

April 29, 1952

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2,594,521

KNITTED FABRIC

Filed April 18, 1946

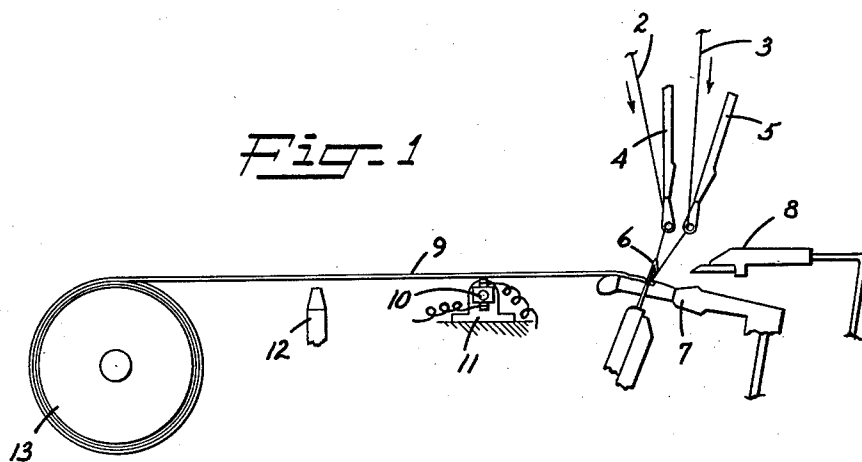


Fig. 3

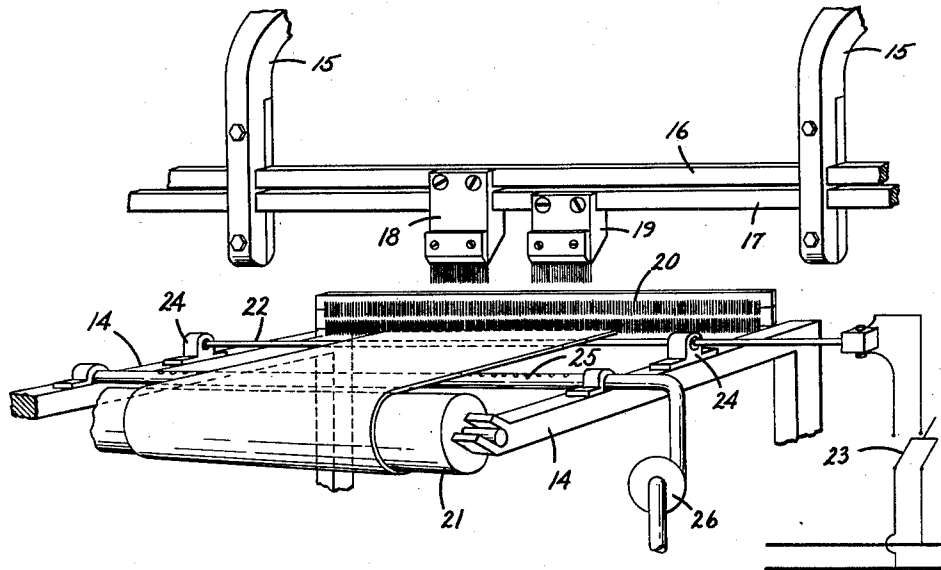


Fig. 2

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2,594,521

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Application April 18, 1946, Serial No. 663,106

8 Claims. (Cl. 28—73)

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This invention relates to knitted fabrics and to a method of manufacturing them. More particularly, the invention relates to stabilized knitted fabrics comprising yarns formed from synthetic resin fibers in which the stitches are bonded or cemented together and are in the original pattern imposed by the needles during the stitch formation, and to a method of manufacturing such fabrics wherein the yarns are knitted in the dry condition.

In the case of fabrics knitted from yarns which are the subject of this invention and comprising the water-insensitive resin fibers of the type of nylon, the vinyl and vinylidene resins, including copolymers of vinyl halides and vinyl esters, copolymers of vinyl chloride and acrylonitrile, polyacrylonitrile, etc., as well as such resins as the polyethylenes, the yarns have a resilient nature and plasticity which causes the loops to have a tendency, during handling, as in the finishing operations, to form distorted stitches and heavy fabric wrinkles. This is further augmented by the fact that the yarns are treated with sizing or softening agents, prior to their knitting, in order to facilitate looping and passage of the yarns through the knitting machine. The knitted fabrics are characterized by limpness and lack of body, rolled edges, and by irregularity of mesh due to excessive stitch distortion during handling thereof.

It has been proposed to improve the stiffness of the knitted fabric by moistening the sized yarns with water as they are fed to or pass through the knitting machines, and subsequently drying out the moisture from the fabricated yarns.

At present, the practice is to treat the sized yarns, that is yarns carrying a softening or lubricating agent, with water, as by running them through water troughs associated with the machines, and glass hoods or other protective devices are provided on the machines for preventing or minimizing evaporation of moisture from the wetted yarns during knitting, the theory being that if the yarns are maintained in the moist condition during knitting, the fabric will become stiffened as the moisture is evaporated therefrom. The difficulty here is that, because the hydrophobic resin fibers do not have the capacity to pick up any appreciable amount of moisture, special water sensitive sizes or softening agents are generally used for modifying the water pick-up capacity of the yarns and insure wetting thereof with the conditioning water. The water-sensitive sizes do not adhere uniformly to the yarns, when the latter are wetted with water, but tend to be

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stripped off and accumulate on the knitting machine parts causing numerous press-offs and deformed stitches. Because the sizes tend to be stripped from the wetted yarns during the knitting operation, any beneficial effect as regards stiffness which might result from drying out of the moistened knitted yarns is offset by the spotty occurrence of the size on the fabric, so that the fabric is not uniformly stiff at all portions thereof. Actually, in addition to necessitating the time-consuming step of wetting the sized resin yarns with water in the vicinity of the knitting machine and the provision of special equipment, the practice of moistening the sized yarns does not solve the problem of manufacturing a knitted fabric having desirable characteristics from yarns comprising the synthetic hydrophobic resin fibers.

The present invention has, as a primary object, the provision of a method of manufacturing a stiff knitted fabric comprising yarns formed from the synthetic hydrophobic resin fibers, the stiffness of which does not depend upon drying out of moisture applied to the yarns prior to or during the knitting operation, the yarns being knitted in dry condition.

It has been found that this and other objectives are attained by sizing or conditioning the yarns comprising the resin fibers, prior to their knitting, with a normally solid substance which is heat-convertible to an at least softened condition which serves as a lubricant for the yarns and facilitates knitting thereof, and which can be softened or melted on the knitted fabric, under the influence of heat, and then set, by subsequent cooling, to a stiff cement-like condition.

The invention involves the steps of applying the normally solid substance to the yarns prior to their knitting, knitting the sized yarns in dry condition, that is, without wetting them with water, heating the fabric immediately after the knitting step to soften or melt the heat-convertible substance, and thereafter cooling the fabric to set the softened or melted substance to a cement-like condition to stabilize the fabric and the substance in intimately bonded relation and stiffen the fabric.

The heat-convertible substance is solid at ordinary temperatures but when heated to a given elevated temperature, softens or melts and tends to spread itself between and around the stitches of the knitted fabric so that, after stiffening or hardening thereof, when the fabric is cooled, the stitches of the fabric are bound to one another by the substance disposed between and around

the stitches in stiff, cement-like condition, the stitches being thus set in the original stitch formation, that is, in the precise pattern imposed by the knitting needles.

Instead of wetting the sized yarns just prior to or during knitting and then relying upon drying out of the fabric to impart stiffness thereto, the yarns are knitted in dry condition, that is without wetting with water, advantage being taken of the inherent properties of the normally solid heat-convertible substance first to lubricate and soften the yarns, and then to stiffen and stabilize the fabric.

The normally solid heat-convertible substance applied to the yarns prior to knitting them in accordance with this invention is a substance which is solid at ordinary temperatures but which softens or melts at a temperature which is sufficiently high to prevent softening or melting thereof to any appreciable extent by the friction involved in passing through the guides, knitting needles, etc., and which, at the same time, is not so high that the heat required to soften them on the fabric is such as to damage the yarns comprising the fabric. Preferably, the normally solid heat-convertible substance softens or melts in the temperature range of from about 100° F. to about 260° F.

There are a number of normally solid heat-convertible substances, or compounds, or mixtures of substances or compounds, which are softened or melted under the influence of heat at the temperatures specified and which may be used in carrying out the invention. Exemplary substances are, for instance, waxes, such as paraffin wax, ceresin wax, carnauba wax, candelilla wax, beeswax, opal wax, etc., or wax-like substances such as stearic acid, palmitic acid, etc.

There may also be used wax-like normally solid substances having a softening temperature in the range of from about 100° F. to about 260° F. and comprising the partial esters of polyhydric alcohols with saturated fatty acids having at least 14 carbons, such as sorbitol distearate. Also, the solid wax-like substance with which the yarns are conditioned, prior to their knitting in the dry condition, may be an ester of an anhydro derivative of a polyhydroxy alcohol with the saturated fatty acids, that is derivatives of polyhydroxy alcohols in which at least one pair of the OH groups have combined to produce a cyclic inner ether; for example esters of glyceride, sorbitan, mannitan, dulcitan, mannide, sorbide, and the anhydro derivatives of such alcohols as hexane pentols, pentols per se, arabitol, or erythritol with palmitic or stearic acid, mixtures of such esters, or mixed compounds such as the technical grades supplied commercially by the manufacturers thereof under the names of the individual compounds. Instead of the waxes and wax-like solids specifically mentioned above, other wax-like solid materials may be used. For instance, the normally solid heat-convertible substance carried by the yarns may be an ester of a polyol-olefine oxide condensation product, for example, esters of condensates of such polyols as glycerol, diglycerol, erythritol, arabitol, sorbitol, mannitol, dulcitol, dulcitan or of related polyols, including the carbohydrates, such as glucose and other sugars, with olefine oxides such as ethylene or propylene oxides. Products suitable for use may be obtained by condensing the selected polyol, or mixture of polyols, with the selected olefine oxide, or mixture of oxides, and then esterifying the condensation product

with a higher saturated fatty acid having at least 16 carbons in a straight chain, or a mixture of one or more of such fatty acids with a relatively small proportion of one or more higher unsaturated acids. In general, it is preferred to use a higher fatty acid ester of a condensation product of a polyol having at least 3 hydroxyl groups with an olefine oxide having not more than three carbons and in which at least 70% of the OH groups are esterified, at least two thirds of the acid radicals in the ester being saturated, and the acid radical having at least 16 carbons in a straight chain. Typical substances of the last-mentioned class which are useful are stearic acid esters of condensates of sorbitol with ethylene oxide containing 4 mols of ethylene oxide and 6 mols of stearic acid, stearic acid esters of diglycerol-ethylene oxide condensates containing 6 mols of ethylene oxide and 4 mols of stearic acid, palmitic acid esters of mannitol-ethylene oxide condensates containing 6 mols of ethylene oxide and 6 mols of palmitic acid, stearic acid esters of mannitan-ethylene oxide condensates containing 6 mols of ethylene-oxide and 4 mols of stearic acid.

These substances, when applied to the yarns formed from synthetic hydrophobic resin fibers, either in the molten condition or from aqueous or non-aqueous media, whichever is most convenient and practicable in the case of any given substance, centrifuging to remove the surplus if needed, and drying, provide firmly adhering coating on the yarns which imparts good running properties, and lubricity to the yarns. The coating is not stripped off during the knitting operation and is uniformly distributed over the yarns in the fabric. In accordance with the invention, immediately after dry-knitting the yarns coated with the normally solid heat-convertible substance, and preferably as soon as the fabric leaves the machine, and immediately of the machine and the take-up, the fabric comprising the dry-knitted yarns is heated to a temperature at which the heat-responsive or convertible substance melts or softens, after which the fabric is cooled to set and stiffen the softened substance, the heating and cooling being advantageously effected in immediate sequence.

Heating of the fabric to soften or melt the heat-convertible substance may be effected by subjecting the fabric to a stream of hot air, by traveling the fabric past a heating element disposed in the path of the fabric as it advances from the knitting machine to a take-up, by passing it over and in contact with a heated surface, between a pair of spaced electrodes associated with the machine, or by exposing it to radiant energy. Also, the fabric may be passed between a pair of heated rotating rolls, in which case the pressure exerted by the rolls may assist in stabilizing and controlling the shape of the fabric and in fixing the at least softened substance thereto.

The fabric carrying the heat-convertible substance in softened or melted condition may be cooled by directing a stream or blast of cool air on the fabric as it passes from the heating zone to the take-up, or the fabric may be cooled while it is on the take-up if desired. Alternatively, the fabric may be allowed to cool as it travels from the heating element to the take-up.

The amount of normally solid heat-convertible substance to be applied to the hydrophobic yarns for accomplishing the objectives of the invention may vary, but generally is in the neighborhood of from 1 to about 10% on the weight of the yarn.

The heat-convertible substance may be removed from the finished fabric or fabricated articles by the usual scouring procedures, or it may be permitted to remain on the fabric as a protective coating therefor.

The knitted fabric is characterized in that the stitches are bonded together and set in the pattern imposed by the knitting needles, as soon as the yarns are knitted, the bonding and setting operations being performed before the fabric is subjected to handling. The presence of the heat-convertible substance in stiffened, cement-like condition on the fabric and between and around the stitches permits subsequent handling of the fabric to any extent necessary and eliminates the problems of yarn slippage, loss of shape of the fabric, and irregularity of mesh such as usually occur when fabrics knitted from yarns of the nylon and "Vinyon" type are handled. The treated fabric is also stabilized against edge rolling or curling. The fabric will remain in stabilized condition throughout the finishing operations.

By subjecting the knitted fabric comprising yarns of the present type, immediately after the knitting operation, to temperatures in the range indicated, and particularly to the higher temperatures in the neighborhood of from about 200 to 260° F., it is possible to effect a setting of the yarns themselves similar to the initial setting of the yarns effected by conventional pre-boarding operations, and such pre-boarding operations may be eliminated, the fabric being dyed directly after knitting thereof, and thereafter given a final shaping and finishing treatment. This possibility of omitting the usual pre-boarding treatments to which the knitted fabric is conventionally subjected in the manufacture of hosiery from nylon, "Vinyon," etc. prior to dyeing, represents a marked saving in the cost of manufacturing the stockings.

Illustrative arrangements for carrying out the invention are shown in the drawing, in which Fig. 1 is a diagrammatic side elevation of one embodiment of the invention in association with a warp knitting machine; and Fig. 2 is a view illustrating the application of the invention to a full-fashioned hosiery machine; and Fig. 3 is a flow diagram.

With reference to Fig. 1 a plurality of yarns 2 and 3 supplied by warp beams (not shown) and which have been coated with a normally solid heat-convertible substance, in accordance with the invention, are shown proceeding to guides 4 and 5 and then to needles 6 and sinkers 7 operatively associated with pressure bar 8 to perform the knitting cycle repeatedly to form a fabric 9. The fabric 9 passes over a heating bar 10 supported in brackets 11 and is heated to the softening or melting temperature of the heat-convertible substance. The fabric then immediately passes over a perforated tube 12 supplied with cool air from a fan (not shown). Thereafter the fabric in which the stitches are bonded or cemented together is forwarded to a take-up beam 13, which is driven in the conventional manner.

In Figure 2, there is shown a flat knitting machine unit, such as is used for the production of full-fashioned hosiery, and comprising the supporting frame 14 and the narrowing frame arms 15 which is rocked in conventional fashion in response to a conventional narrowing cam and associated linkage and carries the bars 16 and

17 which in turn carry the fingers 18 and 19 and are moved longitudinally to narrow or widen the fabric by conventional controlling mechanism. As the fabric proceeds from the needles 20 to the take-up 21, it passes over an electrical heating tube or element 22 having suitable connections with a source of current and controlled by a switch 23. The tube is supported in brackets 24 secured to the frame 14. As the fabric passes over the heating element, the heat-convertible substance is at least softened. The fabric then passes over a perforated tube 25 which is supplied with cool air by blower 26, to set the heat-convertible substance in stiffened cement-like condition to bind the stitches together.

In Figure 3, there is given a flow diagram of the process of the invention. Step 30 is the application of the wax-like conditioning substance convertible by heat to a softened condition; step 31 shows the drying of the conditioned yarn; step 32 represents the knitting; step 33 represents the step of heating the fabric immediately after knitting to soften the conditioning substance; and step 34 represents the cooling of the fabric to set the stitches of the fabric.

It will be understood that changes and variations may be made in carrying out the invention without departing from the spirit and scope of the invention as defined in the appended claims:

I claim:

1. The method of manufacturing fabrics from yarns comprising synthetic resin fibers which consists of the steps of conditioning the yarns for knitting by applying thereto a normally solid, wax-like substance which is convertible by heat to an at least softened condition, drying the conditioned yarns, knitting the dried, conditioned yarns to produce a fabric, subjecting all portions of the knitted fabric, immediately after the knitting operation, to dry heat to at least soften the heat-convertible wax-like substance, and thereafter cooling the fabric to set the softened substance in a cement-like condition to thereby bind the stitches of the fabric together and set them in the original pattern imposed by the needles during the stitch formation, and stiffen the fabric, the softening and stiffening being effected without loss of the wax-like substance from the fabric.

2. A method as in claim 1, wherein the normally solid wax-like substance softens at a temperature of between 100° F. and 260° F., and the knitted fabric is heated, immediately after the knitting, to a temperature in the range of 100 to 260° F.

3. A method as in claim 1, wherein the normally solid wax-like material is a partial ester of a polyhydroxy alcohol with a saturated fatty acid containing at least 14 carbon atoms.

4. A method as in claim 1, wherein the normally solid wax-like material is a partial ester of an anhydro derivative of a polyhydroxy alcohol with a saturated fatty acid containing at least 14 carbon atoms.

5. A method as in claim 1, wherein the normally solid, wax-like material is an ester of a condensate of a polyhydric alcohol with an olefin oxide.

6. A method as in claim 1, wherein the synthetic resin yarns are yarns of a vinyl resin.

7. A method as in claim 1, wherein the synthetic resin yarns are yarns of a copolymer of a vinyl halide and a vinyl ester.

8. A method as in claim 1, wherein the syn-

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thetic resin yarns are yarns of a copolymer of vinyl chloride and vinyl acetate.

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