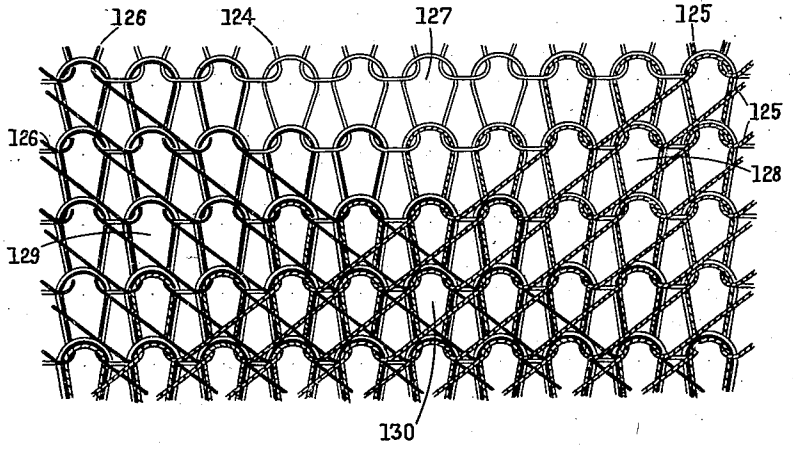


FIG. 7.



INVENTORS
SIDNEY ARTHUR WELSH
ALBERT FAIRHOLME GUYLER
JOHN THOMAS ASHBY
WILLIAM HENRY BOALER
by
Skelton and Wilkinson
ATTORNEYS

April 23, 1935. S. A. WELCH ET AL 1,998,473

KNITTING MACHINE

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FIG_8_

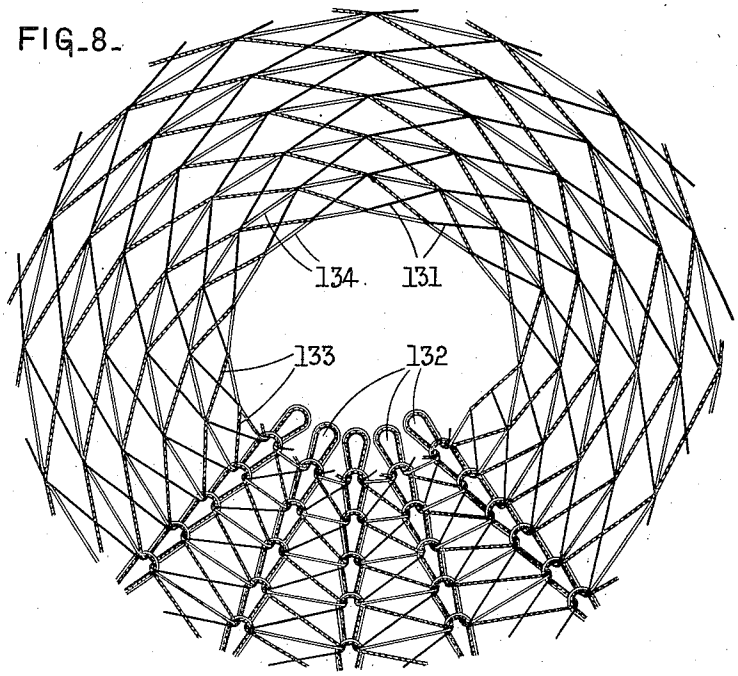
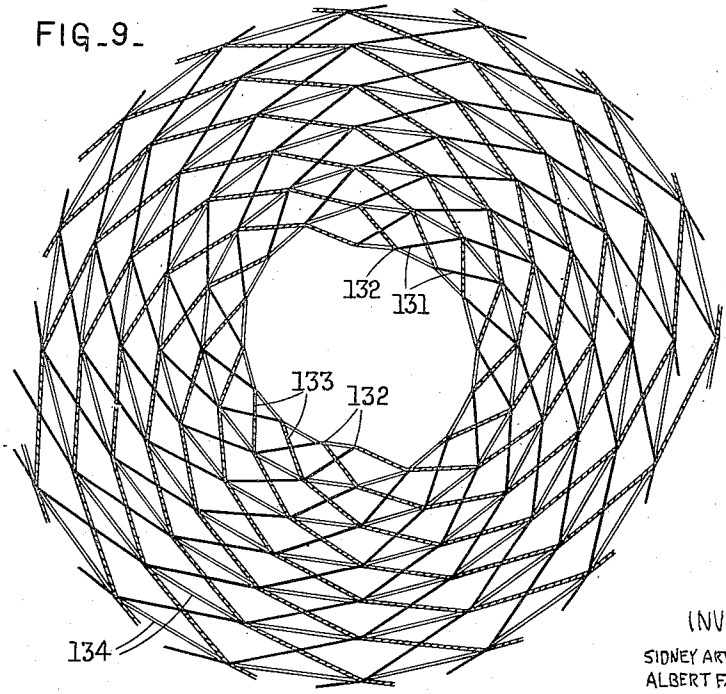


FIG_9_



INVENTORS

SIDNEY ARTHUR WELSH
ALBERT FAIRHOLME GUYLER
JOHN THOMAS ASHBY
WILLIAM HENRY BOALER

by

J. Belton and Robinson

ATTORNEYS

Patented Apr. 23, 1935 1,998,473

UNITED STATES PATENT OFFICE

1,998,473

KNITTING MACHINE

Sidney Arthur Welch, Albert Fairholme Guyler, John Thomas Ashby, and William Henry Boaler, Spondon, near Derby, England, assignors to Celanese Corporation of America, a corporation of Delaware

Application April 22, 1930, Serial No. 446,276
In Great Britain May 16, 1929

27 Claims. (Cl. 66—8)

This invention relates to knitting machines, and more particularly circular knitting machines, the principal object of the invention being the production of warp-knitted fabrics in which, as in Milanese fabric, for example, each warp thread progresses successively from wale to wale across the fabric. A further object of the invention is to produce on circular knitting machines knitted fabrics containing weft thread in addition to warp threads.

In its broadest aspect, a circular knitting machine according to the invention comprises a needle cylinder, thread guides for feeding a series of warp threads to the needles, means for causing the thread guides to lap the threads over any desired number of needles, and a knitting-cam cylinder rotating round the needle cylinder to knit on each needle in turn a single thread of the warp series. Since in each revolution of the knitting cam round the needle cylinder the thread guides have moved over a predetermined number of needles either in the same direction as the movement of the knitting cam or in the opposite direction thereto, while the knitting cam requires to meet and knit in such revolution a number of warp threads equal to the number of needles in the cylinder, the number of thread guides is greater or less than the number of needles according to the direction of the said lapping of the threads. The difference between the number of guides and the number of needles is the same as the number of needles over which the guides lap between successive knitting positions. Where there are two or more knitting positions round the needle cylinder, the number of guides exceeds the number of needles by the number of needles lapped by any one thread between all the knitting positions.

It is to be understood that the term "lap" refers to the passing of a thread laterally over one or more needles, the thread being subsequently knitted on the needle over which it was last lapped.

One set of warp thread guides may be used to produce fabric on the machine, but the best results are obtained by using two sets of guides, one lapping its threads in one direction over the needles and the other in the other direction. From the explanation given above, one set of guides will be greater in number than the number of needles and the other less, the differences depending on the extent of lapping, but not necessarily being equal with regard to both sets of guides.

Knitting may take place at more than one point round the needle cylinder by using two or more sets of knitting cams and arranging the number of guides and their lapping movements so that the required lapping takes place between each knitting point.

The above-mentioned particulars as to the relative numbers of guides and needles have special reference to the knitting of fabrics in which each needle is supplied with a warp thread from each series. It is possible, however, in any set of guides to use a less number than there are needles, and to knit such less number of threads into the fabric on selected needles only. Thus, for example, one set of warp threads may be knitted on to every needle while a second set may be knitted on to every third needle, each thread passing the two intermediate needles. In this case, the second set of guides will number only one third of the number of needles between each knitting position, plus or minus one guide to achieve the lapping over three needles between successive knitting positions. The needles are actuated by suitable cams to receive and knit the required threads only. The numbers of guides necessary to obtain any other required selection may be similarly determined.

A weft thread or threads may be readily introduced at any knitting position to add to the range of effects obtainable on the machine, it being convenient to mount the weft thread supply on the rotatable cam cylinder and direct the thread to the needles by suitable guides.

The relative rotary movement between the thread guides and the needles may be continuous or intermittent. In the former case, the needle cylinder may remain stationary while the or each set of guides moves round the cylinder to effect the lapping, or the cylinder may rotate with respect to one set of guides, the other guides, if any, also moving relatively to the moving cylinder. In the latter case it is desirable to maintain the cylinder stationary and to move the guides in sections in the direction in which lapping is to take place.

Whether the lapping be continuous or intermittent, as described above, none or substantially none of the lapping takes place over the needles which are engaged by the knitting cams. In the case of continuous lapping, the guides begin to lap the threads at or just after each thread loop has been knitted into the fabric, and lapping is not completed until just before the needle round which the thread has been passed comes into knitting position. In the case of intermittent lapping, knitting takes place while the guides

which have lapped the loops to be knitted are stationary, and lapping takes place between knitting positions by the movement of the guide sections.

The knitting machine according to the invention enables fabrics of the Milanese type to be produced at speeds such as are commonly employed in circular knitting machines, the lapping of the threads to give a progression from wale to wale across the fabric proceeding constantly in advance of the knitting operation which is then performed continuously on all the needles in turn.

The fabrics produced may be identical in character with the usual Milanese fabrics produced on flat machines, but, since threads having different characteristics may be used in the two sets of warp threads employed, a wider range of effects is possible. Further, this range may be increased by the use of weft thread, which again may have different characteristics from the warp threads.

The invention will now be described in greater detail with reference to the accompanying drawings, but it is to be understood that the following description is given by way of example only and is in no way limitative.

In the drawings, Fig. 1 is a part sectional elevation of one form of machine according to the invention;

Figs. 2 and 3 are a plan and sectional elevation respectively of a second form of machine of which Figs. 2*a* and 2*b* show details;

Fig. 4 is a development diagram showing the operation of the needles and a single set of guides.

Fig. 5 is a part sectional elevation of a third form of machine;

Fig. 5*a* is a detail view of the machine shown in Fig. 5;

Figs. 6 and 7 show diagrammatically various forms of fabric which may be produced on the machine according to the invention, and

Figs. 8 and 9 are views which enable the circular structure of the fabric to be visualized.

Referring firstly to Fig. 1, a stationary needle cylinder **21** is provided with needls **22** which are actuated by knitting cams **23** carried by a cam cylinder **24** which rotates round the cylinder **21**. The needles **22** are of the bearded type and operate in connection with sinkers as usually employed with this class of needle. The sinkers **141** are carried upon a plate **142** secured to the needle cylinder and are operated by means of sinker cams **143** connected with the knitting cams **23** by means of a connecting piece **144** and rotating with the knitting cams. Presser jacks **145** are also provided in the vertical tricks of the needle cylinder **21**, the jacks **145** being maintained in position by means of a spring **146** which passes completely round the needle cylinder **21**. Several sets of knitting cams **23** may be provided round the cylinder **24** according to the size of the cylinder and class of fabric to be produced.

Located above the level of the tops of the needles is an annular cam ring **25** whose internal diameter is somewhat greater than the diameter of the needle cylinder. The ring **25** is driven at the same speed as the cam cylinder **24**, being provided with an external gear **26** that meshes with a pinion **27** on a shaft **27'** driven from the main shaft **28** of the machine. On the upper and lower sides respectively of the ring **25** are two annular guide rings **29**, **30** each provided with radial tricks to receive inwardly projecting thread guides **31**, **32**, there being cams **33** on the sides of the ring **25** for the operation of the guides as will be described hereafter.

A short spindle **35** is journalled at right angles to the plane of the cam ring **25** at a point near the periphery of the ring, and a pinion **36** at one end of the spindle meshes with an annular gear **37** fixed to the machine frame, and also with teeth **38** formed round the periphery of the upper guide ring. There are more teeth in the ring **38** than in the gear **37**, the ratio between the numbers of teeth being equal to the ratio between the numbers of guides **31** and the number of needles **22**. There is some slackness between the pinion **36** and the two annular gears **37**, **38**, in order that the pinion **36** may effectively engage with both gears despite the difference in the number of teeth in the two gears. It will be seen that the members **36**, **37**, **38** constitute a differential gear which drives the upper guide ring **29** slowly round the needle cylinder in the direction in which the cam cylinder is rotating round the needles. This movement of the guide ring **29** causes the guides **31** to advance over a predetermined number of needles between each knitting operation performed on the needles, the extent of the advance in each revolution of the knitting cam being equal to the difference between the number of guides and the number of needles.

At the lower end of the spindle **35**, a second pinion **39** is provided meshing with teeth **40** cut round the periphery of the lower guide ring **30**, the number of teeth in this guide ring being less than the number of teeth in the fixed gear **37**, this arrangement constituting a further differential gear to cause the guide ring **30** to proceed backwards round the needle cylinder by an amount equal to the lapping which the guides **32** are required to perform between successive knitting operations. By means of the arrangement just described the thread guides **31** are caused to lap continuously in one direction over the needles **22**, i. e. in the same direction as the knitting and guide cams, and the other guides **32** move continuously in the opposite direction. Any other suitable form of differential gear may be employed.

Though the thread guides have been described as being driven from a single spindle **35** journalled in the cam ring **25**, further spindles with pinions meshing with the gears **37**, **38**, **40** may be provided round the periphery of the cam ring to drive the rings **29**, **30** at several points.

The inner ends of the thread guides **31**, **32** extend downwardly to form fingers **31***a*, **32***a* provided with guide holes **41** through which threads **42**, **42'** are led, the fingers **31***a* being longer than the fingers **32***a* so that threads are delivered to the needles at the same level from each set of guides. The fingers **31***a*, **32***a* are able to lead their respective threads between the needles after lapping has been effected, and the horizontal parts of the guides pass clearly over the heads of the needles while the guides occupy their innermost position. The threads **42**, **42'** for the two sets of guides respectively are supplied from yarn packages **43** supported by and travelling with the guide rings. For the supply of the thread **42**, an upstanding framework **44** is mounted on the upper guide ring **29** and carries a series of pegs **45** to receive bobbins, there being preferably one bobbin for each thread guide. If desired, however, small thread beams may be used each containing sufficient threads to supply several guides. A similar framework **46** depends from the lower guide ring **30** and carries pegs **47** for supporting the bobbins for the supply of thread **42'** to the lower guides **32**.

Thread is drawn from the bobbins by the action

of the needles during knitting, passing from the bobbins over rods **48** to a tension device comprising an inflatable tube **49**. The threads pass over a flexible pad **50** supported by the tube **49**, and a ring **51** is caused to press on the threads so as to apply a uniform tension to all the threads. This tension may be adjusted by varying the pressure of the ring **51** on the tube **49** or by varying the pressure of the tube.

The lower set of threads **42'** is caused to pass upwardly to an annular ring **52** located above the needle level and then over the ring and down to the guides **32**. The upper set of threads proceeds directly to the guides **31**.

By carrying the threads **42'** over the ring **52**, they are caused to move in substantially vertical paths down to the needles, this arrangement ensuring that practically no slackening or undue tensioning of either set of threads occurs during the passage of the guides horizontally through the needles. It is also preferable to provide two guide holes **41** in each thread guide, it being found that this arrangement assists in avoiding slackening of the threads.

The cams **33** are arranged to move the thread guides **31**, **32** inwardly through the needles after lapping of the threads **42**, **42'** has been effected by the lapping movement of the rings **29**, **30** round the needles. The threads are thus brought into position to be knitted by the operation of the knitting cams **23**. After the needles have seized the loops of warp thread the guides **31**, **32** are withdrawn through or over the needles by the cams **33** and continue lapping the threads to form the next loops to be knitted. The cams **33** employed in Fig. 1 are similar to those shown in Fig. 2 and their operation will be described in greater detail hereafter with reference to Fig. 4.

It will be understood that although the number of guides in each of the two series differs from the number of needles in the cylinder, there being more guides than needles in one set and less guides than needles in the other, that is there are more warp threads progressing round the cylinder in one direction and less in the other, knitting takes place uniformly on all the needles round the needle circle, and for each operation of the knitting cams as many loops are knitted on the needles from one set of guides as from the other. This is due to the fact that the movement of the guides round the needle cylinder means causes the knitting cam as well as the guide cams to meet the lesser number of guides, but require to overtake the greater number of guides. Thus, just as the knitting cam actuates all the needles in the cylinder during each revolution it performs round the cylinder, so also do the guide cams actuate as many guides as there are needles during each revolution they make round the cylinder.

Referring now to Figs. 2 and 3, the thread guides **31**, **32** are mounted in a similar manner to those shown in Fig. 1, but are evenly spaced with the needles, and are contained in a plurality of segmental guide sections **55**, **56** which together do not occupy a full circle round the cylinder, there being a small amount of space through which the sections may be caused to move, as is clearly shown in Fig. 2. This space enables the sections to be moved in the case of one set of guides forwardly with respect to the direction of knitting, and in the case of the other set of guides backwardly. As in Fig. 1, there are more guides **31** and less guides **32** than there are needles, the guides **31** being movable in the same direction as the knitting cam cylinder and the guides **32** in the opposite direction. The guides are actuated by cams **33**, Fig. 2 showing the lower set, which contains less guides than there are needles. The guide sections shown in Fig. 2, however, are those belonging to the upper set of guides, which are left out of the figure for the sake of clearness. In the case of the upper set, provision has to be made for extra guides to be mounted in the sections **55**, **56** to provide for the lapping movement of the guides. This arrangement is shown in Fig. 2*a*. The extra guides **31***a*, **31***b* are mounted in the end tricks of the sections and arranged to spring away from the adjacent guides **31***c* of the same sections when the guide sections have moved apart as shown with regard to the guide **31***a*. When the sections are closed together however, the guides are capable of being sprung inwards and pressed close to the adjacent guide **31***c* by the end guides of the adjacent section of this arrangement as shown with respect to the guides **31***b*. This arrangement provides for a spacing of the guides equal to the needle spacing over the gaps between the sections, notwithstanding the necessity for a number of guides in excess of the number of needles. Accurate lapping of the threads is thereby achieved, and the guide fingers are always able to pass through the needles to complete the lapping without danger of the guides fouling the needles.

The sections **55**, **56** are progressed round the needle cylinder as follows:—

An annular ring **57** having teeth on its inner edge is provided in connection with each set of guide sections, each ring being secured to the machine frame. Journalled in a bracket or arm **59** projecting from each guide section is a short spindle **60** having at one end a pinion **61** meshing with one of the annular gears above referred to, and at its other end a star wheel or pinion **62** which projects into the path of a pin or pins **63** carried by the rotating cam ring. Thus, as a pin **63** carried by the cam ring strikes the star wheel **62** it causes the pinion **61** carried on the star wheel spindle **60** to rotate, and be driven a small amount round the annular gear **57** with which it meshes, carrying with it the corresponding guide section **55** or **56**, which is thus moved angularly round the cam ring over the space of any desired number of needles. The guide sections are thus caused to move intermittently relatively to the needles, and the pins **63** on the cam ring are so arranged that they rotate the star wheels **62** pertaining to one set of guide sections in one direction, and those pertaining to the other set in the other direction, so obtaining the required lapping of the threads over the needles in both directions. The number of pins **63** carried by the cam ring **26** in connection with each set of thread guides depends on the number of knitting positions round the needle cylinder, it being necessary, of course, to advance the guide sections by the amount corresponding to the lap desired between each knitting position. The threads are fed to the thread guides in a manner similar to that shown in Fig. 1.

It will of course be understood that instead of both sets of thread guides moving relatively to stationary needles, as described in Figs. 1–3, one set of guides may be stationary the required lapping of the threads from these guides being effected by a rotary movement of the needle cylinder carried out in a manner similar to that described above for moving the thread guides.

The other set of guides moves over the needles as previously described to produce the lapping of its threads. Such an arrangement is shown in Fig. 5, as will be described later.

It has been stated with reference to Figs. 1–3 that the cams **33** operate to pass the guide fingers **31***a*, **32***a* through the needles after the completion of the lapping. It will be understood that in the arrangement described in Fig. 1, where the guides progress at a uniform rate round the needles, the guides can only pass between the needles at such points round the needle circle where they are in "mesh" with the needles. Thus, where there is one guide more or less than the number of needles and the guides progress at a uniform rate round the needles, this meshing will only take place at one point in the needle circle. In the case of a machine employing fine gauge needles, there is the danger of the guides or threads fouling the needles during the passing of the guides between the needles. Similar difficulties may also arise in the case of small diameter machines. Even in the arrangement shown in Figure 2, where the guides have equal spacing with the needles, and are stationary when they are required to pass through the needles, such fouling may occur. In order to overcome this difficulty, it is preferred to adopt an arrangement of knitting and guide cams such as is shown in Figure 4. For the sake of simplicity in this figure, the guides **31** are represented as being in the same plane as the needles instead of at right angles, and following parallel paths towards the needles instead of radial ones. The needles **22** are shown at the lower part of the figure, long and short butts **64**, **65** being provided on alternate needles. **23** are the knitting cams, and in advance of these is a cam **66** arranged to lower all the long butted needles so that a wide spacing is left between the heads of the short butted needles. The guides **31** are provided either with long or short butts alternately, or with butts for engaging two different cam tracks **33**, and at the time the long butted needles have been lowered, the guides corresponding to the remaining short butted needles are advanced by the cams **33** to pass their threads, which have already been lapped over the desired number of needles by the movement of the guides round the needle circle, between these needles. The short butted needles are then lowered by a cam **67**, and the long butted needles are raised by a cam **68** the remaining guides being passed between the upstanding long butted needles to effect the lapping of the remaining threads. It is possible to return the guide fingers to the outside of the needle circle over the tops of the needles, while the knitting operation is taking place, but it is preferred to adopt a similar procedure for retracting the guides to that used to advance them in completing the lapping, and for this purpose additional needle cams **66'**, **67'**, **68'** are used, this second operation of the needles and guides being clearly shown to the right of the cams **23** in Figure 4. Wider spacing for the passage of the guide between the needles may be effected by the use of suitable butts and cams for the selection of the needles and guides.

One or more sets of knitting cams **23** may be provided in the cam cylinder **24** it being understood that where more than one set of cams is employed, the requisite lapping between consecutive knitting positions is obtained by suitable formation of the thread guide cams and by suitably choosing the numbers of teeth on the thread guide rings in relation to the number of teeth on the fixed ring from which the thread guide rings derive their lapping motion. Fig. 2*b* shows the arrangement of two sets of needle cams **23'**, **23''** together with two sets of thread guide cams **33'** and **33''**, these being the cams employed for one half of the machine as shown in Fig. 2. A plurality of sets of cams of the same nature as those shown in Fig. 2*b* is also employed in connection with the machine illustrated in Fig. 1.

Referring now to Figure 5, one guide ring **71** carrying guides **72** is held stationary, being attached to the machine frame **73**. The needle cylinder **74** rotates at a rate determined by the lapping to be effected by the guides **72** over the needles and the other guide ring **75**, carrying guides **76**, rotates at a faster rate than the cylinder. The actual rates of revolution of the cylinder **74** and the ring **75** to effect the lapping will be determined by the differences between the number of needles and the number of guides in the two rings, as in the case in the forms of machine previously described. The cylinder **74** is driven from the shaft **77** by a gear train **78**, **79**, **80**, **80'**, the member **80'** carrying rods **80''** adapted to support a fabric take up device (not shown) of the usual type. The guide ring **75** is driven by a gear train **82** . . . **85**. The sets of guides **72**, **76** are pivoted in annular grooves **86**, **87** in the rings **71**, **75**, respectively, their movement being controlled by cams **88** . . . **91** carried by a cam ring **92** which is driven from the shaft **77** by a pinion **81**. The needles **93** are actuated by a cam cylinder **94** driven by a pinion **95**, the cams being of any desired form, either to effect similar actuation of all the needles or a selective actuation such as is illustrated in Figure 4. The needles shown in the figure are of the latch type and are provided with butts in two positions on their stems for actuation by two sets of cams to effect a wide spacing of the needles during passage of the guides, the knitting, however, being effected by a single set of cams only. The thread guides **72**, **76** may be operated in the manner shown in Figure 4 by a suitable arrangement of butts and cams, short and long butts **96**, **97** being shown for this purpose. The short and wide butts **96** are engaged by the outer cams **88**, **89**, and the long butts **97** are narrow, so as to pass through the wide cam slots for the butts **96** in the cams **88**, **89**, and are engaged by the inner cams **90**, **91**.

The threads **98**, **99** for the two sets of guides **72**, **76** are fed from small warp beams **100**, **101**, of which the beams **100** are stationary, while the beams **101** are mounted for rotation with the guides **76**. The threads are fed from the beams to the guides by means of rubber rollers **102**, **103**, and steel rollers **104**, **105** respectively. The steel rollers are adjustably mounted and may be caused to make different pressure with the rubber rollers so as to control the rate of the thread fed to the needles. The roller **102** is driven by a gear train **106'** from a worm **106** on the shaft **77** and the roller **103** is driven from an annular gear **107** on the cam ring **92** through a pinion **207**, worm gear **208**, **209**, and chain gearing **210**. It is of course necessary to provide a number of beams **100**, **101** and corresponding feed rollers **102**, **103** round the machine. It is convenient to arrange that the rollers **102**, **103** are geared together by means of bevel gears to form one or more series, each of which is driven as described above.

Means are shown in Fig. 5 for feeding weft thread to the needles, it being necessary to carry the weft thread round the needle cylinder at

the same rate as the cam cylinder. The weft thread 108 is fed from a bobbin 109 carried on a bracket 109' mounted on the cam cylinder 94. The thread leaving the bobbin passes through the guide eye 110, laps round the tension rod 111, and is fed to the needles through a tube guide 112. A guard 113 is provided to limit ballooning of the thread as it proceeds from the bobbin. In any of the machines described above any suitable patterning means may be provided to modify the appearance of the fabric, for example, in the case of spring bearded needles, a cut presser wheel or other means for selectively pressing the spring beards may be employed. Further, pattern wheels, pattern chains, jacquard mechanism, or other means may be used to select the needles or to effect tucking or plating to produce any desired pattern.

Figs. 6 and 7 show two types of fabric which may be produced on the machine. In knitting the fabric shown in Fig. 6, every third needle is fed with weft thread 121, while half of the remaining needles are fed with warp thread 122 and the other half with warp thread 123. Each of the threads laps over three needles between each knitting position, the needles being suitably selected to take required thread only.

For feeding the warp threads to the needles, the guides in each set number only ⅓ of the number of needles, plus and minus one guide in the two sets respectively to effect the lapping. The guides are, of course, evenly spaced round the needle circle.

The threads 122, 123 progress from left to right and from right to left respectively across the fabric, ascending from course to course, while the weft thread follows each course. Every third needle contains one only of the three series of threads used in the fabric, and these three series of threads may be different in colour, composition, or character, every third wale of the fabric may appear as a distinct stripe in the fabric.

In Fig. 7, the structure of a fabric employing two series of warp threads together with weft thread is shown. Each warp thread laps over two needles, there being a warp thread to each needle. The weft thread 124 forms a "ground", as shown in the area 127, and the warp threads 125, 126 of the two series are superposed on this ground, as shown in the areas 128, 129. The area 130 shows how all three types of thread combine to give three thread loops on each needle.

Figs. 6 and 7 do not, of course, show the tubular structure of the fabric, and this can best be visualized in the manner shown in Figs. 8 and 9. These give distorted views of the fabric, obtained by looking downwards on to the tube of fabric as it is produced on the machine and imagining the lower part of the tube increasing gradually in size and at the same time rising up to the level of the uppermost edge, which consists of the stitches last knitted. The fabric now appears as a perforated disc, the last series of stitches knitted surrounding a hole in the centre of the disc.

Fig. 8 shows such a view in the case of a fabric containing two sets of warp threads, each thread of which is lapped over one needle only in every revolution of a single knitting cam round the needle cylinder. The stitches which appear in the actual fabric to constitute a single helical course appear as a spiral of constantly increasing radius, the stitches of each wale all falling on a radial line extending from the centre of the spiral. Each thread 131 of the set which is less in number than the number of wales passes from its loop 132 in the turn of the spiral last knitted to a loop in the preceding turn in a direction opposite to that in which stitch spiral is increasing, i. e., each of this set appears as a spiral increasing in a direction contrary to the stitch spiral.

Each of the other set of threads 133 passes from its loop in the turn of the spiral last knitted to a loop in the preceding turn in the same direction as that in which the stitch spiral is increasing, and each such thread appears as a spiral increasing in the same direction as the stitch spiral but more rapidly.

A similar fabric is shown in Fig. 9, but in this case two knitting positions have been used round the needle circle so that each of the two helical stitch courses in the actual fabric is represented by a spiral, one starting from each knitting position. The warp threads again appear as spirals, similar to those in Fig. 8.

In both of the views, weft threads 134 appear along the stitch spirals. The two sets of warp threads and the weft threads are represented in the same way as corresponding threads in Figs. 6 and 7. A few wales of knitted fabric are shown in Fig. 8.

What we claim and desire to secure by Letters Patent is:—

1. Machine for knitting tubular warp knitted fabric, comprising a circularly disposed endless series of needles, a series of thread guides adapted to feed the warp threads to said needles, means for traversing said guides always in the same direction round the needle circle so as to lap the threads over the needles, and cam means adapted to move said guides between the needles after lapping of the threads over the needles so as to bring the threads successively into position to be knitted on said needles.

2. Machine for knitting tubular warp knitted fabric, comprising an endless series of needles, a series of thread guides differing in number from the number of needles and adapted to feed warp threads to the needles, means for traversing said guides always in the same direction with respect to said needles so as to lap the threads over the needles, and cam means adapted to move the guides between the needles as the traversing movement brings them into register with the needles so that the threads are brought successively into position to be knitted on said needles.

3. Machine for knitting tubular warp knitted fabric, comprising a circularly disposed series of needles, two circularly disposed series of thread guides each adapted to feed warp threads to said needles, one series of guides being greater in number than the number of needles and the other series less in number than the number of needles, and means for traversing the two series of guides in opposite directions round the needle circle to present the warp threads successively to the needles, the guide series being traversed in their respective directions at rates proportional to the differences between the number of needles and the respective number of guides so that each needle is fed in turn with a thread to be knitted by one guide of each series.

4. Machine for knitting tubular warp knitted fabric, comprising an endless series of independently movable needles, a series of thread guides adapted to feed warp threads to said needles, cam means arranged to operate said needles successively, means for traversing said

guides always in the same direction with respect to said needles so as to lap the threads over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles.

5. Machine for knitting tubular warp knitted fabric, comprising a series of needles, a series of thread guides adapted to feed warp threads to said needles, cam means adapted to operate said needles successively, means for traversing said guides with respect to said needles so as to lap the threads over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles, the said needle cam means being adapted to retract needles at spaced intervals to form gaps in the needles series, and said guide means being adapted to advance guides at corresponding spaced intervals so that said guides pass through said gaps.

6. Machine for knitting tubular warp knitted fabric, comprising a needle cylinder, an endless series of independently movable needles mounted in said cylinder, a series of thread guides adapted to feed warp threads to the needles of said cylinder, cam means arranged to operate said needles successively, means for traversing said guides at a uniform rate always in the same direction with respect to said needles so as to lap the threads over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles.

7. Machine for knitting tubular warp knitted fabric, comprising a needle cylinder, a series of thread guides adapted to feed warp threads to the needles of said cylinder, cam means adapted to operate said needles successively, means for traversing said guides at a uniform rate with respect to said needles so as to lap the threads over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles, the said needle cam means being adapted to retract needles at spaced intervals to form gaps in the needle series, and said guide means being adapted to advance guides at corresponding spaced intervals so that said guides pass through said gaps.

8. Machine for knitting tubular warp-knitted fabric, comprising a needle cylinder, a series of needles, sections of thread guides adapted to feed warp threads to the needles of said cylinder, cam means adapted to operate said needles successively, and means for traversing the guides by sections with respect to said needles so as to lap the threads over the needles between successive knitting operations on such needles.

9. Machine for knitting tubular warp knitted fabric, comprising an endless series of independently movable needles, two series of thread guides each adapted to feed warp threads to said needles, cam means arranged to operate said needles successively, and means for traversing the two sets of guides in opposite directions with respect to the needles so as to lap the threads in opposite directions over the needles between successive knitting operations on such needles.

10. Machine for knitting tubular warp knitted fabric, comprising an endless series of independently movable needles, two series of thread guides each adapted to feed warp threads to said needles, cam means arranged to operate said needles successively, means for traversing the two sets of guides in opposite directions with respect to the needles so as to lap the threads in opposite directions over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles.

11. Machine for knitting tubular warp knitted fabric, comprising a series of needles, two series of thread guides each adapted to feed warp threads to said needles, cam means adapted to operate said needles successively, means for traversing the two sets of guides in opposite directions with respect to the needles so as to lap the threads in opposite directions over the needles between successive knitting operations on such needles, and cam means operative in synchronism with said needle cam means and adapted to move said guides between the needles after lapping of the threads over the needles, the said needle cam means being adapted to retract needles at spaced intervals to form gaps in the needle series, and said guide means being adapted to advance guides at corresponding spaced intervals so that said guides pass through said gaps.

12. Machine for knitting tubular warp knitted fabric, comprising a series of needles, a series of thread guides greater in number than the number of needles and adapted to feed warp threads to said needles, cam means adapted to operate said needles successively to knit the warp threads on the needles, and means for traversing said guides with respect to said needles in the direction of knitting at a rate whose ratio to the rate of knitting equals the ratio of the difference between the numbers of guides and needles to the number of needles, so that each needle is fed by one guide of the series at each knitting operation of such needle.

13. Machine according to claim 12 comprising means adapted to supply a weft thread to said needles.

14. Machine according to claim 12 comprising means adapted to traverse the guides continuously with respect to the needles.

15. Machine for knitting tubular warp-knitted fabric, comprising a series of needles, a series of thread guides less in number than the number of needles and adapted to feed warp threads to said needles, cam means adapted to operate said needles successively to knit the warp threads on the needles, and means for traversing said guides with respect to said needles in a direction opposite to that of knitting at a rate whose ratio to the rate of knitting equals the ratio of the difference between the numbers of guides and needles to the number of needles, so that each needle is fed by one guide of the series at each knitting operation of such needle.

16. Machine according to claim 15 comprising means adapted to supply a weft thread to said needles.

17. Machine according to claim 15 comprising means adapted to traverse the guides continuously with respect to the needles.

18. Machine for knitting tubular warp knitted

fabric, comprising a series of needles, two series of thread guides each adapted to feed warp threads to said needles, one series of guides being greater in number than the number of needles and the other series less in number than the number of needles, cam means adapted to operate said needles successively to knit the warp threads on the needles, and means for traversing the two series of guides with respect to the needles, the greater number of guides being traversed in the same direction as that of knitting, and the lesser number of guides in a direction opposite to that of knitting, each at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of needles to the number of needles, so that each needle is fed by one guide of each series at each knitting operation of such needle.

19. Machine according to claim 18 comprising means adapted to traverse the guides continuously with respect to the needles.

20. Machine according to claim 18 comprising two series of thread guides mounted in sections and means adapted to traverse said guides by sections with respect to the needles.

21. Machine for knitting tubular warp-knitted fabric, comprising a needle cylinder, two series of thread guides each adapted to feed warp threads to said needles, one series of guides being greater in number than the number of needles and the other series less in number than the number of needles, cam means adapted to operate said needles, means adapted to rotate the needle cylinder with respect to one set of guides and means adapted to rotate the other set of guides in the same direction as and with respect to the needle cylinder, whereby the two sets of guides are traversed with respect to the needles, the greater number of guides being traversed in the same direction as that of knitting, and the lesser number of guides in a direction opposite to that of knitting, each at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of needles to the number of needles, so that each needle is fed by one guide of each series at each knitting operation of such needle.

22. Machine for knitting tubular warp-knitted fabric, comprising a needle cylinder, an endless series of needles mounted in said cylinder, a series of thread guides greater in number than the number of needles and adapted to feed warp threads to said needles, a plurality of cam means spaced round the cylinder, each cam means being adapted to operate said needles successively and means for traversing said guides always in the same direction as said cam means with respect to the needles at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of needles to the number of needles so that each needle is fed by a guide at each knitting operation of such needle.

23. Machine according to claim 22 comprising means in connection with at least one of the cam means to supply a weft thread to the needles.

24. Machine for knitting tubular warp-knitted fabric, comprising a needle cylinder, an endless series of needles mounted in said cylinder, a series of thread guides less in number than the number of needles and adapted to feed warp threads to said needles, a plurality of cam means spaced round the cylinder, each cam means being adapted to operate said needles successively and means for traversing said guides always in the opposite direction from said cam means with respect to the needles at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of needles to the number of needles so that each needle is fed by a guide at each knitting operation of such needle.

25. Machine according to claim 24 comprising means in connection with at least one of the cam means to supply a weft thread to the needles.

26. Machine for knitting tubular warp-knitted fabric, comprising a series of needles, two series of thread guides each adapted to feed warp threads to said needles, one series of guides being greater in number than the number of needles and the other series less in number than the number of needles, a plurality of cam means spaced round the cylinder, each cam means being adapted to operate said needles successively to knit the warp threads on the needles, and means for traversing the two series of guides with respect to the needles, the greater number of guides being traversed in the same direction as that of knitting, and the lesser number of guides in a direction opposite to that of knitting, each at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of needles to the number of needles, so that each needle is fed by one guide of each series at each knitting operation of such needle.

27. Machine for knitting tubular warp-knitted fabric, comprising a series of needles, two series of thread guides each adapted to feed warp threads to selected needles, one series of guides being greater in number than the number of needles fed thereby and the other series less in number than the number of needles fed thereby, cam means adapted to operate said needles successively, and means for traversing the two series of guides with respect to the needles, the first set of guides being traversed in the same direction as that of knitting, and the second set in a direction opposite to that of knitting, each at a rate whose ratio to the rate of knitting equals the ratio of the difference between such number of guides and the number of selected needles fed thereby to such number of needles, so that each of such number of selected needles is fed by one guide of the series at each knitting operation of such needle.

SIDNEY ARTHUR WELCH.
ALBERT FAIRHOLME GUYLER.
JOHN THOMAS ASHBY.
WILLIAM HENRY BOALER.