Dec. 29, 1970 L. H. COLTON 3,550,402

MANUFACTURE OF KNITTED FOOTWEAR

Filed July 2, 1968

Fig.1.

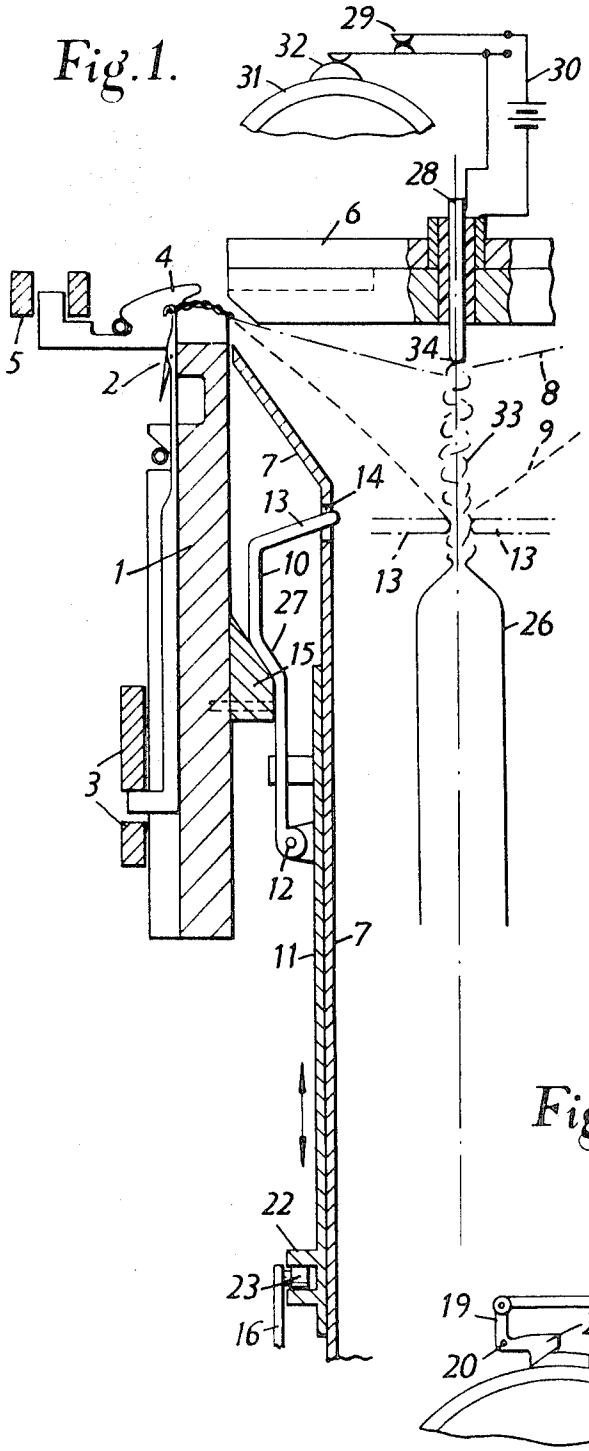


Fig.2.

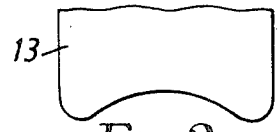


Fig.3.

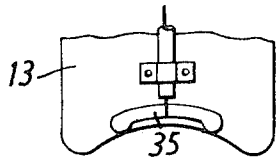


Fig.5.

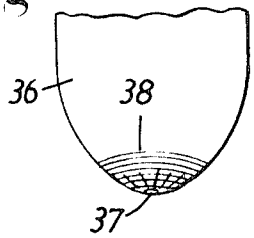
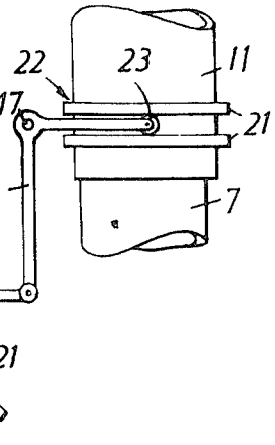


Fig.4.



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MANUFACTURE OF KNITTED FOOTWEAR

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ABSTRACT OF THE DISCLOSURE

A method of and equipment for the manufacture of a stocking having a toe whereof at least the end portion includes thermoplastic yarn. The toe is closed by combined constriction and fusion of the toe fabric. The equipment employed for carrying out this method comprises constriction means for action upon the fabric and heating means adapted to apply to the constricted fabric heat of a degree sufficient to cause fusion of the thermoplastic yarn at the constriction.

The invention relates to the manufacture of knitting stockings, by which is meant in its primary consideration, knitted footwear for women and girls, and shorter articles such as three quarter hose, half hose, and socks, for wear by men, women and children, which initially have open toe ends.

The invention is thus principally concerned with the toe ends of such stockings and has as its object an improved method of and means for closing that end in a much simpler and quicker manner as compared with the conventional methods and machines used heretofore, such as by sewing, linking, looping, or the linkless or loopless toe method, with the commensurate reduction in the costs of production.

In this respect, the invention is applicable to stockings the toe portions of which consist wholly or in part of thermoplastic yarns, such for example as nylon.

Broadly considered, the invention comprises closure of the toe ends by fusion. This includes the application of heat of a degree sufficient to fuse the thermoplastic yarn i.e. reduce it to a fluid state at or/and adjacent to the initially open toe end, whereby loops or stitches of the said yarn are melted together and thus united so that the toe is closed.

According to one manner of carrying the invention into effect, the toe closure is effected by constricting and applying heat to the toe end of the fabric after the latter has been knitted.

In this respect the expression constricting is intended to include "twisting" where the context so admits.

The heat may be externally applied to the toe fabric. Alternatively the heat may be applied internally, i.e. from the interior of the toe.

Accordingly, in one aspect, the invention comprises a method of toe closing, comprising the steps of (a) constricting the fabric so that the toe end is initially tightly closed, and (b) applying heating means to the said constriction thereby fusing the same, and thus completing the closure.

According to one development of the invention the toe closure is effected in the kitting machine by automatically constricting the toe fabric and then automatically applying the heat to the constricted fabric so as to complete the closure.

Preferably the constriction of the toe fabric is effected by twisting it and the heat is applied to the twist to complete the toe closure.

For example, according to one development of the invention applicable to tubular knitted footwear, the toe fabric is constricted and heated as the stocking extends from the needles of the knitting machine. Consequently, the constricting and heating means are with advantage applied to, and thus form components of the knitting machine, so that the stocking extends through the constricting means after leaving the needles while being knitted, and the heating means are arranged for application to the toe fabric externally.

The constricting and heating means may constitute independent component parts of the knitting machine, controlled and operated separately so that they function successively at the required times. Alternatively, the said means may be conjoined so as to constitute a single component but nevertheless controlled and operated so that they are adapted to perform their respective functions in the required timed relation.

Accordingly in one embodiment of the invention the constricting means consist of mechanism including grippers adapted to be automatically closed on the toe fabric and the heating includes an electrical heater in connection with a low voltage circuit adapted to be automatically switched on in delayed timed relation with the operation of the said mechanism.

It follows from the foregoing description that when automatic twisting of the toe fabric is involved there must be rotation—one in relation to the other—of the knitted fabric and the twisting mechanism, as for example in a circular seamless hosiery machine with a rotary needle cylinder on which a knitted article, such as a stocking, is produced complete, apart from the partly open end of the toe pouch remaining when the toe fabric is drawn off the needles.

As it is mainly the intention to carry the invention into practical effect in connection with footwear knitted on circular knitting machines, the constricting means are adapted to be located within the needle cylinder (or the cylinder through which the fabric is drawn off the needles in the case of a machine having co-axially opposed (superimposed) cylinders) so that the fabric passes through the constricting means, whereby when the latter are closed upon the toe fabric and the said means and the cylinder are rotated, either one in relation to the other, the toe fabric is twisted. In such case, the heating means are so arranged as to enable the heat for fusing the fabric to be applied externally as aforesaid.

For instance, in the case of a circular knitting machine having a sinker cap, or a welt dial, formed with a central opening, the heating means are suitably mounted in proximity to the cap or dial so that a rod-like heating element can be located in the opening for contact with the 'constricted' toe fabric.

The constricting means, and the heating means, may be automatically controlled and operating in timed relation either from the main timing or controlling mechanism of the machine, or from an equivalent auxiliary control.

The constricting means may be non-rotatably mounted within a rotary cylinder, so that the constriction is effected by reason of rotation of the cylinder in relation to the constricting means, in which case if necessary appropriate means may be provided for reducing the speed of the cylinder before the constricting means are closed upon the toe fabric.

Alternatively, in an arrangement applicable to either a rotary or a fixed needle cylinder, the constricting means may be mounted for rotation within the cylinder and driven at appropriate times through the medium of clutch or otherwise mechanically controlled gear. In the case of a rotary cylinder the latter may be temporarily stopped, or slowed down when the constricting means are to be operated so that they are rotated at an appropriate speed

in relation to the stopped cylinder or faster than the rotating cylinder.

The following is a description with reference to the accompanying drawings, of particular illustrative examples of the invention as carried into effect in a circular seamless hose machine with a rotary cylinder and a welt dial.

Referring to the drawings:

FIG. 1 is a vertical sectional elevation of so much of the machine as will suffice to show the connection of a constricting component and a fusing component therewith,

FIG. 2 is a fragmentary plan view of a simple constricting jaw,

FIG. 3 is a similar view of a conjoined constricting jaw and a fusing element,

FIG. 4 is a diagrammatic representation of mechanism for operating the constricting component, and

FIG. 5 is a diagram of the toe portion of a stocking with a fused toe end.

The portion of the machine shown in FIG. 1 comprises a rotary needle cylinder **1** with a latch needle **2**, part of a knitting cam system **3**, web holding sinkers **4**, part of the sinker cam system **5**, a rotary welt dial **6**, and an inner fixed tube **7** which forms part of a conventional pneumatic or suction take-up whereby the fabric is drawn off the needles as knitting proceeds. For convenience this figure illustrates alternative methods of toe closure. In one case the fabric is represented by dot and dash lines **8** and in the other case by the dotted lines **9**.

According to the arrangement shown in FIG. 1, the constricting component comprises a plurality of grippers and, concentric with the needle cylinder, a cylindrical support on which the grippers are pivotally mounted. There may be two grippers diametrically opposed on the support, or more than two equi-angularly spaced around the support. Only one gripper **10** is shown in FIG. 1. In the illustrated example the cylindrical support consists of a sleeve **11** which is slidably mounted for movement up and down on the inner tube **7**. As shown each of the grippers is disposed vertically within the cylinder **1** on a pivot **12** located at the lower end of the gripper so that the latter is capable of rocking to move its jaw **13** into and out of the tube **7** which is formed with a corresponding aperture **14** to admit of these movements. A cam ring **15** is mounted on the inner wall of the cylinder **1** and the sleeve **11** is connected with a conventional control mechanism which as shown in FIG. 4 comprises a bell crank lever **16** fulcrumed at **17**, a link **18**, a bellcrank lever **19** fulcrumed at **20**, and a control drum **21** which may be the main timing or control drum of the machine. The sleeve **11** is formed or fitted with a collar **22** to receive a roll **23**, and the lever **19** has a cam formation **24** for action upon by a cam bit **25** on the drum **21**. Thus when the lever is turned by a cam bit, the sleeve **11** is pulled down and the cam ring **15** acts upon the grippers to close their jaws **13** upon the fabric **26** within the tube **7** as represented by the dot and dash lines. The shank of each gripper has an angular formation **27** to conform with the bevel of the cam ring **15**. Upon reverse movement of the control mechanism the sleeve **11** lifts and so frees the gripper from the cam ring, whereupon the grippers open either by self action or under bias provided by spring means or additional weight. The control mechanism on the sleeve **11** may also be similarly biassed to assist the reverse movement. The gripper component so far described is separated from the heating component now to be referred to which consists of an electric heater **28** located generally on the axis of the tubular stocking fabric in an insulated housing in the welt dial **6** or a rib component so that it projects into the needle cylinder **1**, a switch **29** through which the element is connected to a low voltage circuit **30**, supplied with current from any conventional source, and an ancillary control drum **31** with a cam bit **32**, for action upon the switch in timed

relation with the operation of the grippers. If desired the drum **31** may be dispensed with and the bit **32** may be provided on the main drum **21**. With this arrangement of the respective components when the grippers are closed upon the fabric the latter is twisted up as shown at **33** by reason of the normal rotation of the fabric while held by the grippers until it makes contact with the heater element as represented by the dot and dash lines **8**. At or about that instant the switch **29** is closed under the timed influence of the cam bit **32**. Thereupon the element is instantaneously heated to the required degree and thus functions to fuse the twisted fabric at the point **34** to complete toe closure.

In the gripper mechanism just described the jaw **13** of each of the grippers is of the simple flattened form shown in FIG. 2, whereas when the gripping mechanism and the heating component are conjoined, as hereinbefore referred to, a heater element **35** which may be a protected filament is conveniently embodied in each of the jaws as shown in FIG. 3, and connected with the switch mechanism, whereby after the gripper mechanism has moved to grip the rotating fabric the heater elements will fuse the fabric from the outside.

In either arrangement, after fusion the suction take-up mechanism takes the completed stocking away and the fabric remaining on the needles is cast off in the usual way. Any other conventional type of take-up mechanism may be used.

Referring to FIG. 5 which represents a toe portion **36** with a twisted and fused toe closure **37**, the said portion may be formed with a succession of thin courses **38** preparatory to fusion. If desired, in order to reduce the bulk of the toe fabric provision may be made for reducing the number of wales as by needle selecting means to put spaced needles out of action while the toe fabric is being knitted.

The invention is applicable principally to manufacture of seamless hosiery of any conventional kind knitted in the ordinary way mainly from natural or synthetic yarns or mixtures thereof, including stretch yarn singly or is string formation on circular seamless hose machines either initially fashioned or shaped during knitting by varying the quality of the knitting and of the formation of heel and toe pouches by reciprocatory knitting in conventional manner, or in the form of virtually shapeless tubular blanks—the knitted articles being in either case subsequently treated as by pre-boarding, dyeboarding or final boarding or finishing, or plasticising and finishing which eliminates pre-boarding. If extra strength is required in the toe portion, the latter may be reinforced as by the introduction of a splicing yarn, or the substitution of a heavier yarn. Preferably the toe fabric includes non-run courses more particularly in the areas where fusion is effected.

Moreover, the method and means hereinbefore described may be used in association with the manufacture of stockings for women and girls which (briefly) are all of particular standard size—as distinguished from the manufacture of stockings in ranges of different sizes—the characteristic feature being that at least the panel and the foot portion possess an exceptional degree of elasticity and the lower leg portion, or at least, the angle and foot portion are virtually straight, i.e. not shaped except for the closed toe portion, so that the foot portion takes the shape of the wearer's foot only when the stocking is put on, and by virtue of the abnormal degree of stretchability the complete stocking can be pulled up to the required extent so that it virtually moulds itself to the wearer's leg and foot. Such a stocking is produced either by the use of yarns possessing a high degree of elasticity or "stretch," and/or by appropriate stitch formation, and is preferably knitted mainly from highly elastic synthetic stretch yarns such as those twisted, crimped or otherwise treated to enhance the elasticity. The method of making this standard stocking comprises initially forming a tubular blank, vir-

tually straight throughout its length, and then boarding the blank on a form normally shaped to form the upper leg portion, including the panel or calf portion of the stocking, but otherwise straight, i.e. not shaped, so far as the lower leg portion, or at least the ankle portion and the foot portion of the stocking are concerned, except for the toe part which is rounded off to impart the required shape to the toe end of the stocking.

In a machine equipped with a welt dial or a rib component capable of being raised, e.g. swung or lifted axially upwards the heating component may be arranged so as to enable the heater element to be introduced angularly between the said dial component and the needle cylinder 1 for contact with the constricted fabric to effect fusion at the required point. The same may apply to the rib cylinder of a circular knitting machine of the double axially opposed needle cylinder type.

It may be within the scope of the invention to utilize the dial or the rib component as the twisting means by transfer of the toe fabric to welt instruments, or to needles in the rib component, as the case may be, in conventional manner and to provide means for effecting rotation of the needle cylinder and the welt dial or rib component, one in relation to the other through a number of degrees sufficient to twist the toe fabric prior to fusion, with subsequent transference of the toe fabric back to the cylinder needles.

In this respect, if desired, the arrangement may be such that a welt is produced in conventional manner, then twisted to effect wale displacement and fused to complete toe closure.

The expression "heat of a degree" is intended to include any temperature within a range conventionally included in the plastics art for causing thermoplastics to flow and thereby become fused, suchwise that in the case of the toe closure that the latter will not be fused again under normal wear or handling.

It is to be understood from the foregoing description that where the context so admits the expression stocking is intended to include shapeless tubes closed by fusion at one end equivalent to a toe to serve as coverings analogous to stockings as well as to abnormally long legged stocking-type workpieces with leg and foot portions formed integrally with, or separately, and subsequently joined to trunk or waist portions, or themselves cut and joined together to form undergarments conventionally described as panti-hose, tights and so-called hipsters. As regards tights or panti-hose, the legs and the integral upper trunk part may be constituted by the opposite end portions and an intermediate portion respectively of a single, one-piece seamless knitted tube: in this case both ends of such a tube may be closed by the fusion method of this invention.

It is also within the scope of the invention to carry the same into effect in connection with fully-fashioned stockings or stocking-like workpieces consisting initially of blanks produced on flat knitting machines and subsequently seamed together except at the toe ends.

Accordingly in this respect the invention may envisage the provision of an ancillary machine or mechanism comprising a carrier for the workpiece, e.g., a component with a series of loop receiving elements or points, in combination with constricting and heating components, separate or conjoined such as that hereinbefore described, with gears, preferably automatic, for effecting relative rotation of the carrier and the constricting component, i.e. either one in relation to the other, to constrict (twist) the fabric and causing the requisite degree of heat to be applied to the constricted fabric at the required location and time in relation to the constriction.

Moreover the invention is applicable to the manufacture of stockings which are wholly or in part rib knitted, viz with rib tops, panels, insteps, and plain foot bottoms, heels and toes, or other stitch variations well known to those skilled in the art to produce non-run, pattern, or fancy effects, as and where desired as well as to wholly plain knitted stockings.

As will be appreciated the stockings may be knitted toe or welt first and, if desired, entire courses may be introduced adjacent to the toe end if need be, to facilitate constriction and fusion of the toe ends. These extra courses may be removed afterwards to provide a neatly finished comfortably fitting toe portion.

Moreover the invention is to be regarded as including a knitted stocking with a toe end closed by fusion, the method and means, and machines incorporating the said means by which the invention is to be performed.

I claim:

1. A method of closing the toe of a stocking on a circular knitting machine comprising the steps of: producing on needles of a needle cylinder of a circular knitting machine a tubular stocking fabric, at least a portion of which includes thermoplastic yarn; constricting the tubular stocking fabric; while the tubular stocking fabric is on the needles, twisting the tubular stocking fabric by causing relative rotation between the tubular stocking fabric and the needle cylinder such that a twisted portion builds from the constriction in the direction opposite to the direction of travel of the tubular stocking fabric through the cylinder, said twisted portion including at least of some of said thermoplastic yarn; and heating the twisted portion by contacting the twisted portion by a heating element located generally on the axis of the tubular stocking fabric to fuse the thermoplastic yarns a sufficient amount to close the toe.

2. The method of claim 1 wherein the steps of twisting and heating comprise building the twisted portion from a stationary constriction means until it contacts a staionary heaing element.

3. The method of claim 1 wherein the step of constricting comprises closing constricting elements onto the tubular stocking fabric in response to movement of a rotating cam.

4. The method of claim 3 wherein the step of heating comprises applying electrical current to the heating element in response to movement of a rotary cam.

5. A circular knitting machine comprising a needle cylinder, needles mounted in said cylinder, means cooperating with the needles for producing a tubular stocking fabric, at least a portion of which tubular stocking fabric includes thermoplastic yarn, constricting means located within the cylinder through which the tubular stocking fabric is drawn off the needles as knitting proceeds for constricting the tubular stocking fabric at a point corresponding generally to the toe portion of a stocking being formed, twisting means operable when the constricting means is constricting the tubular stocking fabric for effecting relative rotation between the constriction means and the needle cylinder for causing the tubular stocking fabric to twist such that a twisted portion builds from the constriction in the direction opposite to the direction of travel of the tubular stocking fabric through the cylinder and such that the twisted portion includes at least some of said thermoplastic yarn, and heating means located generally within the tubular stocking fabric and generally on the axis of said tubular stocking fabric for heating the said twisted portion to fuse the thermoplastic yarn located therein a sufficient amount to close the toe of the stocking.

6. A circular knitting machine according to claim 5 wherein the constricting means includes cam operated means for automatically closing the constricting means upon the fabric at predetermined time intervals and cam means for applying electrical current to said heating element to heat the same automatically in timed relation to the twisting of the fabric, whereby the heated element contacts the twisted portion of he fabric to fuse the thermoplastic yarns to close the toe.

7. A circular knitting machine according to claim 5 wherein the constricting means and the heating means

constitute independent component parts of the machine automatically controlled and operated separately so that they function successively at required times.

8. A circular knitting machine according to claim 7 wherein the constricting means includes grippers, means for automatically closing the grippers upon the toe portion of the tubular stocking fabric, said heating means being selectively electrically connected with a low voltage electrical source, and means for automatically switching on the source to the heating element in timed relation with the closure of the grippers.

9. A circular knitting machine according to claim 8, wherein the grippers are provided on an apertured cylindrical support concentric with the cylinder through which the stocking is drawn downwardly off the needles, said apertured cylinder being slidably mounted for up and down movement relative to the needle cylinder, a control mechanism for causing said up and down movement, a cam is provided in the cylinder for closing the grippers by actuation of the control mechanism and said heating element is located in an insulated housing and is located generally on the axis of said tubular stocking fabric, whereby when the fabric is twisted, the twisted portion ultimately builds upwardly into contact with the

heating element whereupon the latter is connected to said electrical source to fuse the thermoplastic yarns of the twisted portion and hence close the toe of the stocking.

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