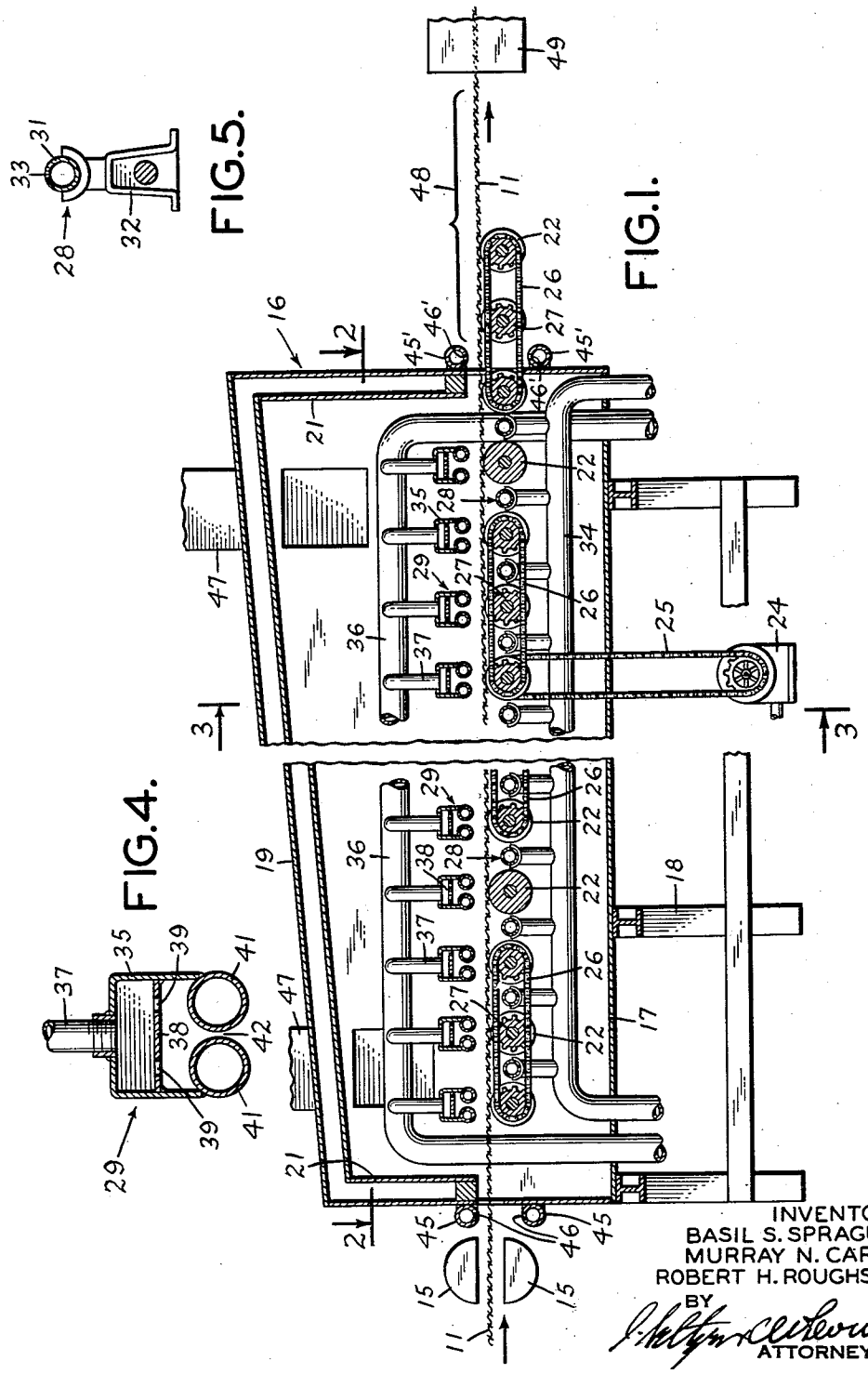
Jan. 15, 1957 B. S. SPRAGUE ET AL. 2,777,750

PROCESS OF STABILIZING THERMOPLASTIC KNITTED FABRIC CONTAINING CELLULOSE ESTER YARNS WITH SUPERHEATED STEAM

Filed Nov. 13, 1952 3 Sheets-Sheet 1



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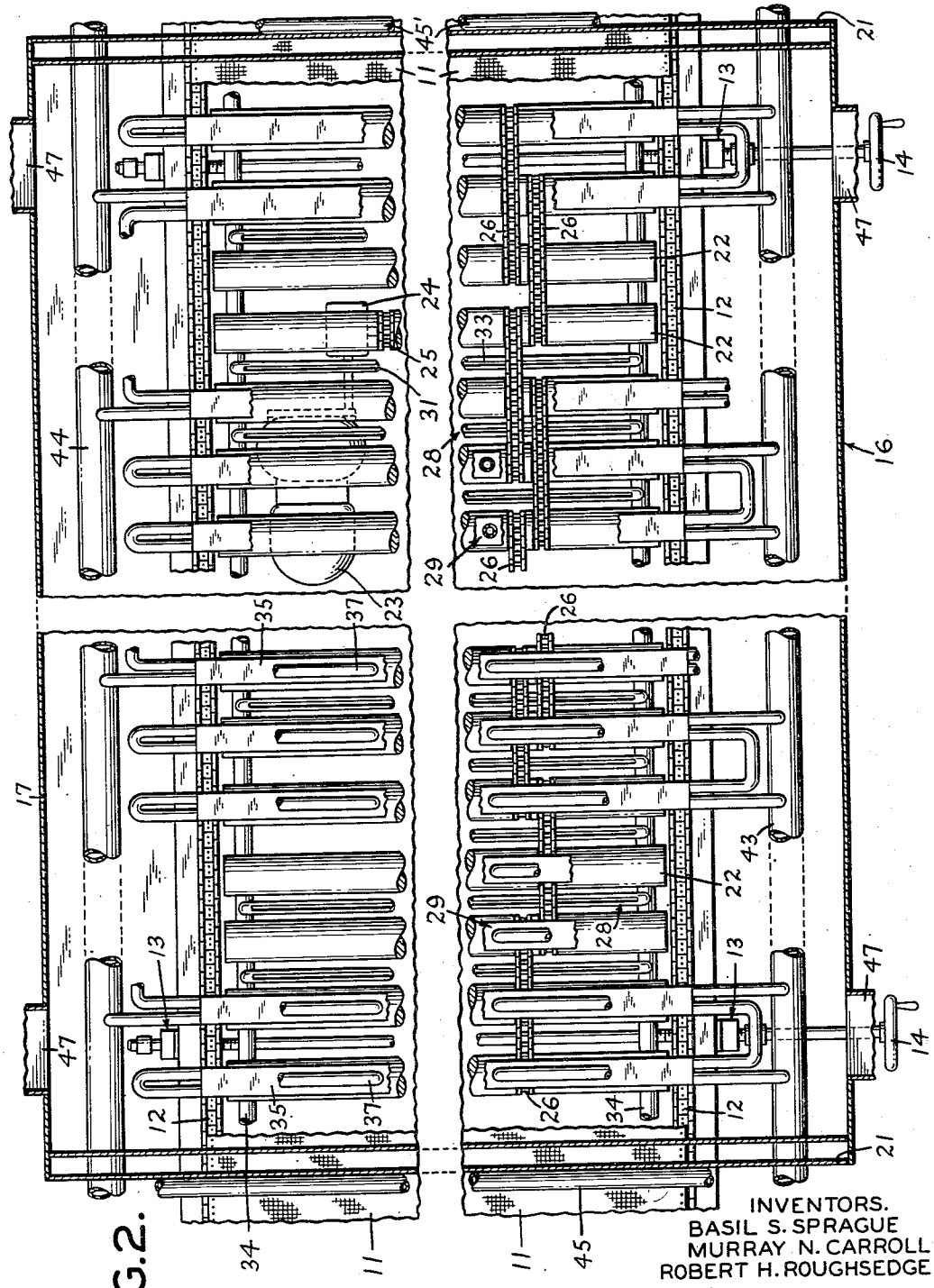


FIG. 2.

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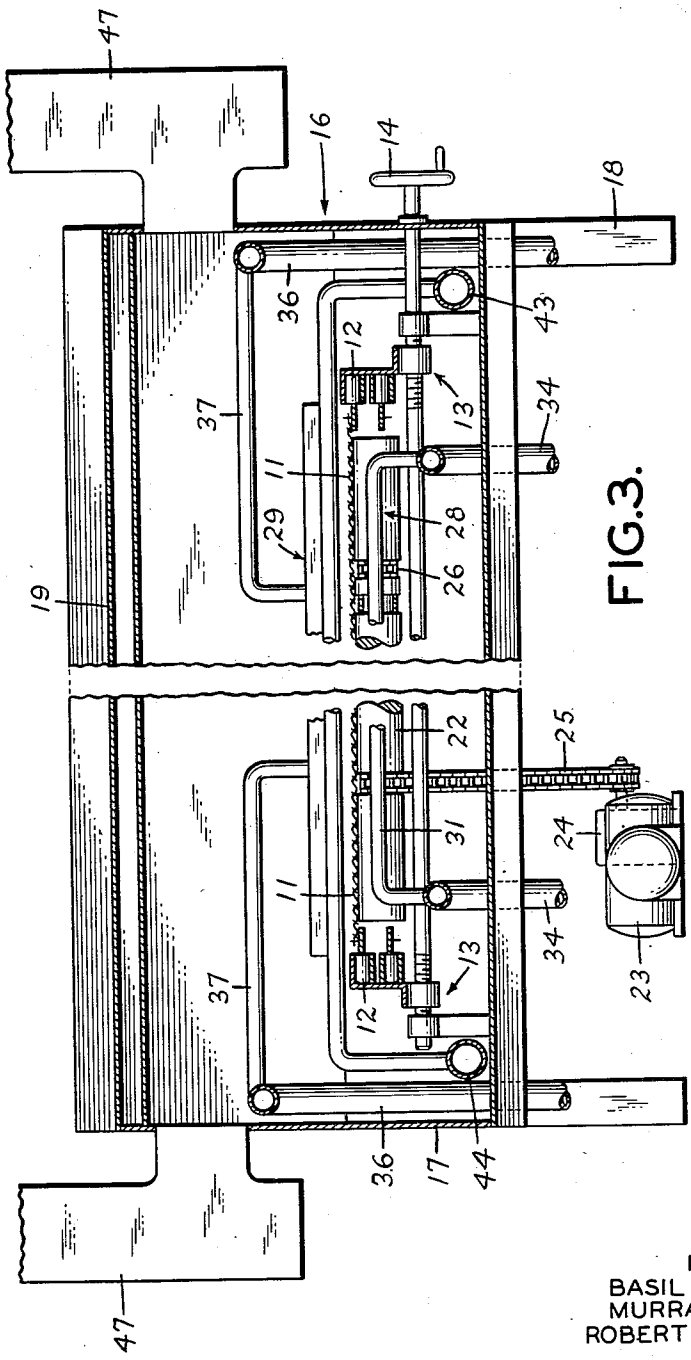


FIG.3.

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PROCESS OF STABILIZING THERMOPLASTIC KNITTED FABRIC CONTAINING CELLULOSE ESTER YARNS WITH SUPERHEATED STEAM

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Application November 13, 1952, Serial No. 320,282

9 Claims. (Cl. 8—131)

This invention relates to the treatment of textile fabrics and relates more particularly to a process and apparatus for the treatment of knitted fabrics containing yarns of cellulose acetate or other organic acid esters of cellulose.

It has long been known that knitted fabrics containing yarns of cellulose acetate or other organic acid esters of cellulose exhibit a certain degree of dimensional instability when subjected to laundering processes. When garments made of warp knitted cellulose acetate are laundered in water at 140° F. and then dried without stretching, their dimensions may change as much as 30% in width and 10% in length, the "length" direction denoting the direction in which the fabric is formed during knitting. The extent of such dimensional change depends, in part, on the manner in which the garment is finished after laundering, i. e. ironing or pressing. Mainly, however, the extent of dimensional change depends on the previous treatment of the fabric, for example the treatment of the fabric during and after the scouring and dyeing operations. Customarily these scouring and dyeing operations are conducted in hot aqueous baths. If the wet knitted fabric leaving such baths is dried without stretching, the resulting fabric is commercially unacceptable for most uses, since the wales of the fabric are drawn together and are directly in contact with one another, thereby greatly reducing the width of the fabric. Accordingly, it has been customary to treat the wet fabric coming from the dyeing operation by stretching it on a tenter frame and drying it, while stretched, to a low moisture content, such as a moisture content of less than 6% based on the bone dry weight of the fabric, i. e. less than 6% regain. This process introduces internal stresses into the yarns comprising the knitted fabric, and when the fabric is laundered, or subjected to other wetting and mechanical working treatment, the fabric tends to return to its former configurations and dimensions. Such dimensional change is manifestly undesirable.

It is an important object of this invention to provide a process and apparatus for the treatment of knitted fabrics containing yarns of cellulose acetate or other organic acid esters of cellulose which will overcome the foregoing and other difficulties and which will be especially efficient in operation.

A further object of this invention is the provision of a process and apparatus for the treatment of knitted fabrics containing yarns of cellulose acetate or other organic acid esters of cellulose which will impart to said fabrics a high degree of dimensional stability.

Other objects of this invention, together with certain details of construction and combinations of parts of the apparatus, will be apparent from the following detailed description and claims.

According to the present invention, a knitted fabric containing yarns of cellulose acetate or other organic acid esters of cellulose carrying a film of liquid water is raised to an elevated temperature in a gaseous atmosphere, preferably of steam, while the fabric is held to a definite width and while the fabric is supported throughout substantially its entire area. The wet fabric is maintained at the elevated temperature until the cellulose acetate or other organic acid ester of cellulose of which the yarns are composed is swollen and any internal stresses in the yarns are released, but care should be taken so as not to cause the yarns or the fibers making up the yarns to fuse or coalesce one with the other. During this treatment the moisture content of the fabric should not fall below its saturation regain value, which is defined as the moisture regain value of the fabric in contact with an atmosphere of 100% relative humidity at the temperature of the fabric. The fabric is cooled and, if desired, dried. Following this treatment, it is found that the fabric exhibits a high degree of dimensional stability so that garments made of said fabric will, from a practical viewpoint, retain their shape and dimensions substantially unchanged during normal use.

In our preferred procedure, a wet knitted fabric of cellulose acetate is subjected to superheated steam, and the moisture content of the fabric before contact with the superheated steam and the time of contact with the superheated steam are so regulated that the excess surface moisture on the fabric is not completely evaporated and the moisture content of the fabric does not fall below its saturation regain value. That is, despite the evaporation of some of the water due to the drying effect of the superheated steam, an excess of water is maintained on the surface of the yarns throughout the exposure to the superheated steam. The presence of this excess of water is critical. If the moisture content of the fabric is below the 100° C. saturation regain value when it is first placed into contact with the superheated steam, adequate dimensional stability will not be obtained. If, on the other hand, through evaporation the moisture content drops below the saturation regain value during contact with the superheated steam the yarns of cellulose acetate will deluster.

Since the 100° C. saturation regain value of cellulose acetate yarns is generally about 14% to 16%, the fabric advantageously should have a water content prior to steam treatment of at least about 20% by weight, preferably at least 50% by weight, based on the weight of the dried fabric, to insure that the water content of all portions of the fabric is above the minimum value, thereby avoiding "dry spots" whose dimensional stability will differ from that of the remainder of the treated fabric. The maximum water content of the fabric should normally not exceed about 120% by weight to avoid the necessity of heating large quantities of water to an elevated temperature during the steam treatment. Moreover, it is difficult to distribute such larger quantities of water in a uniform manner throughout the fabric before the treatment with steam. The presence of uniformly distributed larger quantities of water in the fabric will, however, not interfere with the successful treatment of the fabric to impart a high degree of dimensional stability thereto. The desired amount of water may be added to a dry knitted fabric to prepare it for treatment in accordance with the process of this invention. Commercially, however, the process is best applied to the fabric immediately following the final liquid treatment constituting a step in the finishing of the fabric. For example, the fabric in its wet condition following a wet finishing treatment is first treated to reduce its water content to the desired level, as by centrifuging, and then stretched by about 5 to 30% to a definite width before being subjected to the heat treatment in the manner set forth above. Not only does carrying out the process of this invention following the final liquid treatment in the finishing of the fabric effect important economies, but it also produces a fabric having the highest degree of dimensional stability since the said

fabric is not subjected to any further stresses while in a hot, wet state before it is processed into garments. If desired, the knitted cellulose ester fabric while being stabilized may have thereon any of the softening and antistatic finishes usually applied to such fabrics.

As stated, the wet fabric is treated, in accordance with this invention, with steam while it is held to a definite width and while it is supported throughout substantially its entire area. One form of apparatus for carrying out this treatment comprises a chamber provided with an inlet and exit slot, through which the fabric enters and leaves the chamber, and equipped with tenter chains for holding the fabric to a definite width and moving the fabric continuously through the chamber. There are also provided in the chamber, between the tenter chains, a plurality of rubber covered rollers for supporting the fabric throughout substantially its entire area. The rollers are positively driven so as to have a peripheral speed substantially equal to the linear speed of the fabric moving through the chamber so that no stresses will be applied to said fabric. Instead of rollers, other means such as screens, belts or the like may be used to support the fabric during the treatment. As the fabric moves through the chamber it is treated with steam which is advantageously introduced into the chamber through distributing heads positioned both above and below the fabric at a plurality of points spaced along the path of the fabric. The steam raises the temperature of the fabric to a point where the wet cellulose acetate or other organic acid ester of cellulose comprising the yarns of the fabric is swollen and in a condition in which the internal stresses in the yarns are released rapidly. This temperature is preferably about 100° C. The steam treatment should, however, not be continued to a point where the yarns or the fibers making up the yarn tend to coalesce or where the hand of the fabric in changed in an undesirable manner. It is essential that the fabric be supported throughout its entire area while it is at this elevated temperature. If no such support is provided, the fabric will tend to sag and be distorted due to its weight, thereby introducing stresses which will be locked into the fabric during the treatment and will cause dimensional changes in the fabric during use.

The superheated steam, which is desirably at atmospheric pressure and at a temperature above about 230° F., preferably in the range of about 240° F. to 250° F., is admitted to the chamber through a plurality of openings. The spacing of the openings throughout the chamber is such that there is obtained an even distribution of steam throughout the area of the chamber. Moreover, the entering steam is caused to impinge on the fabric at fairly high velocity so as to effect an efficient transfer of heat to the fabric. In addition, a very even steam distribution is necessary because of the previously described hazard of delustering which occurs if the fabric is over dried at any point during passage through the stabilization chamber. The waste steam is exhausted from the chamber by means of exhaust ducts mounted at the side of the chamber.

In order to prevent the inrush of cool atmospheric air to the chamber, the exhaust rate is adjusted so that the rate of removal of spent steam at the exhaust ducts does not quite balance the input rate. That is, more steam is admitted to the chamber than is removed through the exhaust ducts. Hence, during operation a small amount of steam escapes through the slots through which the fabric enters and leaves the chamber. In addition, these exit and inlet slots have mounted, above and below, slotted conduits through which heated air is forced. These conduits are mounted and aligned so that the heated air from the slots forms an air curtain through which the fabric passes. This air curtain further serves to dilute the escaping steam and prevent condensation on the surrounding equipment. If desired, the wet fabric may be preheated in any desired manner to an elevated temperature below the stabilizing treatment temperature prior to its entry into the chamber so as to reduce the period of time needed for the steam to bring the fabric to the treatment temperature. The time of treatment varies, depending upon a large number of factors, including the percentage of water present initially in the fabric, the temperature at which the wet fabric enters the chamber, the weight of the fabric, the steam temperature, the degree of suprheat and the like. Control of the time of treatment is effected by adjusting the rate at which the fabric passes through the chamber, that is, by regulating the speed of the tenter chains.

Following the steam treatment, the fabric is cooled. At least during the preliminary stages of the cooling, the fabric should be held to a definite width and supported throughout its entire area so as to avoid imposing stresses upon the hot fabric. Cooling may be effected simply by passing the fabric through the air, or, if desired, the rate of cooling may be accelerated by passing a stream of cool air over the fabric.

During the treatment of the wet fabric with superheated steam, at least a portion of the water in the fabric will be driven off. After the cooling of the fabric is completed, any further drying of the fabric that may be necessary is carried out by passing the fabric through a dryer of any desired type. It is preferred to reduce the moisture content of the cellulose acetate to about 5 to 7% regain. Over-drying tends to impart an objectionably harsh hand to the fabric. The dried fabric exhibits a high degree of dimensional stability and is eminently suited for a wide variety of applications.

A preferred embodiment of the apparatus of this invention is shown in the accompanying drawings wherein:

Fig. 1 is a side view of the apparatus, partly in section,

Fig. 2 is a cross-sectional view of the apparatus, taken on the line 2—2 in Fig. 1, in the direction of the arrows,

Fig. 3 is a cross-sectional view of the apparatus, taken on the line 3—3 in Fig. 1, in the direction of the arrows,

Fig. 4 is a detail view of the upper steam distributor, and

Fig. 5 is a detail view of the lower steam distributor.

Referring now to the drawing, the reference numeral **11** designates a fabric whose edges are secured to tender chains **12** that act to hold the fabric at a definite width. The tenter chains **12** are mounted on supports, indicated generally by reference numeral **13**, that may be operated by means of hand wheels **14** to adjust the lateral spacing between the tenter chains **12** in a manner well known in the art. The tenter chains **12** carry the fabric **11** between a pair of heaters **15** equipped with infra-red heating elements to effect a preheating of the said fabric. The fabric **11** is then moved by the tenter chains **12** into a treating chamber, indicated generally by reference numeral **16**. The treating chamber **16** comprises a shell **17** that is supported on a framework **18**. The top **19** and upper portion of the ends **21** of the shell **17** are of double wall construction and a heating fluid such as steam is passed through said walls to raise them to an elevated temperature so that no water will condense on said walls to drop onto the fabric **11**.

Positioned in the chamber **16** are a plurality of rubber covered rolls **22** that extend transversely of the chamber between the tenter chains **12** and act to support the fabric during its treatment. The rolls **22** are driven at a peripheral speed equal to the linear speed of the tenter chains **12** by means of a motor **23** through a variable speed drive **24**, a chain **25** and a series of chains **26** and sprockets **27** that act to interconnect all said rolls. Steam is introduced into the chamber **16** through a plurality of lower distributors, indicated generally by reference numeral **28**, that are positioned between the rolls **22** beneath the fabric **11**, and a plurality of upper distributors, indicated generally by reference numeral **29**, that are positioned above the fabric **11**.

Each of the lower distributors **28** comprises a conduit

31 supported on a pedestal 32 (Fig. 5) and having a slot 33 extending through the uppermost portion thereof for the discharge of the steam which is supplied to said lower distributors from headers 34. The upper distributors 29 each comprises an elongated rectangular enclosure 35 to which steam is supplied by headers 36 through conduits 37. Extending longitudinally of the enclosure 35 are partitions 38 having apertures 39 therein which act to distribute the steam emerging from the conduits 37 more uniformly. To insure that there will be no drops of water in the steam emerging from the upper distributors 29 to fall on and spot the fabric 11, there are provided a pair of conduits 41 extending the full length of the enclosure 35 and being spaced apart a short distance to provide a passageway 42 therebetween. A heating fluid, such as steam, which may be at a higher temperature than the steam in the headers 36, is introduced into the conduits 41 from a header 43 and is discharged from said conduits through a header 44. All the steam flowing through the passageway 42 will come into intimate contact with the heated surfaces of the conduits 41 thereby turning into steam any drops of water that may be present in the steam emerging from the headers 36. Moreover, when the steam which is at super-atmospheric pressure in the headers 34 and 36 enters the chamber 16, which is at approximately atmospheric pressure, the essentially adiabatic drop in the pressure of the steam will impart a degree of superheat thereto and tend to eliminate water droplets therefrom.

If atmospheric air were permitted to enter into the chamber 16 freely together with the fabric 11, there would be a tendency for the cold atmospheric air to cause water to condense on all surfaces adjacent the entrance passageway. To avoid this possibility, there are provided adjacent the entrance and exit passageways pairs of conduits 45 and 45' having slots 46 and 46' therein that face toward the fabric 11. Heated air under pressure is introduced into the conduits 45 and 45' and flows through the slots 46 and 46' toward the fabric 11 thereby acting as an air curtain to prevent the flow of cold atmospheric air into the chamber 16 and also acting to assist in the preheating of the said fabric. The chamber 16 is provided with exhaust ducts 47 through which pass a constant flow of steam together with any air that may enter into the chamber during operation.

Upon leaving the chamber 16, the fabric 11 passes through a cooling section, indicated generally by reference numeral 48. In at least the first portion of the cooling section 48, the fabric 11 is held at a definite width and supported throughout substantially its entire area in the same manner as during its passage through the chamber 16, namely, by the tenter chains 12 and rolls 22. Cooling of the fabric 11 may be effected simply through the action of atmospheric air. However, if desired, means such as slotted conduits, fans or the like may be provided for producing a forced flow of a cooling medium, such as air, over the fabric 11 and, if even more rapid cooling is desired, the cooling medium may be refrigerated.

The fabric 11, after cooling, is carried by the tenter chains 11 into a dryer 49 of any type. Means may be provided for supporting the fabric throughout its entire area as it passes through the dryer 49, although this has been found unnecessary when the drying conditions are not severe. When the temperature and other drying conditions are such as to reduce the moisture content below about 4% regain, such supporting means is desirable to prevent the introduction of a small, but not highly objectionable, degree of dimensional instability into the fabric 11. If the drying conditions are not so severe and fabric supporting means are not employed in the drier, the lateral spacing between the tenter chains 12 may be widened slightly, e. g. by about 4%, as these chains pass through the drier, in order to avoid any substantial sagging of the fabric in the drier.

The following example is given to illustrate this invention further.

Example

A large number of pieces of fabric warp knitted of 55 denier yarns of cellulose acetate having an acetyl value of 54.5%, measured as combined acetic acid, are scoured, dyed and washed and are then centrifuged to bring their moisture content to about 100%, based on the dry weight of the fabric. The wet fabrics, which are at room temperature and have a width of about 90 inches, are sewn end to end and are then passed one after another through the apparatus shown in the drawings, without using preheater 15, at the rate of about 1300 pounds of wet fabric per hour while the fabrics are maintained at a width of 111 inches and while saturated steam at a pressure of 150 pounds per square inch gauge is passed at the rate of about 5,000 pounds per hour through a throttling valve (not shown), through which it expands in an essentially adiabatic manner into the conduits leading to the lower distributors 28, upper distributors 29 and conduits 41. The overall temperature of the treating chamber is above 230° F. After a treatment time of 15 seconds, the fabric is cooled and dried. The dried fabrics, when laundered in an automatic washer at 140° F. and dried in substantially tensionless condition, exhibit an average area shrinkage of less than 4%. Subsequent laundering effects no appreciable change in dimensions. When similar pieces of the same fabric are finished and dried in conventional manner they exhibit an average area shrinkage of 15% to 30% after the first washing.

While the process of this invention has been described specifically in connection with the treatment of fabrics containing cellulose acetate yarns at the present time, it may also be employed for the treatment of the fabrics containing yarns of othr organic acid esters of cellulose such as, for example, cellulose propionate, cellulose butyrate, cellulose acetate propionate and cellulose acetate butyrate.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of our invention.

Having described our invention, what we desire to secure by Letters Patent is:

1. A process for improving the dimensional stability of knitted fabric containing a thermoplastic lower aliphatic acid ester of cellulose yarns which comprises subjecting said knitted fabric, wetted with at least 20% of water based on the weight of the dried fabric, to superheated steam having a temperature above about 230° F., maintaining said fabric at a definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam.

2. A process for improving the dimensional stability of knitted fabric containing cellulose acetate yarns which comprises subjecting said knitted fabric, wetted with at least 20% of water based on the weight of the dried fabric, to superheated steam having a temperature above about 230° F., maintaining said fabric at a definite width and at a moisture content above the saturation regain

value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam.

3. A process for improving the dimensional stability of knitted fabric containing yarns of cellulose acetate having a saturation regain value at 100° C. of about 14 to 16% which comprises subjecting said knitted fabric, wetted with at least 50% of water, based on the weight of the dried fabric to superheated steam having a temperature above about 230° F., maintaining said fabric at a definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation rgain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam.

4. A process for improving the dimensional stability of knitted fabric containing cellulose acetate yarns which comprises subjecting said knitted fabric, wetted with at least 20% of water based on the weight of the dried fabric, to superheated steam having a temperature above about 230° F., maintaining said fabric at a definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam, said superheated steam being applied to both the upper and lower surfaces of said fabric.

5. A process for improving the dimensional stability of knitted fabric containing a thermoplastic lower aliphatic acid ester of cellulose yarns which comprises subjecting said knitted fabric, wetted with at least 20% of water based on the weight of the dried fabric, to superheated steam having a temperature above about 230° F., maintaining said fabric at a definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarn, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam and during at least the initial stages of cooling.

6. A process for improving the dimensional stability of warp knitted fabric containing cellulose acetate yarns after said fabric has been subjected to hot water under such conditions that the number of wales per inch of the fabric has been increased, which comprises stretching said fabric to a definite width to decrease the number of wales per inch and subjecting said fabric containing 50–120%, based on the weight of the dried fabric, of water to superheated steam having a temperature above about 230° F., maintaining said fabric at said definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam.

7. A continuous process for improving the dimensional stability of warp knitted fabric containing cellulose acetate yarns after said fabric has been subjected to hot water under such conditions that the number of wales per inch of the fabric has been increased, which comprises continuously stretching said fabric to a definite width to decrease the number of wales per inch and continuously subjecting said fabric containing 50–120%, based on the weight of the dried fabric, of water to superheated steam having a temperature above about 230° F., maintaining said fabric at said definite width and at a moisture content above the saturation regain value of said cellulose ester throughout the treatment with superheated steam, said treatment with superheated steam being continued until said cellulose ester is swollen and the internal stresses in the yarns are released and the dimensions of the fabric are stabilized to subsequent washing, the time and temperature of said treatment being insufficient to effect fusion or coalescence of said yarns, continuously removing the fabric from contact with the superheated steam before the moisture content of said cellulose ester has been reduced below said saturation regain value so that said fabric still carries an excess of water on the surface of said yarns, and continuously cooling the treated fabric, said fabric being supported throughout substantially its entire area while it is subjected to the superheated steam.

8. Process as set forth in claim 7 in which said cellulose acetate has a saturation regain value at 100° C. of about 14 to 16% and the water content of said fabric just before it is subjected to the superheated steam is at least 50%, based on the weight of the dried fabric.

9. Process as set forth in claim 8 in which said fabric is supported throughout substantially its entire area during at least the initial stages of cooling and the fabric is dried, until its moisture content is about 5 to 7% regain, after said cooling.

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