

## UNITED STATES PATENT OFFICE

2,157,119

## METHOD OF MAKING FABRIC

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No Drawing. Application June 28, 1938, Serial No. 216,409. In Germany February 10, 1938

6 Claims. (Cl. 28—1)

This invention relates to knitted fabrics, and more particularly to the preparation of high quality hosiery from synthetic linear condensation polyamide yarns.

5 An object of this invention is to provide an improved commercial process for making hosiery from synthetic linear condensation polyamide yarns. Another object is to prepare a dyed polyamide stocking by an improved commercial process. Other objects will become apparent as the description proceeds.

10 These objects are accomplished by subjecting a stocking or stocking fabric knitted from a synthetic polyamide yarn to a "board-setting" operation, followed by the steps of scouring, dyeing and reboarding, as well as by other operations that may desired, e. g., finishing and rinsing.

15 The board setting operation which is effected after knitting and before subjecting the fabric to any other treatment involving hot, wet conditions, such as scouring, dyeing or rinsing, consists in positioning the stocking on a smooth, rigid form of such a shape that the stocking will become slightly tensioned when it is subjected to the hot, wet action of a non-solvent swelling agent for the polyamide yarns, preferably hot water or saturated (wet) steam, for a time sufficient to set the yarn in a substantially permanent form. In other words, board setting fixes the character of the needle and sinker loops in the stocking, as formed by the knitting machine. For convenience, this board setting operation prior to any hot, wet treatment of the fabric will hereinafter be referred to as "pre-boarding".

20 The synthetic linear condensation polyamide filaments or fibers used in this invention are described by W. H. Carothers in Patents Nos. 2,071,250, 2,071,251 and 2,071,253. In copending application Serial No. 125,886, filed February 15, 1937, Carothers has shown that his fibers, unlike other artificial fibers, yield knitted stockings fully equal to and under most conditions superior to natural silk stockings in elasticity, clinging properties, freedom from bagginess, and wearing qualities. He attributes these advantages in large measure to the surprisingly good "bending elasticity" of the fibers.

25 The preferred commercial process for dyeing stockings, e. g. silk stockings, comprises rapidly agitating the stockings contained in open mesh bags in a hot, aqueous dye bath. If this procedure is applied to polyamide stockings comprising synthetic polyamide fibers, the stockings develop persistent wrinkles unless special precautions are taken. The reason this difficulty is encountered

is that the hot scouring, dyeing or rinsing treatment applied before boarding tends to "set" in the stockings any wrinkles which are present as well as to set the yarn in the form of needle and sinker loops, and that it is difficult to remove these wrinkles by subsequent boarding. In this respect the synthetic polyamide fabrics differ radically from silk, rayon or other synthetic fabrics. Silk and cellulosic fabrics can be made to assume a given form by wetting, followed by drying while held in the desired shape. One such treatment does not prevent the fabric from assuming a new shape imparted by a second similar treatment. With these fabrics this action is easily reversible and setting takes place during the drying step. With the synthetic polyamide fabrics, on the other hand, setting is accomplished by contact with hot water, steam or other mild swelling agents for the polyamide yarns even in the absence of subsequent drying, and setting is not easily reversible. In other words, the effects of a setting treatment on a polyamide fabric cannot be overcome by a second setting treatment of equal severity. However, if the second treatment is made more severe, e. g., by means of a wet treatment at a higher temperature and/or by a much more prolonged treatment, the fabric can be set in another form quite successfully. Obviously, it is desirable to avoid these drastic or time consuming resetting operations.

30 In practicing the present invention, in order to eliminate this difficulty of resetting, the stocking is first subjected to setting conditions in substantially its ultimate form by the pre-boarding operation. By pre-boarding the stocking for relatively short periods and at easily attainable temperatures, it is possible to subject the stocking to any common commercial scouring, dyeing or rinsing operations without forming persistent wrinkles.

35 Also, in practicing this invention, the knitted synthetic linear condensation polyamide stockings before being subjected to any hot, wet treatment are carefully fitted on to a non-yielding boarding form which holds the stocking in approximately its desired shape. The stocking may be placed on the form wet or dry. If it is placed on the form dry, it is preferable to wet it before the setting treatment and this can conveniently be done by dipping or spraying. While on this form the stocking is given a board setting treatment. As already indicated, this consists in a hot, wet treatment with the liquid or vapor of a non-solvent swelling agent for the polyamide yarn. The degree of swelling produced by the

preferred setting agents, e. g., water and the lower aliphatic alcohols, is small, usually in the range of 1% to 6%. The time of treatment required to secure adequate setting of the fabric will depend upon the temperature and the nature of the setting agent employed. The preferred treatment consists in subjecting the stocking to the action of hot water or saturated steam at a temperature between 95° and 110° C. for a time ranging from about one to fifteen minutes, depending upon the temperature. For example, a one minute treatment with saturated steam at 100° C. is approximately equivalent to five minutes' treatment with water at 95° C. The degree of setting in a given time is roughly a linear function of the temperature.

Since pre-boarding is the first hot, wet treatment applied to the polyamide stocking fabric, it determines to a large degree the permanent characteristics of the stocking. In other words, pre-boarding is a controlling setting treatment, the effects of which are not destroyed by the normal treatments subsequently applied to the stocking.

After the pre-boarding step, the knitted fabric, for example a stocking, is scoured, e. g., to remove finish, being then dyed upon being subjected to a bath containing a suitable dye, both the dyeing and scouring operations normally taking place at an elevated temperature, e. g., 80° to 100° C. The fabric is rinsed, treated with a suitable finish, and is wrung to remove excess liquid. During the treatments subsequent to pre-boarding, the fabric will acquire superficial wrinkles, i. e., wrinkles which may easily be removed, and for this reason, the fabric is subjected to a boarding operation, in which the fabric is placed over a non-yielding boarding form, wet with water if desired or treated with steam, and in any event dried on the form whereby to acquire a neat, unwrinkled appearance. This step is called reboarding for convenience and is intended to include within its scope any equivalent treatment, such as ironing, which will eliminate distortions or wrinkles temporarily induced in the fabric subsequent to pre-boarding.

Stockings produced in accordance with this invention as indicated above are substantially wrinkle free and present an excellent appearance. The stockings are characterized by excellent loop formation and elastic properties since the yarn has been set in the loop formation before it has had much opportunity to slip and slide in an effort to straighten out. The stockings of this invention can also be laundered and dried repeatedly without materially destroying their good appearance.

The following examples illustrate my invention in greater detail. The yarns used in these examples were prepared from polyhexamethylene adipamide, the polymer derived from the condensation polymerization of hexamethylene diamine and adipic acid. The yarns were made up of oriented fibers obtained by cold drawing filaments spun from the polymer to approximately four times their original length.

#### Example I

Yarns are prepared in the following constructions:

45 denier—15 filament—20 turn Z twist—dull  
69 denier—23 filament—10 turn Z twist—dull  
135 denier—45 filament—10 turn Z twist—dull

Following twisting, these yarns are exposed on pirns to air at 76° C. and 78% relative humidity

for one hour to reduce the liveliness of the twist. This procedure makes it possible to perform the subsequent operations of coning and knitting successfully in spite of the high twist in the yarn. These yarns are then knit on a full-fashioned hosiery machine to dimensions as determined by trial. The yarn, in knitting, is passed over a wick or roller moistened with water or through water in the traditional manner. The 69 denier yarn is used for the welt, heel, sole, and splices. The 45 denier yarn is used for the leg and instep, which are knit with a three-carrier setup. The 135 denier yarn is used for the toe. Following knitting, the stocking is looped and seamed in the customary manner. The completed, undyed stocking is now moistened with water at 20° C. and is carefully fitted over a metal hosiery boarding form. This form is then placed in a closed chamber to which a sufficient amount of saturated steam is admitted to elevate the temperature quickly to 100° C. and to maintain it at that temperature thereafter. After five minutes' treatment, in this chamber at 100° C. the stocking is removed, allowed to cool, withdrawn from the form and subjected to the normal operations of scouring, dyeing, rinsing, finishing (with splash-proof finish), wringing, and reboarding.

#### Example II

The yarns used are:

50 denier—20 filament—7 turn Z twist—dull  
75 denier—30 filament—7 turn Z twist—dull  
125 denier—50 filament—7 turn Z twist—dull

The yarns are coned after twisting and are knitted without further treatment into a fabric of predetermined size. The operations of looping and seaming are normal and the stocking is exposed on a boarding form in a steam chamber as in Example I, but using only sufficient steam to elevate the temperature to 95° C. After 15 minutes exposure to this hot, wet treatment, the stocking is removed from the form and then scoured, dyed, finished, wrung, and reboarded in the normal manner.

#### Example III

Yarns of the following constructions are prepared:

18 denier—10 filament—7 turn Z twist—dull  
75 denier—30 filament—7 turn Z twist—dull  
125 denier—50 filament—7 turn Z twist—dull

The twist of the 18 denier yarn is increased to 40 turns Z, and two ends of this yarn are then plied with 26 turns S twist to form the yarn for knitting the leg and instep. The 75 denier yarn is used for the welt and splice, and the 125 denier yarn is used for the toe.

The stocking is knit wet with a single carrier, looped and seamed normally. It is then placed on a stocking form and subjected to the action of boiling water for 5 minutes. It is then removed from the form and subjected to the normal scouring, dyeing, finishing, wringing, and reboarding operations.

#### Example IV

Yarn is prepared in the following constructions:

30 denier—10 filament—25 turn Z twist—dull  
69 denier—23 filament—10 turn Z twist—dull  
135 denier—45 filament—10 turn Z twist—dull

The 30 denier yarn is used for leg and instep, the 69 denier yarn for splice and welt, and the 135 denier yarn for the toe. The liveliness of the twist is removed as in Example I and the yarns

are knit with a single carrier, looped and seamed normally. The stocking is then placed on a form and exposed to saturated steam under pressure at 105° C. After the stock and form have reached the temperature of the steam, they are maintained at this temperature for 2 minutes. The stocking is then removed from the form and subjected to normal scouring, dyeing, finishing, wringing, and reboarding operations.

#### Example V

The yarn used in this stocking is 160 denier—60 filament—7 turn Z twist—bright. It is coned directly after twisting without further treatment and is knit on the machines normally used for the preparation of men's half hose, giving a ribbed top and plain leg. Cotton yarn is used for the heel, welt and toe. The stocking is then placed on a suitable boarding form and is subjected to treatment with hot water at 96° for 15 minutes. The stocking is then boiled-off, dyed, finished and reboarded in the normal manner.

#### Example VI

Yarn is prepared of the following counts:

45 denier—15 filament—20 turn Z twist—dull  
69 denier—23 filament—10 turn Z twist—dull  
135 denier—45 filament—10 turn Z twist—dull

This yarn is coned, following twisting, without further treatment, and is knit dry on a circular knitting machine of the type commonly used for the production of seamless hosiery, using the 45 denier yarn for the leg, the 69 denier yarn for the welt, sole, and heel, and the 135 denier yarn for the toe. The stocking is then placed on a boarding form of essentially the same shape used for full fashioned hosiery and is exposed to steam under the conditions described in Example II. The completed stocking is then removed from the form, scoured, dyed, finished, wrung and reboarded. By means of the setting in the shape of the boarding form produced in the preboarding operation a circular knit stocking is obtained which has a permanent shape similar to that of a full fashioned knit stocking and this shape is not lost when the stocking is washed. The stocking had remarkable elastic and clinging properties, returning to its boarded shape after distortion.

Although the examples described in this invention have reference to stockings knitted from polyhexamethylene adipamide, it is to be understood that it is not to be so limited. The invention is applicable to stockings made from other synthetic linear condensation polyamides, interpolyamides, or mixtures of polyamides. As additional examples of such polyamides might be mentioned polytetramethylene sebacamide, poly-pentamethylene adipamide, polypentamethylene sebacamide, polyhexamethylene suberamide, polyhexamethylene sebacamide, polyxylylene sebacamide, polymerized 6-amino-caproic acid, and polymerized 9-aminononanoic acid. There may also be used modified polyamides such as those derived from the condensation polymerization of polyamide-forming reactants containing another bifunctional reactant, such as a glycol or hydroxy acid. As examples of such polyamides might be mentioned those derived from a mixture of diamine, dibasic acid, and glycol, or those derived from a mixture of amino acid and hydroxy acid. The various polyamides referred to in this paragraph are all included under the term "synthetic linear condensation polyamide". By the term "linear condensation polyamide" I mean to designate polyamide compounds of the types herein

disclosed and their equivalents, whether or not such compounds are produced by chemical condensation or by some other process.

In making polyamide stockings according to the process of this invention, it is preferred to use yarn which has not been subjected to any hot, wet shrinkage treatment which has a strong setting effect on the yarn. This does not mean that the invention is restricted to the use of unshrunk yarns. Yarns which have been shrunk by processes which do not set the yarn with respect to the subsequent board setting step can be used. A suitable shrinkage treatment of this type consists in exposing the yarn to a dry temperature of about 150° C. for a short time in a condition which allows it to decrease in length.

It will be understood that the stocking can be made from single yarns or yarns of any desired denier and filament count at any twist; or that several threads can be plied and twisted in the usual way. It is preferred to use a yarn the twist of which has not been set by a drastic setting process for reasons similar to those given above. However, mild treatments to reduce the liveliness of the twist which do not set the yarn are desirable. This may be done conveniently as illustrated in Example I or by the application of a suitable size or finish.

It will also be understood, of course, that the threads or yarns may be coated with a finish or size in any manner suitable for the textile operations to be employed. It is sometimes advantageous to lubricate them by the addition of a suitable oily substance such as a sulfonated oil, sulfated alcohol, soap and paraffin oil, or with similar soaplike materials. Sizing compositions such as a mixture of glue and sulfonated olive oil may also be used. Hygroscopic materials, such as glycol, diethylene glycol, glycerin, etc., may also be used. It has been found that water is a very effective softener. At least, wet yarns knit more readily than dry yarns.

It has been indicated in the examples that bright yarns or delustered yarns may be used. Various materials may be used as delusterants, e. g., titanium dioxide. Yarns containing any of several modifiers as may be desired for different purposes may also be used. Although it is generally desirable to prepare the stocking from yarns derived from straight, continuous polyamide filaments, it is within the scope of the invention to prepare the stocking from yarns consisting of crimped polyamide filaments. Staple fibers, whether straight or crimped, can also be used in making the stocking. It is also within the scope of the invention to use yarns containing in addition to polyamide filaments some silk, wool, cotton, or artificial fibers. The preferred stockings, however, are made entirely of synthetic polyamide filaments.

While it is preferred to knit the stockings on a full-fashioned hosiery machine with a single carrier, it is clear that several carriers or a circular knitting machine may also be used, as is well understood in the art. Since the polyamide yarns are very strong and elastic, a very tight knitting under considerable tension may be used, if desired, and a very dense knitted structure produced.

While it is normally preferred to use a boarding form of the same size and shape for both pre-boarding and after-boarding, it has been found for certain purposes where a stocking of extreme extensibility is desired that the pre-boarding operation can be carried out on a form

somewhat smaller than that used for the after-boarding. For example, the form used for the pre-boarding may be uniformly reduced in its dimensions from 2.5% to 10%. If, however, increased extensibility of only the leg is desired, then it is necessary to reduce only the dimensions of the leg portion of the form leaving the foot portion unchanged. Reductions of 2.5% to 5% in dimensions are especially desirable.

While the examples illustrate the use of hot water or saturated steam as setting agents in the board setting operation, this invention is not so limited. Instead of water or steam, other liquids may be used which have a mild swelling action on the filaments under the conditions employed. Hydroxylated non-solvents for the polyamides are particularly useful as setting agents. Examples of such substances are methanol, ethanol, propanol, and isopropanol. Aniline can also be used as a setting agent. Mixtures comprising one or more of these substances with or without water may also be used. The temperature and period of exposure necessary to set the thread will vary depending upon a number of factors including the substances used and the yarn employed.

Although the examples have illustrated the use of boarding forms initially at room temperature, pre-heated forms may be used to raise more quickly the temperature of the boarded stocking to the temperature of its surroundings. Forms heated from the interior by means of gas, electricity, steam, etc., to expedite the boarding operation may also be used. Similarly, the boarding form may be perforated to permit the egress of hot or cold water and/or steam or other setting agents to wet the boarded stocking or to maintain it in a hot, wet atmosphere.

For convenience, the manufacture of stockings has been discussed. It will be understood that this invention is equally applicable to the manufacture of knitted structures generally wherein a finishing or after-treatment comparable to that used in making stockings is applied to the knitted structure.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not to be limited to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. The process of fabricating knitted goods

containing synthetic linear condensation polyamide fibers which comprises knitting yarns comprising said fibers, pre-boarding the knitted goods, thereafter subjecting the goods to a hot liquid treatment, then re-boarding the goods whereby to impart to the goods a smooth, wrinkle free appearance.

2. The process of fabricating hosiery containing synthetic linear condensation polyamide fibers which comprises forming hosiery from yarn comprising said fibers, pre-boarding the hosiery, thereafter subjecting the hosiery to a hot liquid treatment, then re-boarding the hosiery whereby to impart to the hosiery a smooth, wrinkle free appearance.

3. The process of fabricating hosiery containing synthetic linear condensation polyamide fibers which comprises forming full-fashioned hosiery from yarn comprising said fibers, pre-boarding the hosiery, thereafter subjecting the hosiery to a hot liquid treatment, then re-boarding the hosiery whereby to impart to the hosiery a smooth, wrinkle free appearance.

4. The process of fabricating hosiery containing synthetic linear condensation polyamide fibers which comprises forming hosiery from yarn comprising said fibers, pre-boarding the hosiery, thereafter dyeing the hosiery by contact with a hot dyeing solution, then re-boarding the hosiery whereby to impart to the hosiery a smooth, wrinkle free appearance.

5. The process which comprises fabricating hosiery comprising synthetic linear condensation polyamide fibers which comprises knitting yarn comprising said fibers, forming full-fashioned hosiery from the knitted goods so formed, subjecting the hosiery to a pre-boarding operation, scouring and dyeing said hosiery, then subjecting the hosiery to a re-boarding operation whereby to impart thereto a smooth, unwrinkled appearance.

6. The process which comprises fabricating hosiery comprising synthetic linear condensation polyamide fibers which comprises knitting yarn comprising said fibers, forming full-fashioned hosiery from the knitted goods so formed, subjecting the hosiery to a pre-boarding operation, scouring, dyeing, finishing and wringing said hosiery, then subjecting the hosiery to a re-boarding operation whereby to impart thereto a smooth, unwrinkled appearance.

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