June 11, 1968 D. A. E. MATTINGLY ETAL 3,387,468

CIRCULAR KNITTING MACHINES

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FIG. 14.

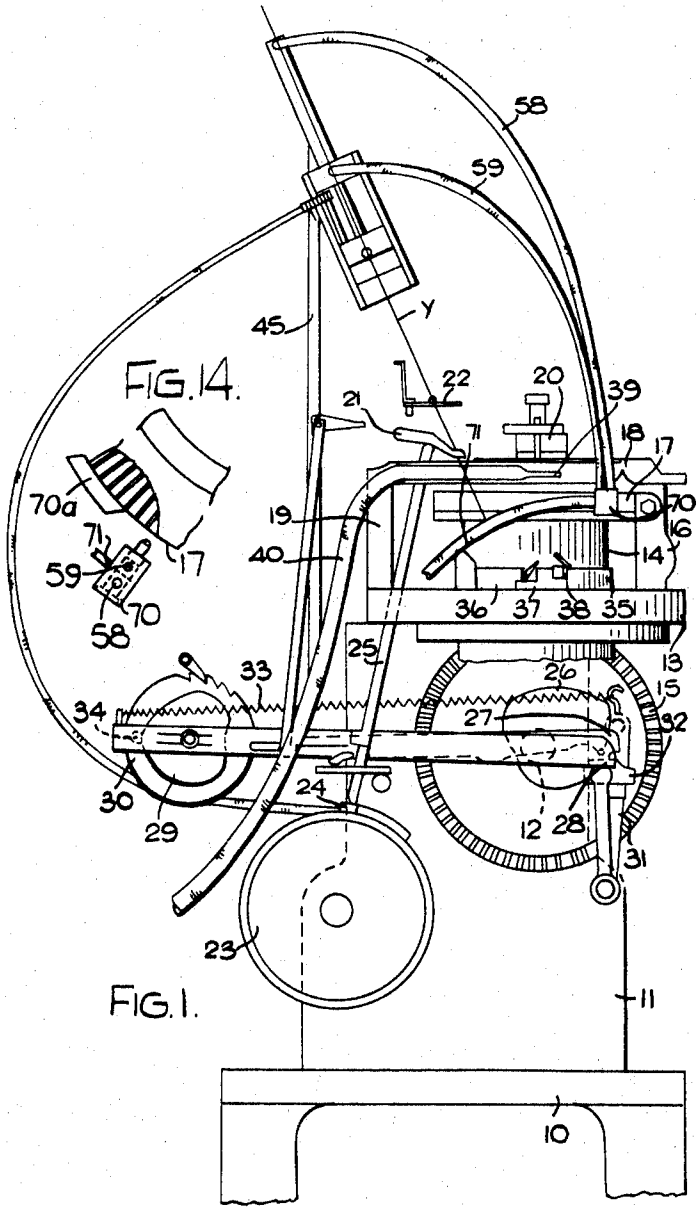



FIG. 1.

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June 11, 1968 D. A. E. MATTINGLY ETAL 3,387,468

CIRCULAR KNITTING MACHINES

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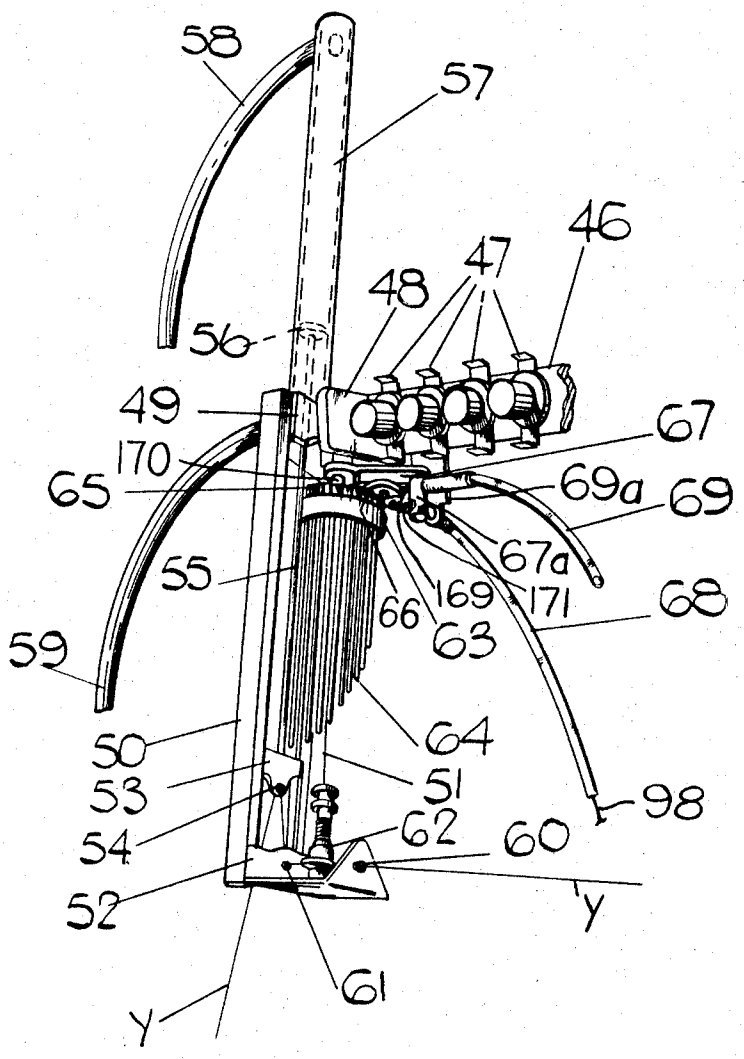



FIG. 2.

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June 11, 1968 D. A. E. MATTINGLY ET AL 3,387,468

CIRCULAR KNITTING MACHINES

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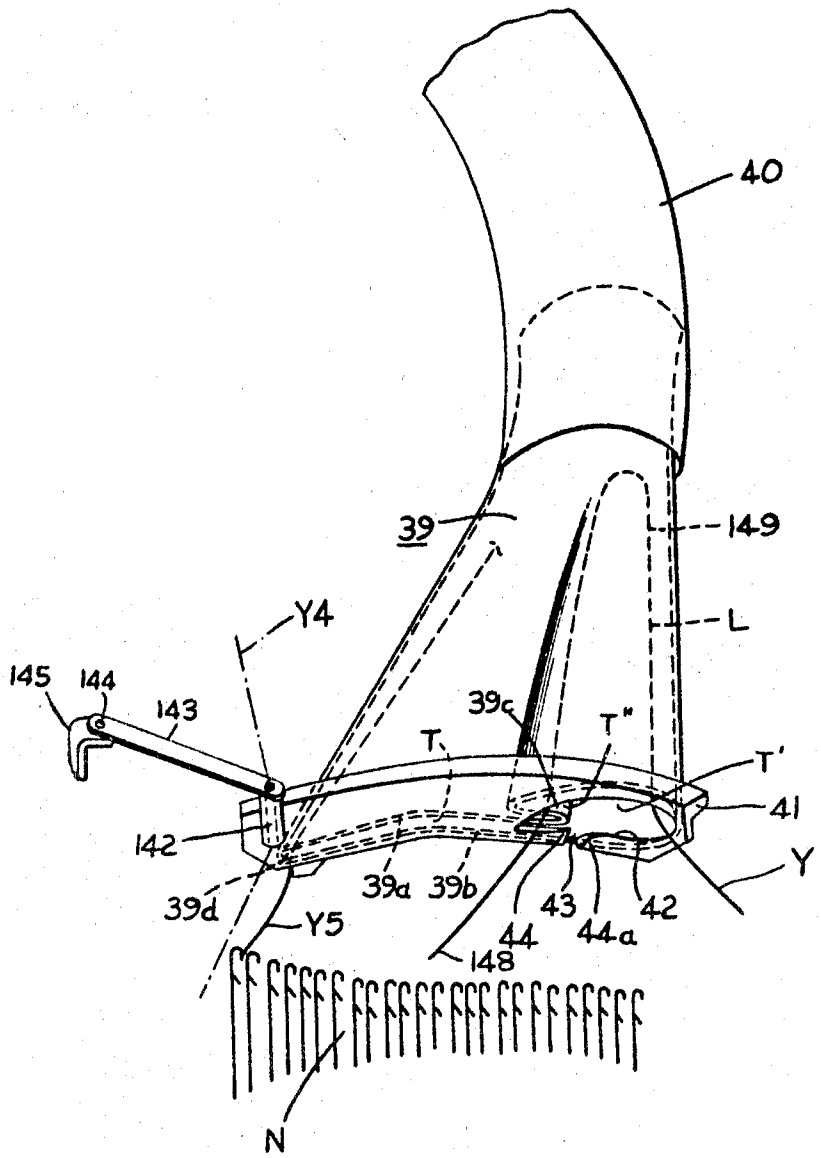



FIG. 3.

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June 11, 1968 D. A. E. MATTINGLY ETAL 3,387,468

CIRCULAR KNITTING MACHINES

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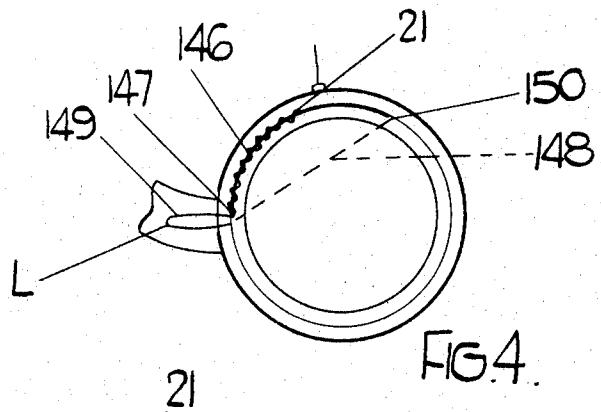



FIG.4.

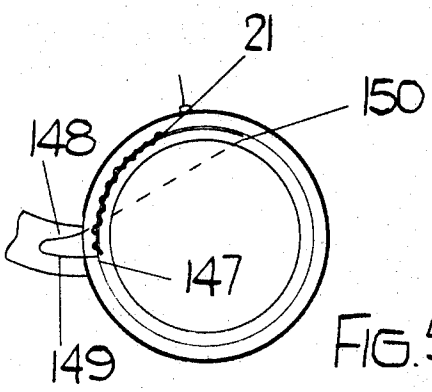



FIG.5.

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CIRCULAR KNITTING MACHINES

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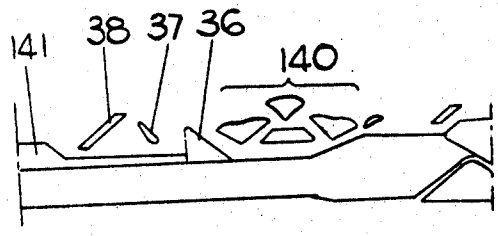



FIG. 6.

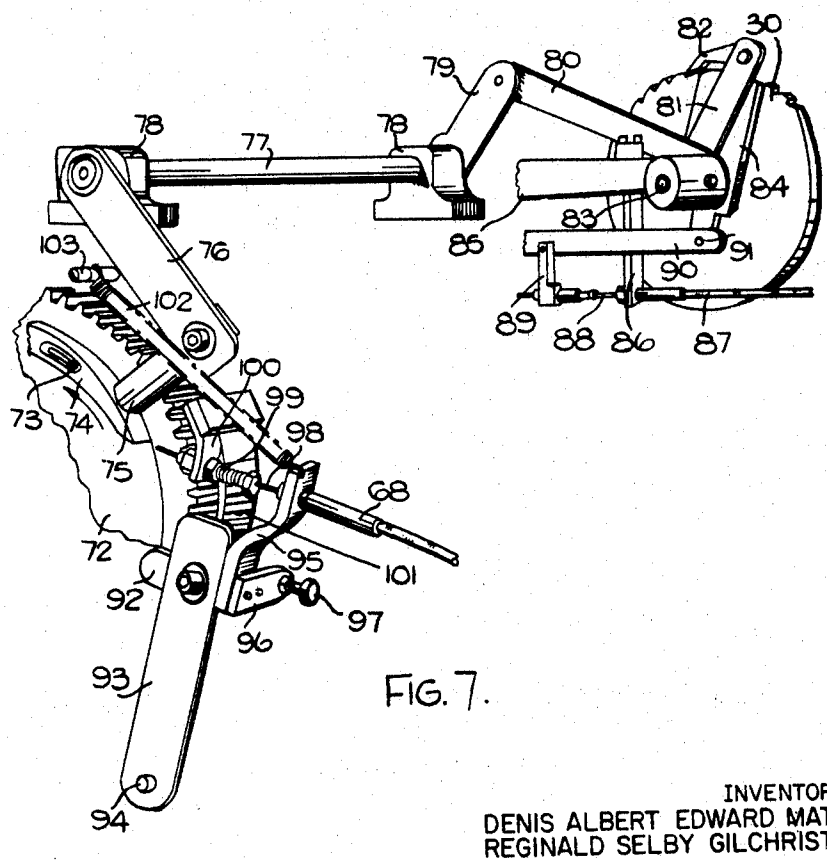



FIG. 7.

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CIRCULAR KNITTING MACHINES

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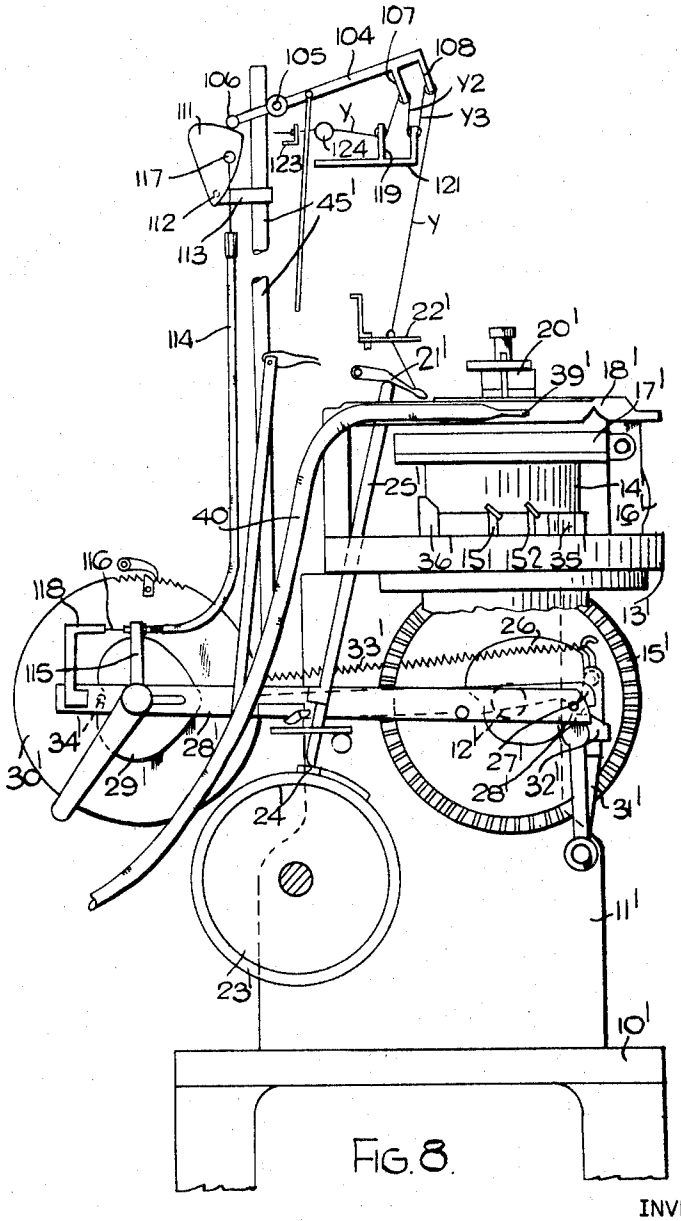



FIG. 8.

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June 11, 1968 D. A. E. MATTINGLY ETAL 3,387,468

CIRCULAR KNITTING MACHINES

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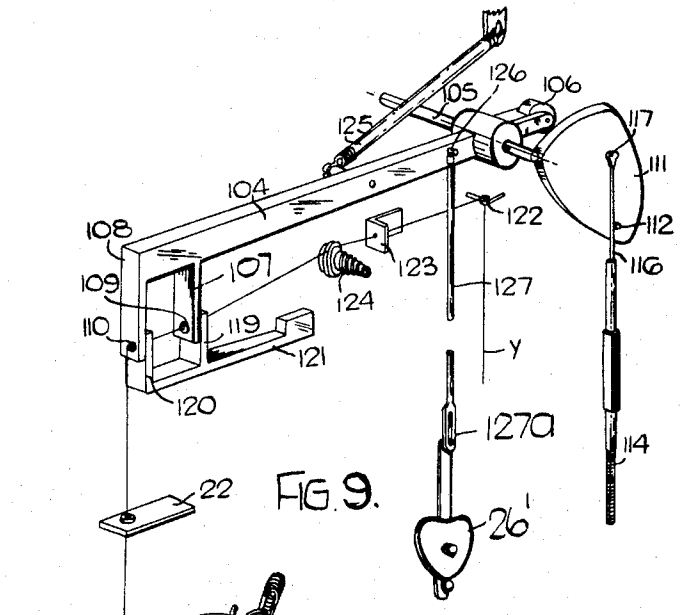



FIG. 9.

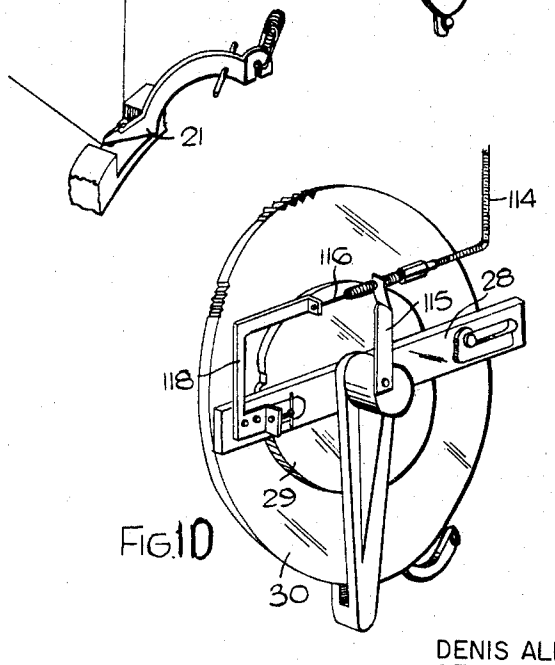



FIG. 10

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June 11, 1968 D. A. E. MATTINGLY ETAL 3,387,468
CIRCULAR KNITTING MACHINES
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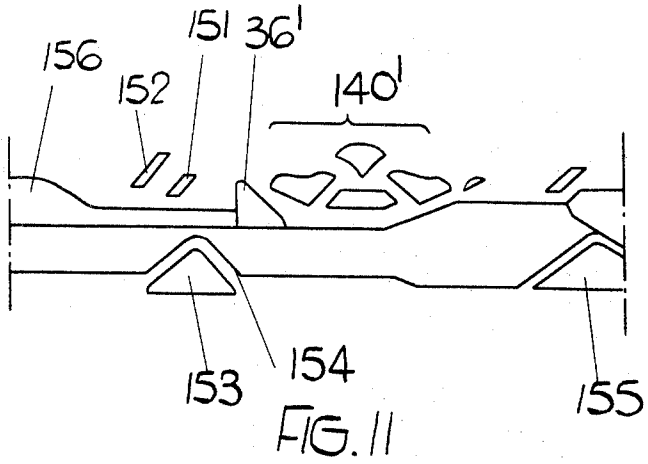


FIG. 11

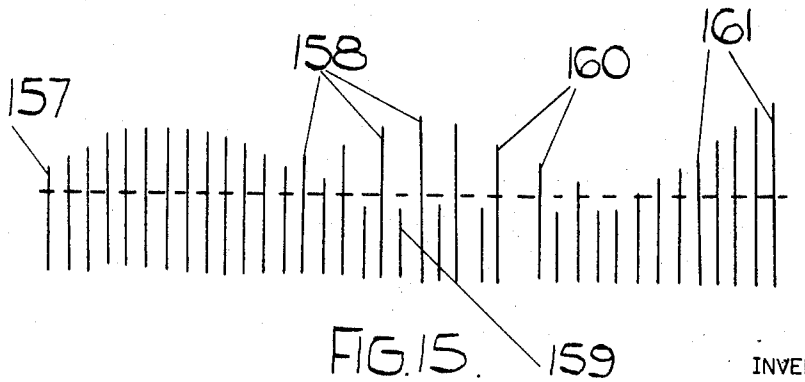


FIG. 15.

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CIRCULAR KNITTING MACHINES

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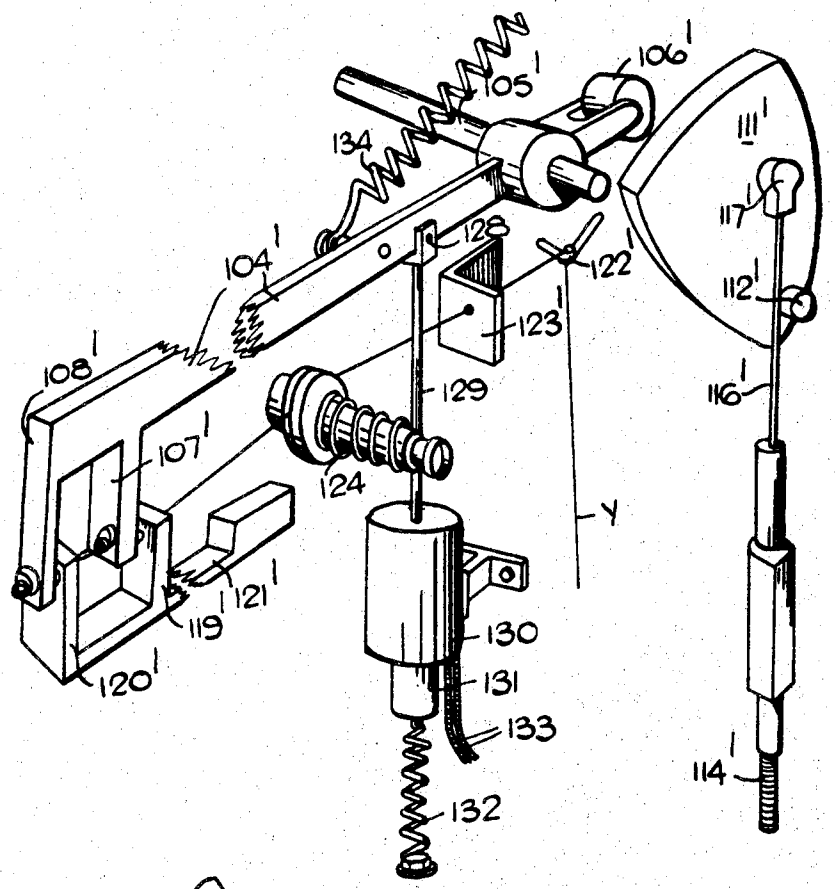



FIG. 12

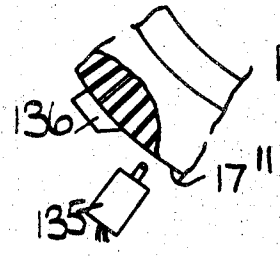



FIG 13

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United States Patent Office 3,387,468 Patented June 11, 1968



3,387,468

# CIRCULAR KNITTING MACHINES

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Continuation-in-part of application Ser. No. 257,393, Feb. 11, 1963. This application Aug. 26, 1966, Ser. No. 575,339

11 Claims. (Cl. 66—133)

## ABSTRACT OF THE DISCLOSURE

A float measuring procedure and apparatus in a circular knitting machine wherein yarn on its way to a beating feeder is drawn out laterally between movable and fixed yarn guiding means to form a measured bight between the feeder and a tension device for the incoming yarn. The yarn length so measured is then drawn through the feeder by suction into a nozzle from which it is guided for presentation to the knitting needles.

This invention is for improvements in or relating to circular knitting machines and the present application is a continuation-in-part of applicants' co-pending patent application Ser. No. 257,393, filed Feb. 11, 1963, now abandoned. The invention has for an object to provide a convenient and effective method and means for controlling the lengths of yarn floats formed when knitting is performed around a part only of the needle circle in a machine of the rotary cylinder type. The invention may be used with advantage for regulating the lengths of floats suitably to enable them to be worked neatly into the knitted fabric during the performance of the knitting operation by continuous rotary action. Such procedure is especially useful in the knitting of seamless hose for incorporating neatly into the fabric, without the need for cropping, floats of a splicing yarn or floats between the ends of part courses used for shaping the fabric.

The invention provides a procedure in the operation of a circular knitting machine for controlling the lengths of yarn floats formed between positions in the knitting circle at which a yarn is withdrawn and reintroduced, comprising the steps of deflecting the yarn into a bight of predetermined length between the yarn supply and the feeder for the yarn and causing the yarn to be drawn through the feeder sufficiently to remove such bight whilst the feeder is withdrawn from feeding position. Thus when the yarn is reintroduced to the needles by the feeder a length of yarn float is determined which is dependent upon the amount of yarn drawn into said bight. In general it can readily be arranged that the length of the float is any length from the diameter of the needle cylinder upwards to any practical requirement. A sufficient length of yarn can be made available in the float for feeding to the needles around any part of the circumference of the needle circle from about one-third to approximately a full circumference. The float length can be varied as required by varying the length of the bight formed in it as aforesaid.

Conveniently in practising the procedure the drawing of the yarn through the feeder to remove the bight is effected by the action of a localised air current, preferably produced by suction, serving to accumulate free yarn at a position adjacent to the needle circle from which it can readily be introduced to the needles. Conveniently when formed into the bight the yarn is drawn from the supply through a tension device and the bight is subsequently released to permit the drag of the localised air current on the yarn to draw it through the feeder, such drag being insufficient to draw the yarn any further through the tension device.



The invention includes the provision in a circular knitting machine of the rotary needle cylinder type of apparatus comprising means for forming a bight in a yarn by deflecting it from its normal path at a position between the yarn supply and a feeder for supplying the yarn to the needles, means for causing the yarn supplied by said feeder to be introduced to and withdrawn from the needles at appropriate times during rotation of the needle cylinder, and means for creating a localised air stream across the needle line beyond the position of said feeder to deflect free yarn extending from the needle circle. The means for creating the bight in the yarn is arranged to be released after formation of a bight and whilst the yarn is withdrawn from the needles before its reintroduction thereto. Preferably the air stream producing means is a suction mouth connected to a source of suction causing air to be drawn into the mouth in the neighbourhood of the needle line.

The deflection of the yarn into a bight of predetermined length may be effected pneumatically, mechanically or electromagnetically, for example by the aid of a piston and cylinder device, a cam operated lever or a solenoid, to actuate a movable yarn guide through which the yarn passes between two fixed guides, so as to deflect the movable guide transversely of the path of the yarn.

The yarn introducing means may be arranged to operate with variable timing for introduction of the yarn to the needles over variable extents of the needle circle, and in the case of a beating feeder may be adjusted progressively by a cam such as an orthodox splicing width control cam. In this case the bight forming means has its stroke correspondingly adjusted so that for a longer length of introduction of the yarn a longer bight is formed in the yarn and vice versa.

The provisions of the invention will be apparent from the following description of convenient ways of carrying out the invention given with reference to the accompanying drawings illustrating examples of mechanism suitable for performance of the invention. In the drawings,

FIGURE 1 is a general elevation view with certain parts omitted and others broken away showing a circular knitting machine of orthodox type fitted with apparatus used in carrying out the invention,

FIGURE 2 is an enlarged perspective view of float measuring means forming part of the apparatus shown in FIGURE 1, seen from the opposite side,

FIGURE 3 is an enlarged perspective view showing a suction device for controlling the yarn,

FIGURES 4 and 5 show diagrammatically in plan view different stages in the control of a formed float of yarn to enable it to be taken up in the knitted fabric,

FIGURE 6 is a somewhat diagrammatic development view of a cam layout as seen from within the needle circle,

FIGURE 7 is a somewhat diagrammatic perspective view, with portions broken away, of details of racking means for varying the lengths of part courses and floats,

FIGURE 8 is a view corresponding to FIGURE 1 showing an alternative form of construction,

FIGURES 9 and 10 together illustrate in perspective on a larger scale control mechanism for a mechanical yarn deflector used in the construction of FIGURE 8,

FIGURE 11 is a view corresponding to FIGURE 6 but showing a cam layout for the machine construction of FIGURE 8,

FIGURE 12 shows in perspective on a scale somewhat larger than that of FIGURE 9 apparatus operated electromagnetically for forming a bight in the yarn,

FIGURE 13 is an enlarged detail fragmentary view showing the operation of a micro-switch,

FIGURE 14 is a view corresponding to FIGURE 9 showing the operation of a pneumatic control valve, and

FIGURE 15 is a diagram showing in elevation part of the paths of needles in the machine construction of FIGURE 8.

The machine selected for illustration and shown in FIGURE 1 is a circular knitting machine of Scott & Williams type and generally orthodox construction adapted for knitting ladies hose, as will be readily understood by persons skilled in the art of knitting machinery. It comprises a base or table **10** carrying a main frame **11** which supports a main driving shaft **12** and cylinder bed plate **13**. A rotary needle cylinder **14** mounted to rotate in an aperture in the bed plate **13**, is driven by a gear wheel **15** on shaft **12** to rotate anti-clockwise as seen from above. Supported by a bracket **16** from the bed plate **13** is a sinker cam ring **17**. Above this is the usual latch guard ring **18** which is pivoted at its rearward part, on the left of FIGURE 1, to a supporting bracket **19** so that it can be raised when required for access to the top of the cylinder within the sinker cam ring **17**. The usual trapping and cutting mechanism indicated generally at **20** is carried centrally at the top of the latch guard ring on a fixed trapper plate over a rotary welt dial mounted within the ring **18**.

For feeding yarns to the needles the machine has a group of yarn feeders positioned on the left of the upper part of the machine, as seen in FIGURE 1, one such feeder being a splicing yarn feeder indicated at **21**. The yarn Y passes downwardly through a fixed guide **22** to the splicing feeder **21**. The feeder **21** is brought into and out of operation in orthodox manner to enable splicing to be performed at different parts of the hose and when operative is rendered active and inactive during each cylinder rotation at variable time intervals wherever part round splicing is required, as at a Cuban heel and under foot areas. The known mechanism by which this is achieved comprises a control drum **23** which is racked around at appropriate times and has a segment **24** (shown much shorter than is normally required) operating through a push rod **25** to hold the feeder **21** in a raised inactive position until required; a cam **26** on main shaft **12** and related follower mechanism for rocking a lever **27** to introduce and withdraw the feeder **21** during part round splicing; a slide bar **28** carrying the lever **27**; and a splicing width control cam **29** on a rack wheel **30** for shifting the slide bar **28** to vary the timing of introduction and withdrawal of the feeder **21**. Such timing variation alters the width of splicing, for instance for shaping the splicing of a Cuban or in a spliced foot bottom near the toe and heel ends. The cam **26** acts on a rock arm **31** to oscillate it and cause a cam projection **32** to rock the lever **27**. The slide **28** is acted on by a spring **33** to hold a follower **34** on the slide against the cam **29**. The same mechanism may act on other instrumentalities to control the action of parts of the trapping and cutting mechanism **20** if required.

On the cylinder bed plate **13** there is mounted a cam ring **35** which supports the needle operating and similar cams (not shown) positioned at the main feeding station which is at the left of the cylinder **14** as seen in FIGURE 1. The cam ring **35** also supports additional needle and jack operating cams at an auxiliary station some of which are shown at **36**, **37** and **38**. The cams at the auxiliary station are related in position to a suction nozzle **39** fitted to and passing through the latch guard ring **18** and connected by a flexible pipe **40** to a source of air suction. The nozzle **39** when operative creates a localised air current across the needle line beyond the position of the feeder **21** so as to draw a length of free yarn extending from the needles across to the outside of the needle circle and take up any slack yarn extending from the needles to the feeder **21** into the throat of the nozzle **39**. The suction in the nozzle holds the yarn in position to be supplied to the needles when acted on by the cams at the auxiliary station in such manner as to cause the yarn to be laid into or knitted into the fabric at that station. This procedure is explained more fully by B. T. R. Reymes-Cole in his U.S. Patent No. 3,120,115, issued Feb. 14, 1964.

The nozzle **39** is a generally flattened tubular member having a top **39***a* and a flat bottom **39***b*, see FIG. 3. The nozzle **39** terminates in a curved opening or suction throat, the left-hand portion T of which is thin and elongated, while the right-hand portion T′ is substantially larger and includes an upper portion T″ above the level of the portion T. Upper portion T″ is formed by an S-shaped fold **39***c* in the top **39***a*.

The nozzle is affixed closely adjacent a plate **41** which is connected to the latch guard ring. As shown in FIG. 3, plate **41** has an opening **42** opposite to, and more or less co-extensive with, portions T′, T″ of the nozzle opening. Plate **41** is slightly inwardly spaced from the nozzle opening so that a gap between the latter and the opposing surface of the plate is provided. As will appear in more detail, a portion of a yarn loop drawn into the parts T′, T″ of the nozzle opening through opening **42** in plate **41** can thus slide to the left (as viewed in FIG. 3) along the bottom **39***b* of the nozzle to the left-hand yarn guiding end **39***d* of the nozzle.

Plate **41** is of elongated form which fits in a recess in the latch guard ring **18** and is curved along the curved line of the latter. The bottom of opening **42** is defined by substantially horizontally extending portions **44**, **44***a* of the plate **41**, the opposing ends of which are spaced apart to provide a slot or gap **43**. The extension **44**, which has a slightly upwardly projecting end, is herein referred to as a "cusp." The nozzle **39** and its plate **41** are shown in FIGURE 3 in relation to a group of the needles N of the needle cylinder **14** and this figure shows how the yarn Y extending from the needles is drawn by the suction into the nozzle **39** to form a loop indicated at L so that slack is taken up in the yarn.

The mechanism for measuring the lengths of floats formed between the ends of the partial courses of the splicing yarn is shown in FIGURES 1 and 2. Mounted on a post **45** which upstands from the frame **11** is a tension bar **46** shown partly broken away in FIGURE 2 at its end which is attached to the post **45**. On the tension bar **46** there is a row of tension devices **47** related to yarns other than the splicing yarn. The tension bar **46** supports from its bent over end **48** by means of a bracket **49** a depending frame comprising parallel side bars **50** and **51** joined by cross members at their upper and lower ends the lower cross member being provided by one end of a trough like tension bracket **52**. The bars **50**, **51** present a slideway along which a slide block **53** can move up and down. This slide block is formed with a yarn guide eye **54**. The block **53** is secured to the lower end of a piston rod **55** carrying a piston **56** which slides in a double acting pneumatic cylinder **57** having air supply pipes **58** and **59** connected to its opposite ends. Thus when air is supplied through lower pipe **59** and the upper pipe **58** is connected to exhaust, the piston **56** is caused to move upwardly and carry the block **53** with it, and with converse energisation the block **53** is lowered to the bottom end of the slideway formed by the bars **50** and **51**.

The tension bracket **52** has at opposite ends upstanding wings provided with yarn guide eyes **60** and **61** between which there is positioned a tension device **62**. Thus as seen in FIGURE 2 the yarn Y from the supply passes first through eye **60** then through the tension device **62** and out through eye **61** from which it extends through the eye **54** and then downwardly through the fixed guide eye **22** and on to the yarn feeder **21**. It will thus be seen that by raising the block **53** a loop of required length can be formed in the yarn between the tension device **62** and the feeder **21**, which loop extends upwardly from the guide eye **61** and down from the guide eye **54**. This

loop supplements the length of yarn extending from the needles to the feeder 21 to provide a required total length of yarn to form a float. The extra length of yarn taken up in forming the loop is drawn through the tension device 62 from the yarn supply. After the formation of the loop lowering of the block 53 will release it and permit a length of yarn corresponding to that composing it to be drawn by air flow into the suction nozzle 39 through the feeder 21 and held in readiness for presentation to the needles of the cylinder 14 in a manner later explained.

To actuate the piston 56 of the pneumatic cylinder 57 the air supply pipes 58 and 59 are connected to an air control valve 70 of known type mounted on the sinker ring 17 where it can be actuated by control cams 70*a* FIGURE 14, to connect for convenience suction pipe 71 either to pipe 58 or pipe 59 in alternate sequence, at the same time opening to atmosphere the pipe not connected to the suction pipe 71. The latter may be connected to the same source of suction as is the pipe 40. The control cams 70*a* are rotated with the needle cylinder 14 and may conveniently be mounted on the sinker bed. These cams are so positioned as to time the operation of the pneumatic piston and cylinder device 56, 57 in the required manner. For example, one cam may serve to connect the pipe 58 to the suction source during a period of activity of the feeder 21 immediately before it is withdrawn from the needles, and the other cam may operate to reverse the connection of the pipes 58 and 59 to release the measured loop formed in the yarn Y after the feeder 21 has been withdrawn from knitting activity and before it is again lowered to the needles.

To measure the length of the loop in the yarn drawn by the movable block 53 stop means is provided to determine the extent of upward movement of the block by engagement therewith. The stop means illustrated is adjustable to vary the extent to which the block 53 can move upwardly so that the lengths of yarn drawn by the measuring device can be made to correspond to the lengths of the partial courses over which the splicing yarn is introduced and can progressively be altered to correspond to variations in extent of such partial courses. To this end the stop means comprises a rotatable ring 63 which encircles the bar 51 and is mounted on an appropriate bearing therearound, which ring has fixed to it at uniformly spaced intervals a succession of stop rods 64 of graded length to provide for the required changes in measurement of the length of the yarn loops formed. In different setting of the ring 63 different ones of the stop rods are positioned in the path of the block 53 and presented endwise thereto to limit its upward stroke of movement. The ring 63 has attached to it a toothed racking ring 65 which is operated on by a pawl 66 on a pawl carrier 67.

Carrier 67 comprises a plate pivotally supported on a post 170 which depends from bracket 49. At its end remote from the pivot, carrier 67 supports a depending post 67*a* to which is connected the center wire 98 of Bowden cable 68, the sheath of which is attached to a bracket 69*a*. Cable 98 is periodically retracted and extended at selected times during knitting, and carrier plate 67 is thereby oscillated about pivot 170. Pawl 66 on carrier 67 is biased inwardly to engage racking ring 65 by a spring 171 which is connected to fixed bracket 69*a*. Accordingly, operation of the Bowden cable 68 and the resultant oscillation of carrier 67 causes pawl 66 to advance rack 65.

Also attached to carrier post 67*a* is the sheath of a second Bowden cable 69. Post 67*a* is suitably bored to permit the passage of a rod 169 which forms an extension of the center wire (not shown) of cable 69. To bluff operation of the pawl 66, the Bowden cable 69 is operated to move the rod 169 against the tail of pawl 66 to rock it against the action of spring 171 out of engagement with the teeth of the rack wheel 65.

FIGURE 7 shows the means for operating the cable 68 and also for racking the splicing width control cam 29. To a gear wheel 72 which forms a standard part of the machine (being a gear which is rotated once for every four rotations of the cylinder 14), there is adjustably attached by a screw 73 a cam segment 74 which co-operates with a followed arm 75 on a lever 76 which is secured to a spindle 77 mounted on bearings 78. The spindle 77 has fixed to its opposite end a lever 79 coupled by a link 80 to a pawl arm 81 on the end of which is a pawl 82 engaging in the teeth of rack wheel 30 to which the splicing width control cam 29 is attached. The rack wheel 30 is mounted on a spindle 83 on which there is also mounted a bluffing plate 84 which can be rocked on the spindle 83 to dis-engage the pawl 82 from the teeth of rack wheel 30 when required so that the pawl 82 will swing idly without advancing the rack wheel 30. The spindle 83 is supported by a fixed bracket 85 from which there depends a fixed arm 86 to which is attached one end of the sheath of a Bowden cable 87 the centre cable 88 of which is connected to the bracket 89 on a slide bar 90 anchored at 91 to a tail of the bluffing plate 84. By operation of the Bowden cable 87 the bluffing plate 84 is brought into and out of operation.

The cam 74 on the gear wheel 72 also co-operates with a follower arm 92 on a lever 93 which is pivoted at 94 to a fixed part. The lever 93 carries a bracket 95 and stop plate 96 fitted with an adjustable stop screw 97 and is arranged to operate the Bowden cable 68 the sheath of which is connected to the bracket 95 and the centre cable of which, indicated at 98, is connected by an adjustable connector 99 to a fixed bracket 100 on an arm 101 mounted on a fixed part of the machine. The lever 93 is urged by a spring 102 connected between a fixed post 103 and the bracket 95 in the direction to engage the follower arm 93 with the cam segment 74. It will thus be seen that in each rotation of the gear wheel 72 the splicing width control cam 30 will be racked round by the distance of one tooth and the ring 63 will be similarly racked round unless the pawls 82 and 66 are bluffed. When bluffing of the pawls is required the Bowden cables 87 and 69 are actuated accordingly at the same time by a suitable control means for example a segment on the control drum 23 or a projection on a timing chain such as is normally provided on the machine.

It will be noted that with the gear wheel 72 rotated anticlockwise as seen in FIGURE 7 the actuation of the follower 92 by the cam segment 74 will precede the actuation of the follower 75 by said cam segment. The actuation of the follower 92 occurs approximately one course ahead of the actuation of the follower 75 to enable the measurement of the yarn loop drawn by operation of the block 53 of the measuring device to anticipate the adjustment of the width of incorporation of the splicing yarn in the fabric at the next partial course over the extent of which the measured float of yarn is to be incorporated in the fabric as will be explained later.

The suction nozzle 39 shown in detail in FIGURE 3 is provided at a position adjacent to an auxiliary feeder station at which there is provided a feeder 142. The latter is mounted on an arm 143 pivoted at 144 to a bracket 145 attached to a fixed part of the machine, the pivot 144 enabling the feeder 142 to be moved between an operative feeding position outside the needle circle to an inoperative position within the needle circle when required. The feeder 142 has associated with it the usual cutter and trapper mechanism (not shown). The feeder 142 supplies a main yarn Y4 to the needles when in operative feeding position. When splicing is being performed the main yarn Y4 is fed to the needles along with the yarn Y from the float the end portion of the float on its way to the needles N being indicated at Y5 in FIGURE 3 and being guided to the needles by the end portion 39*a* of the mouth of the nozzle 39.

The purpose of the particular construction of the nozzle opening and cover plate 41 used herein is to assist

in enabling one arm of the loop L after being taken in the nozzle 39 to pass under the other arm so as to avoid the possibility of a tangle in the loop. Referring to FIGURES 4 and 5 which show very diagrammatically different stages in the controlling of the yarn float, the part of the needle circle at which knitting of the splicing yarn fed by feeder 21 occurs is indicated at 146, the leading end of the arc of splicing knitting being indicated at 147. When the loop is first taken into the nozzle 39 it is sucked through the aperture 42 with its leading end part indicated at 148 in FIGURES 3 to 5 passing from the needles N to above the cusp 44 and into the elevated portion T'' of the nozzle amove the fold 39c. Passage of the leg 148 into nozzle portion T'' is assured by delaying release of the measuring loop (by lowering member 53—FIG. 2) until after the needle from which leg 148 extends has passed the gap 43 in the bottom of plate 41. The trailing end of the loop indicated at 149 is however positioned in portion T' of the nozzle at the right hand end of aperture 42 at a low level. As the needle cylinder rotates beyond the position shown in FIGURE 4 the trailing end 149 of the loop L is required to pass the leading end 148 and it does this by running along the flat bottom 39b of the nozzle, under cusp 44 and then along the slot of the cusp to the feeding end 39a. More specifically, after the slack in loop L has been taken up into the nozzle 39 and as the needle cylinder turns beyond the position indicated in FIG. 4 so that the needle which knits first at the new part course passes the opening 42, the trailing end 149 of the float loop is drawn taut in a condition bearing downwardly. As the leading needle passes further to the left of opening 42, the leg 149 thus is pulled along extension 44a of plate 41, down into slot 43 and then leftward behind cusp 44 into the gap between plate 41 and the nozzle opening to the feeding end 39d of the nozzle.

In due course the leading end 148 of the float has its position controlled by the needle from which it runs passing around the needle circle to a position on the opposite side of that circle which is to the right of the aperture 42. Thus, the float part 148 is caused to move across to the right hand end of the aperture 42. Subsequently, as the needle from which the leg 148 runs passes by the plate 41, leg 148 moves back across part 42 at the bottom of aperture 42 and through the gap 43 as did the leg 149 of the float. The positions of the leading and trailing ends of the float are thus reversed (as required for the feeding of the float to the needles) without risk of entanglement of the different parts of the yarn float. The position beyond the change over is indicated in FIGURE 5 in which it will be seen that the parts 148 and 149 of the loops have become reversed. Subsequently the portion 148 of the loop is drawn across the opening 42 to the right hand end thereof as seen in FIGURE 3 by reason of its connection at 150 to the part course over the arc 146 having moved round to a position which causes the yarn portion 148 to extend at an angle to the nozzle such as to cause it to move to the right hand end of aperture 42. Subsequently as the yarn is drawn from the nozzle on being knitted the portion 148 of the loop will pass under the cusp 44 to the feeding end 39a of the nozzle.

Relevant parts of the cam system of the machine construction illustrated in FIGURE 1 are shown approximately in development view in FIGURE 6 as seen from within the needle cylinder. It will be understood that butts of needles and jacks as normally provided in a machine of Scott & Williams type will during rotation of the needle cylinder pass from right to left of the cam system as seen in this figure. The cams for knitting at the main feed station will be recognised as the group of cams bracketed at 140 and also the raising cam 36 which raises the needles to near or somewhat below tucking height. The cams 37 and 38 at the auxiliary station are bolt cams and during the knitting of the major part of a ladies hose may be out of action completely, or they may be inserted for knitting on two feeds without splicing. When part course knitting of splicing yarn is required to occur (for example with a splicing yarn at the heel and/or under the foot for a hose blank) the cams 37 and 38 are moved in by orthodox bolt cam mechanism operated from the control drum of the machine or by other timing control (or kept in if they are already operative) to a position in which they will engage and operate all of the butts. On the heel needles part course knitting is required to occur at the heel leaving floats extending from end to end of those needles forming the part courses. The raising of these needles by the cam 37 causes them to receive at knitting height in their hooks both the new yarn Y4 from feeder 142 (which is fed to all of the needles) and the last formed float of yarn fed from nozzle end 39d as indicated at Y5. Lowering of the needles down cam 38 then causes them to form knitted stitches so that those carrying the yarn float will knit this along with the new yarn. Subsequently the needles are raised by a cam 141 to tucking height. After partial course knitting has been completed, the bolt cams 37 and 38 may be withdrawn to their inoperative positions by their operating mechanisms.

The operation of the mechanism so far described is as follows. Assuming a hose is being knitted on the machine and knitting has proceeded up to the commencement of a spliced area in which part round splicing is to be performed, the splicing feeder is brought into operation by release of its push rod 25 from the control drum segment 24. The splicing feeder 21 is then brought into and out of knitting activity during each rotation of the needle cylinder 14 by means of the cam 26 acting on the levers 31 and 27. The period during which the feeder 21 supplies yarn to the needles is determined by the position of the slide bar 28 which in turn is determined by the position of the splicing width control cam 29. This will remain stationary or be racked round periodically by the pawl 82 depending on whether the spliced area being knitted is required to be of constant width or variable width. The ring 63 of the measuring device carrying the rod 64 will also remain stationary or be racked round progressively according to whether the cam 29 remains at rest or is progressively racked. Towards the end of each period of lowering of the feeder 21 to feed the splicing yarn to the needles, the pneumatic piston and cylinder device 56, 57 is actuated by suction applied through the pipe 58 to raise the block 53 and draw a loop in the yarn between the guide eye 61 and the yarn guide 22 the yarn so drawn being pulled through the tension device 62 from the yarn supply. The length of the loop so drawn will depend on which of the rods 64 is in position to engage the block 53 and limit its stroke. Matters are so arranged that the amount of yarn drawn into a loop by the movement of the block 53 when added to the length of yarn which must in any case extend from the feeder 21 to the part of the needle circle at which the splicing yarn is withdrawn from the needles will make up just the right amount of yarn for laying into the fabric or knitting into the fabric over the width of the spliced area at the following course of knitting. It will be understood that the level of the nozzle 39 and its position in relation to the feeder 21 are such that shortly after the feeder 21 has been withdrawn the yarn float extending from the feeder will pass over lowered needles to and into the nozzle 39 and will be paid out from the latter across the needle circle so as to pass below the level of the dial during rotation of the needle cylinder.

Shortly after the loop of yarn has been drawn by movement of the block 53 the action of the piston and cylinder device 53, 57 is reversed by applying suction through the pipe 59. This action which may conveniently take place just after the splicing feeder 21 has been withdrawn from the needles, serves to release the drawn loop of yarn. As the cylinder rotates the splicing yarn extending from the point at which it is withdrawn from the

needles passes near to the suction nozzle and is controlled by the localised air stream passing into the nozzle through opening 42 so that the slackness in the yarn is taken up and a loop L of yarn is drawn into the nozzle, as shown in FIGURE 3. This loop is formed through the action of the air stream dragging the yarn through the splicing feeder 21 so as to take up the bight formed in it by the movement of the block 53 which action may be assisted if desired by directing an air current through the yarn tube of the splicing feeder. As aforementioned the leading end of the float passes above the cusp 44, FIGURE 3, whilst the trailing end which extends from feeder 21 passes low down into the right hand end of aperture 42. The cylinder continues to rotate while the splicing yarn is held taut by being looped in the suction nozzle 39 and the splicing feeder 21 is then lowered to feed the yarn Y again to the needles. The reintroduction of the yarn causes the length of the float to be determined and this extends from the point of withdrawal 150 FIGURES 4 and 5, to the point of reintroduction 147 of the yarn with a loop still held in the nozzle 39 to maintain the yarn taut. As the needles at the point of reintroduction move past the mouth of the nozzle 39 they are raised by the cam 37 at the auxiliary station and the part 149 of the float of the yarn Y which leads to the point of reintroduction 147 is fed from the nozzle to the raised needles together with the main yarn from feeder 142 and the needles are subsequently lowered by cam 38 to cause the yarn of the float to be knitted in to the fabric with the main yarn. The part 149 of yarn Y raises under the cusp 44 of the plate 41 and runs to the left hand end of the space between the bottom of the nozzle mouth and the plate 41 being guided to the needles from the end 39*a* of said space. Thus the trailing end of the float is fed to the needles in a direction substantially tangential to the needle circle and taken by needles which at this position have been raised by the raising cam 37.

The yarn float continues to be taken by the needles and drawn from the same end of the said group till only a short length of float remains and extends along the gap and through the opening 42 of the bottom part thereof which is nearer to the feeder. The last length of the float rides under the cusp 44 as previously explained and down the slot 43 and slides under the plate 41 the suction through the narrow gap between the plate 41 and bottom of the nozzle mouth serving to hold the yarn taut against the bottom of the plate 41 till finally taken up by the needles.

At each succeeding rotation of the needle cylinder the same sequence of float formation, measurement by drawing a loop in the yarn before it reaches the feeder, and reintroduction of the float to the needle takes place. When width variation in the spliced area occurs through racking of the width control cam 29 and ring 63 of the measuring device is also racked to vary the length of loop drawn by the sliding movement of block 53. Since the length of float drawn is to be reintroduced to the needles at the course in which the subsequent introduction of splicing yarn by the feeder 21 occurs, it is advantageous to arrange that the yarn measuring device will anticipate changes in the splicing width just before they occur so that the float can be measured to match the change in width. It is for this reason that the cam segment 74 is arranged to operate so as to rack the ring 63 of the measuring device approximately one course before it racks the wheel 30 of the width control cam 29.

In the modified form of construction illustrated in FIGURES 8 to 10 the measuring device is operated mechanically. The bight forming means for the measuring device comprises a lever 104 pivoted at 105 to a bracket attached to the post 45′ and carrying a cam follower 106 at one end, the other end of lever 104 having spaced depending arms 107 and 108 formed with aligned guide eyes 109 and 110, see FIGURE 9. The cam follower 106 co-operates with a cam 111 which forms a measuring cam and is pivoted at 112 to a bracket 113 fixed to the post 45′. Cam 111 is adjustable by means of a Bowden cable 114 the upper end of the sheath of which is attached to post 45′ and the lower end adjustably clamped to a fixed upstanding arm 115, FIGURES 8 and 10. The centre cable of 114 is indicated at 116 and its lower end is connected to a bracket 118 secured to the slide bar 28′, the upper end of the centre cable 116 being anchored at 117 to the cam 111. Thus the cam 111 is stepped round as the position of the slide 28′ is varied by the splicing width cam 29′.

The yarn guides on the arms 107 and 108 co-operate with two similarly fixed spaced yarn guides in upstanding arms 119 and 120 provided on a fixed bracket 121 and are movable into and out of alignment therewith. The splicing yarn Y is led from a supply through a pigtail 122, a fixed guide 123 and a tension device 124 and then on through the guides on the arms 119, 107, 120 and 108, afterwards passing downwardly through the guide 22′ and splicing feeder 21′. Thus when the lever 104 is rocked about its pivot 105 to raise the arms 107 and 108 the yarn Y is formed into two loops or bights Y2 and Y3, FIGURE 8, the extra yarn to form these loops being drawn through the tension device 124 from the supply.

The drawing of the yarn into two loops or bights Y2 and Y3 enables a substantial range of lengths of yarn floats to be measured by a relatively small range of movement of the lever 104. This lever is biased by spring 125 in the direction to tend to hold its follower 106 against the edge of cam 111, that is to say towards the position in which the bights Y2 and Y3 are drawn. The lever 104 has connected to it at 126 a control link 127 which is coupled through a lost motion connection 127*a* to operating means such as a cam 26′ which operates to move the lever 104 downwardly against the action of spring 125 into the position shown in FIGURE 9 in which the guides of movable arms 107, 108 are aligned with the guides on the fixed arms 119 and 120. The cam controlling the action of the link 127 may be cam 26′ or a similar cam which is rotated at the same speed as cam 26′. The timing of the cam control is such that the link 127 is released whilst the splicing feeder 21′ is in active position immediately before it withdraws the splicing yarn from the needles and after a short interval sufficient for the completion of the bight formation the link is operated to return the lever 104 into the position of FIGURE 9 to release the bights in the yarn.

When variable width splicing is being performed the action of the splicing width control cam 29′ in adjusting the slide 28′ will also operate through the Bowden cable 114 to adjust the position of cam 111 which it will be noted determines the extent to which the yarn guides 109, 110 are raised in forming the bights in the yarn to measure the length of float. By suitable shaping of the profile of cam 111 the variation in stroke of the bight forming lever 104 can be correctly adjusted in relation to the length of the periods of activity of the splicing feeder 21′ so that the correct length of float is measured for insertion in the fabric over the width of the spliced area at the next partial course of splicing yarn knitted on the needles.

A modified cam system illustrated in connection with the machine of FIGURE 8 has its cam layout as shown in FIGURE 11. This differs from the cam layout of FIGURE 6 by the fact that, instead of bolt cams 37, 38, provided for knitting in yarn floats, there are substituted bolt cams 151 and 152 adapted to lay in floats of yarn into the fabric by passing the yarn of the floats alternatively in front of and behind knitted loops in the fabric. The cam layout of FIGURE 11 includes the cam assembly 140′ and the raising cam 36′ corresponding to those bearing the same numbers in FIGURE 6. It will be seen that the cams 151 and 152 are both lowering cams for lowering needles which are at different levels.

At the auxiliary feed there is also a jack cam 153 and related cam track 154. It will be appreciated that in a machine of Scott & Williams type provision is made for raising alternate needles by means of jack selection for the purpose of commencement of a hose and welt formation, part of the jack cam used for this purpose being shown at 155 in FIGURE 11. Use is made of the jack selection provision to raise alternate needles in 1 x 1 formation at the auxiliary feed, the alternate needles being acted on through their jacks by jack cam 153 to raise them to tucking height so that their needle butts pass over the cam 151. Such raised needles are subsequently lowered by cam 152 and then pass on to a raising cam 156.

FIGURE 15 illustrates the tops of the needles as seen from outside the cylinder as they approach and pass the auxiliary feed station and shows them all rising from a lowered level indicated at 157 and afterwards passing downwardly to the position at which alternate ones are raised by means of the jack cam 153, the tops of such alternate needles being indicated at 158. The needles that are not so raised are lowered by cam 151 so that the tops of such needles move downwardly as indicated at 159. Subsequently the raised needles are moved downwardly by cam 152 so that their tops follow the path indicated 160 to join the path of the lowered needles. Thereafter all needles move upwardly as indicated at 161. The float of yarn is fed into the hooks of the needles raised as at 158 and at the same time the sinkers are withdrawn as described in B. T. R. Reymes-Cole's U.S. Patent No. 3,120,115. In result the float of yarn is caused to pass in front of the needles into the hooks of which it has been laid and behind the alternate needles which were lowered at that time and at the next knitting station the yarn float is incorporated into fabric by being caused to extend behind alternate loops and in front of the others.

During the procedure just described for laying in the yarn floats instead of knitting them, a yarn feeder such as 142, if provided at the auxiliary feed station, is kept out of action.

In a further alternative arrangement illustrated in FIGURE 12 the operation of the bight forming lever 104' is controlled electromagnetically instead of mechanically. This construction corresponds to that illustrated in FIGURES 8 to 10 differing only in that the mechanical operation through link 127 is omitted and instead the bight forming lever has connected to it at 128 a plunger rod 129 of an electromagnetic device in the form of a solenoid 130. The plunger of the solenoid is shown at 131 and is acted on by a tension spring 132 tending to hold it in lowered position. The coil of the solenoid is energised through leads 133 from a switch such as a micro switch 135, FIGURE 13. This may be mounted on the sinker ring 17'' and be acted on by cam means 136 on the sinker bed at appropriate times during the rotation of the cylinder to energise and de-energise the solenoid 130. When the splicing feeder (as shown at 21' in FIGURE 9) is active and about to be withdrawn the solenoid 130 is energised to raise the left hand end of lever 104' and form the bights Y2 and Y3 in the yarn in the same manner as previously described, the length being determined by engagement of the follower 106' with the edge of cam 111'. Immediately thereafter the solenoid 130 is de-energised and its plunger returned by the spring 132 to release the bights Y2 and Y3 in the yarn so that the yarn is drawn forwardly therefrom through the splicing feeder 21' as previously described. In place of the tension spring 125 there may be a compression spring 134 which assists the action of spring 132 in lowering the left hand end of the bight forming lever 104 when the solenoid 130 is de-energised.

Although in the construction illustrated the invention is applied to a machine in which splicing is performed by means of a beating yarn feeder, it should be understood that the invention is equally applicable to a machine in which what is commonly referred to as needle selection splicing is performed. In the latter case either the normal operating butts on the needles or butts on jacks associated with the needles are used in conjunction with movable cams to select needles that are required to receive or not to receive a reinforcing yarn, the feeder for the reinforcing yarn being placed in such position that only the selected or the non-selected needles are at the proper level to receive such yarn. When the fabric is reinforced or has a splicing produced in this manner, the ring 63 carrying the measuring rods 64 in FIGURES 1 to 4, or the measuring cam 111 or 111' in the constructions of FIGURES 5 to 8 is made to move in conjunction with variations of adjustments made to the needle or jack selecting cam when variable width splicing is performed.

It will be evident that various changes of construction may be made without departing from the invention. For example, the double acting piston and cylinder device, 56, 57 of FIGURES 1 to 7 may be replaced by a single acting piston and cylinder device having spring or other yieldable return means associated with it. Further the invention may be applied to the incorporation into tubular knitted fabric of floats other than splicing floats, for example floats extending between the ends of part courses of a main yarn used in shaping a tubular fabric, or floats formed between ends of part courses of a reinforcing yarn which is introduced in place of a main yarn.

The invention enables floats to be incorporated particularly neatly in the fabric of a knitted tube while the knitting process is being performed uninterruptedly and avoids the need for any subsequent processing for removal of extraneous yarn.

What we claim is:

1. In the operation of a circular knitting machine having a yarn feeder means for causing yarn from the feeder to be knitted in part courses with intervening floats of yarn, and a yarn supply from which yarn extends through said feeder to the needles of the machine, the method of measuring a float formed between part courses, comprising the steps of deflecting the yarn into a bight of predetermined length between said yarn supply and feeder by drawing the yarn from the supply through a tension device, releasing the bight of yarn, and during the intervals between part course knitting of the yarn only drawing the released yarn through said feeder and into a loop between said feeder and needles for incorporation into said fabric.

2. The method defined in claim 1 wherein the yarn is drawn through the feeder and into a loop between the feeder and the needles by the action of localized suction.

3. In a circular knitting machine, the combination comprising a movable needle cylinder having a series of needles, a yarn feeder, means for causing yarn from the feeder to be knitted on some needles only to form part courses with intervening floats of yarn, a yarn tension device, a yarn supply from which yarn extends through said tension device and afterwards through said feeder to said needles, means for measuring a float formed between part courses including means for deflecting said yarn from its normal path into a bight of predetermined length located between said tension device and feeder, means for releasing said bight of yarn, means for drawing said yarn through the feeder and into a loop located between said feeder and needles, and means for causing said float to be incorporated into the fabric.

4. In a circular knitting machine, the combination comprising a movable needle cylinder having a series of needles, a yarn feeder movable between a raised inactive position away from the needles and a lowered active position for laying yarn into the needles, means for moving the feeder, into and out of active position for knitting of part courses with intervening floats a tension device, a yarn supply from which yarn exends through said tension device then through said feeder and to said needles, means for measuring a float formed between part courses includ-

ing means for deflecting said yarn from its normal path into a bight of predetermined length located between said tension device and feeder, means for releasing said bight of yarn, means for drawing said yarn through said feeder when moved to its inactive position by exerting localized suction to form a yarn loop located between said feeder and needles, and means for causing said float to be incorporated into the fabric.

**5.** The combination defined in claim **4** wherein the means for deflecting the yarn into a bight of predetermined length comprises means operable for moving the yarn in a direction transversely of its normal path.

**6.** The combination defined in claim **5** wherein the means for moving the yarn in a direction transversely of its normal path includes a reciprocable yarn guide, and pneumatic piston and cylinder means for actuating said yarn guide thereby to draw and release the bights in the yarn.

**7.** The combination defined in claim **6** wherein means is provided for controlling the stroke of the reciprocable yarn guide thereby to vary the length of the bight formed thereby substantially in direct proportion to the width of the part courses.

**8.** The combination defined in claim **7** wherein the stroke controlling means includes a series of stops each positionable for engaging the reciprocable yarn guide and terminating the movement thereof in bight forming direction in a different position.

**9.** The combination defined in claim **5** wherein the means for moving the yarn in a direction transversely of its normal path includes electromagnetic means operable to draw and release the bights in the yarn.

**10.** In a circular knitting machine, the combination comprising a rotary needle cylinder, a yarn feeder adjacent said cylinder, means causing a yarn fed by the feeder to be taken for knitting over less than the whole of the cylinder circumference to knit the yarn in a succession of partial courses, means for causing variation in width of the partial courses of knitting, a yarn deflecting device to engage the yarn at a position displaced from the needle cylinder and at the yarn supply side of the feeder, a tension device engaging the yarn in advance of said deflecting device, means causing said deflecting device to form bights of yarn of predetermined length by drawing yarn through said tension device and afterwards to release said bight of yarn, suction means for drawing only the yarn so released through the feeder to take up the bights therein formed by the deflecting device, and means for varying the stroke of the deflecting device to vary the length of yarn drawn by the deflecting device progressively in accordance with the variation in length of the partial courses.

**11.** In a circular knitting machine, the combination comprising a rotary needle cylinder, a yarn feeder adjacent said cylinder, a yarn take-up device comprising a suction throat positioned adjacent said cylinder beyond the position of the feeder, means for causing a yarn fed by the feeder to be taken for knitting over less than the whole of the cylinder circumference to knit the yarn in a succession of partial courses, a tension device to engage the yarn on its way to the feeding means, and means for forming a loop of predetermined length in the yarn between the tension device and feeding means by drawing the yarn through the tension device and for subsequently releasing such loop to permit only a length of yarn equal to the released yarn to be drawn through the feeder into the suction throat such that the loop extends between the feeder and needles.

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