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WOVEN FABRIC AND METHOD OF MAKING SAME

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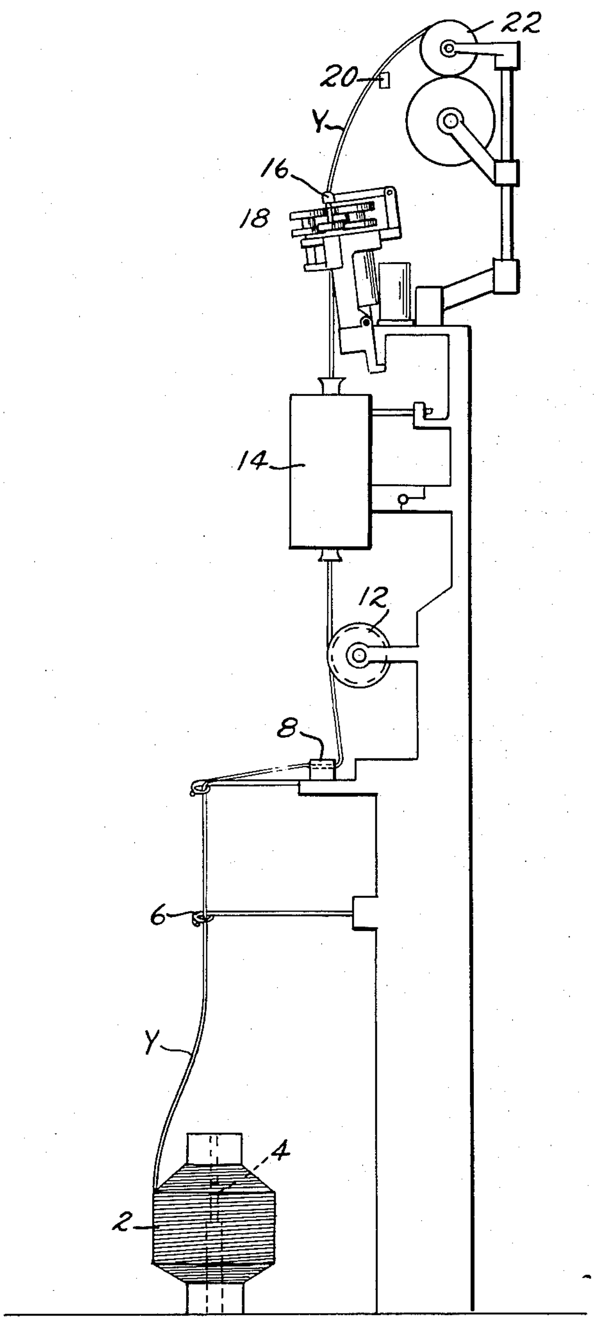

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WOVEN FABRIC AND METHOD OF MAKING SAME

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The present invention relates to stretch yarns, woven fabric containing the same and procedures for preparing such yarn and fabric.

Woven stretch fabrics are becoming increasingly important in the clothing industry, for example, as suiting material or in leisure apparel and sportswear. The principal object of the present invention is to provide a new type of stretch yarn and fabric using nonthermoplastic staple fibers which retain their original nonthermoplastic character throughout the preparation of the stretch yarn and fabric, i.e. the fibers are not treated with resin or the like to render the same functionally thermoplastic. A more specific object of the invention is to provide stretch yarn and woven stretch fabric made up, entirely or in part, of nonthermoplastic spun staple fibers. Other objects will also be hereinafter apparent.

It is well known that stretch yarns may be prepared from spun yarn or continuous filament yarn of thermoplastic material, e.g. nylon or Dacron, by thermally processing the spun or filament yarn, i.e. twisting, setting and untwisting the same (see, for example, U.S. Patent 2,803,109). It has also been proposed that this general type of procedure might be applied to nonthermoplastic yarns, e.g. cotton or wool yarns, provided these yarns are first subjected to a resinous pretreatment in order to render the yarns functionally thermoplastic in character (U.S. Patent 3,025,659).

The present invention is based, in part, on the surprising discovery that spun yarn consisting, in whole or at least in substantial part, of nonthermoplastic staple fibers may be made into highly suitable stretch yarns, for use in the preparation of woven stretch products, by twisting, setting and untwisting operations without any type of resinous pretreatment or equivalent operation designed to render the fibers functionally thermoplastic. This is completely unexpected in the light of prior art practice and knowledge (see, for example, the aforementioned U.S. Patent 3,025,659) wherein it has been considered essential to initially impart a thermoplastic character to the spun nonthermoplastic if twisting, setting and untwisting operations were to have any significant effect thereon.

In addition to the use of staple fibers which truly retain their nonthermoplastic nature throughout the processing described herein, the present invention requires the use of certain specific operations in the preparation of the stretch yarn and fabric prepared therefrom in order to obtain the desired stretch characteristics. Thus, an important aspect of the invention is the feature of reeding out in weaving, i.e. increasing the space between the warp ends in the loom reed so that when the fabric is woven and relax finished, the filling yarn is allowed to bulk and the warp ends will be drawn in closer together thus providing a stretch fabric that will elongate and contract. Additionally, the fabric construction must be such that the sum of the average number of picks and warp ends per inch for any particular weave does not exceed a definite maximum. These and other critical features of the invention are discussed in more detail below, the yarn preparation being described first, followed by a description of the weaving and finishing operations.

STRETCH YARN PREPARATION

Broadly described, the stretch yarn of the invention comprises a single end of spun yarn or two or more plied-together spun yarns containing nonthermoplastic staple fibers which have been thermally processed by a twist, set and untwist operation, notably dry heat set in a false twisted condition, without any type of resinous or chemical pretreatment or the like which might render the fibers functionally thermoplastic. In other words, the fibers are maintained in their nonthermoplastic form throughout the yarn preparation according to the invention.

The thermal processing of the plied yarns may be carried out on conventional false twisting equipment using dry heat. The spun yarns may be made up entirely of nontheromplastic staple fibers (hereinafter referred to as 100% nonthermoplastic spun yarn) or they may comprise an intermingled fiber blend of staple nonthermoplastic and thermoplastic fibers (hereinafter referred to as blend spun yarn). If desired, the plied yarn of the invention may comprise two or more 100% nonthermoplastic spun yarns, two or more blend spun yarns or a combination of these two different types of yarns. By the expression "intermingled fiber blend" it is intended to mean that the single spun yarn has a cross-section showing a thorough mixture or distribution of the various types of fibers present in the yarn whereby the blend is obtained prior to the spinning of the yarn. This is not to be confused with the congregation of fibers noted in plied yarns where each single yarn has a 100% homogeneous fiber content.

The nonthermoplastic staple used herein may be any conventional nonthermoplastic material, e.g. wool, cotton, linen, rayon, silk or mixtures thereof. The thermoplastic material if used, may be any available type of thermoplastic staple including nylon, polyester, acrylics and other man-made fibers of thermoplastic nature or mixtures thereof.

100% NONTHERMOPLASTIC STRETCH YARN

A 100% nonthermoplastic stretch yarn may be prepared according to the present invention starting with an end of spun nonthermoplastic, staple fibers, e.g. an end of 100% worsted. Usually the number of turns in the end of spun yarn will be in the neighborhood of from 5 to 28 turns per inch. This twist may be in either the S or Z direction. The spun yarn selected for use herein should be as uniform as possible in order to obtain optimum results in subsequent processing.

The above-mentioned end of spun yarn may be thermally processed as hereinafter described to give a stretch yarn. However, it is preferred that the end of spun yarn be plied or twisted with one or more additional ends of spun nonthermoplastic fibers before the thermal processing. The twist in this other end or ends may be in the same or different direction and the amount of twist therein may be equal to, or different from, the twist in the first end. Preferably, however, the degree and direction of twist are the same in each end and the ply twist should also be in the same direction. This gives a "twist-on-twist" yarn of desirable characteristics. However, a satisfactory stretch yarn can also be made using a ply twist which is in a different direction to the pre-ply twist in one or all of the spun yarns although this usually requires the application of a higher twist in the subsequent thermal processing or false twisting operations. The pre-ply twist in the "twist-on-twist" combination may be about 33% to 80% greater than the ply twist while, in the case of a regular twist (i.e. where the pre-ply twist in the single yarns is the same but the ply twist is opposed), the ply twist should be from 60% to 120% of the single yarn twist. When using "twist-against-twist" (i.e. where opposite twists are used in the single yarns and the ply twist has the same direction as the twist in one of the single yarns), the ply twist may amount to from 60% of the single yarn twist up to 100% thereof.

Typical illustrations of single yarn, yarn combinations and twists according to the invention are listed below:

TWIST-ON-TWIST

Single yarn	Ply twist
1/50 100% worsted yarn 18S (turns per inch)	plied or twisted together 12S (turns per inch)
1/50 100% worsted yarn 18S (turns per inch)	
1/50 100% worsted yarn 18Z (turns per inch)	12Z (turns per inch)
1/50 100% worsted yarn 18Z (turns per inch)	

REGULAR TWIST

Single yarn	Ply twist
1/50 100% worsted yarn 18Z (turns per inch)	17S (turns per inch)
1/50 100% worsted yarn 18Z (turns per inch)	
1/50 100% worsted yarn 18S (turns per inch)	17Z (turns per inch)
1/50 100% worsted yarn 18S (turns per inch)	

TWIST-AGAINST-TWIST (ONDULÉ)

Single yarn	Ply twist
1/60 100% worsted yarn 20S (turns per inch)	18S (turns per inch)
1/60 100% worsted yarn 20Z (turns per inch)	
1/60 100% worsted yarn 20S (turns per inch)	18Z (turns per inch)
1/60 100% worsted yarn 20Z (turns per inch)	

The plying operation should be carried out under carefully controlled tension conditions, i.e. the yarn should be kept taut during the plying, the tension thereon normally falling within the range of 5 to 30 grams, depending on yarn count, as measured on a Model 2804 Sipp-Eastwood Corp. tensiometer, between the point where two or more pre-ply ends are stabilized in tension and the point where the ends are delivered to the final ply twisting guides.

After the plying operation, the plied yarn is thermally processed, as indicated above, using a conventional false twist machine where the yarn is twisted, subjected to dry heat while in the twisted state and then untwisted. As mentioned, this thermal processing operation is carried out with the fibers retaining completely their nonthermoplastic character, i.e. there is no chemical pretreatment, such as impregnating or coating the fibers with resin, or the like, so that these might function as thermoplastic fibers.

One conventional form of apparatus suitable for thermally processing the plied yarns of the invention is diagrammatically shown in the accompanying drawing.

As shown, the supply package of plied yarn prepared as aforesaid is designated by the numeral **2**. This package is placed on a creel pin **4** which is positioned directly below a centering eye **6** to provide for even delivery tension from the supply package. The yarn Y is drawn from supply package **2** through the centering eye **6** to a pretension assembly including tension disc **8**. The yarn passing through the pretension assembly is threaded between the tension disc **8** prior to an overfeed roll **12**. The purpose of the tension disc is to keep the yarn taut prior to overfeed roll **12**.

The yarn is wrapped one or more times around overfeed roll **12** prior to being passed over or through an appropriate heater element **14**. The roll **12** serves as a block to prevent twist from backing out and also controls the tension of yarn while passing over heater element **14**.

The temperature of the heating element **14** and the exposure time between the element and yarn will vary over fairly wide ranges depending upon such other operating factors as the composition of the yarn, the yarn count, length of the heating element, and the degree of twist and ultimate stretch properties which may be desired. Usually, however, the temperature will be in the area of 150°–245° C. Yarn speed is generally about 10–70 yards per minute and heat exposure times vary for example, from about 0.2 second to 5.0 seconds per linear inch of yarn.

From the heater element **14**, the yarn is fed into an appropriate false twist rotor **16** constituting a component part of spindle **18**. This rotor is revolved at a sufficient speed, typically 20,000 to 150,000 r.p.m. or even higher, to introduce into the yarn the desired number of helical coils or false twist per linear inch, the twist running backwards in the yarn to the overfeed roll **12**. The twist is removed as the yarn leaves the rotor **16** and the thermally processed yarn then passes through an appropriate traverse guide **20** onto a takeup package **22**. The yarn is then ready for use directly in the preparation of a woven stretch fabric as described at a later stage herein.

As indicated, the yarn passes through the heater element in a highly twisted state and the heat is adjusted to set the helical coils in the yarn thus allowing the yarn to stretch up to 400% from the relaxed state after processing. It is a surprising fact that the non-thermoplastic material can be thermally processed in this way to give stretch properties even though there is no pretreatment with resin or other chemicals. In this connection, however, it is to be noted that the heat applied to the plied spun yarns should be dry heat as distinguished from steam or other forms of moist heat in order to obtain the desired twist set and resulting stretch characteristics.

The amount of stretch in the finished yarn can be varied by regulating the number of helical coils applied per linear inch of yarn during the thermal processing. Thus, it has been found that woven fabrics can be prepared by the invention to give as much as 65% stretch in the filling direction of the fabric when a stretch yarn as prepared herein is used as the filling yarn. Usually the false twist applied to the plied yarn during the thermal processing is opposed to the ply twist but this is not absolutely necessary. Additionally, the amount of false twist will normally fall in the range of 20 to 90 turns per linear inch and should be at least equal to, and preferably two or more times greater than the ply twist, although it will be recognized that the degree of twist ultimately selected for any particular situation will depend upon the amount of stretch desired, the nature of the final product and other related factors.

BLEND YARNS

The blend yarns of the invention will usually comprise a substantial amount of nonthermoplastic staple, e.g. blends of 20–80% nonthermoplastic staple and 80–20% thermoplastic staple. Mixtures of several different nonthermoplastic and/or thermoplastic fibers may be used in the same end of spun yarn. For example, the stretch yarn may comprise two identical ends of spun yarn containing 40% wool staple, 40% cotton staple and 20% Dacron polyester staple, plied together and thermally processed as described herein. Alternatively, one end may contain 40% wool, 40% cotton and 20% polyester staple and the other end may be 80% wool and 20% polyester staple. The blend composition which is ultimately selected for any particular situation will depend on the desired nature of the final product.

It will be appreciated from the foregoing that the terms "blend" or "blend yarn" as used herein are not to be confused with the product obtained by plying together a yarn of one material and another yarn of a different material. In contrast, the blends of the present case are prepared by blending together nonthermoplastic and thermoplastic staple fibers prior to spinning a yarn therefrom and the resulting spun yarn has a cross-section which shows a thorough mixture or distribution of the different types of fibers present therein. The blending operation contemplated herein can be accomplished for example, on a conventional card with blending hopper, converter, or end feeding on drawing equipment or other like apparatus or procedures such as roving blending on spinning equipment, in varying percentage ratios of the fibers involved.

The stretch yarn may be made out of one, two or more ends of spun yarn consisting of the desired blend or blends, in the manner described above in connection with the 100% nonthermoplastic stretch yarn. Thus, for example, conventional 1/60's yarn consisting of a predetermined blend of polyester and wool fibers having a select denier and grade respectively, is spun 20 turns per inch in the S or Z direction, care being taken to insure a very uniform yarn, i.e. having a low coefficient of evenness variation. A single end of this 1/60's spun blend yarn is twisted or plied with another similar yarn which preferably has the same direction of twist although an opposite twist may also be used. As in the case of the 100% nonthermoplastic yarn, the plying operation should be carried out under uniform tension. The degree and direction of twist for the single ends of spun yarn and for plying these ends together may be varied as aforesaid in connection with the 100% nonthermoplastic yarn.

Typical examples of suitable single blend yarns, plied yarns and degrees and direction of twist are shown below:

1/60 53% polyester/47% 70's wool 20Z (turns per inch) 1/60 53% polyester/47% 70's wool 20Z (turns per inch)	plied or twisted together 18S (turns per inch)
1/60 53% polyester/47% 70's wool 20S (turns per inch) 1/60 53% polyester/47% 70's wool 20S (turns per inch)	plied or twisted together 18Z (turns per inch)
1/60 53% polyester/47% 70's wool 20S (turns per inch) 1/60 53% polyester/47% 70's wool 20Z (turns per inch)	plied or twisted together 18S (turns per inch)
1/60 53% polyester/47% 70's wool 20S (turns per inch) 1/60 53% polyester/47% 70's wool 20Z (turns per inch)	plied or twisted together 18Z (turns per inch)
1/60 53% polyester/47% 70's wool 20S (turns per inch) 1/60 53% polyester/47% 70's wool 20S (turns per inch)	plied or twisted together 18S (turns per inch)
1/60 53% polyester/47% 70's wool 20Z (turns per inch) 1/60 53% polyester/47% 70's wool 20Z (turns per inch)	plied or twisted together 18Z (turns per inch)

The preparation of stretch yarn from the plied blend yarns is completed by the same thermal processing as described above in connection with the drawing and the 100% nonthermoplastic stretch yarn. The resulting yarn is ready for use in preparing a stretch woven fabric in the manner now described.

STRETCH FABRIC PREPARATION

The thermally processed single or plied yarn obtained in the manner described above and comprising one, two or more ends of spun yarn made up in whole or in part of nonthermoplastic staple, has highly desirable stretch characteristics but these characteristics can be destroyed or impaired if the proper weaving and finishing techniques are not used. Important requirements for the weaving operation have been noted above, including reeding out and maintaining a critical balance between warp ends per inch (sley) and picks per inch in relation to the reed width so that proper allowances are made for finishing losses and still leave desired amount of stretch. The essential balance between the number of picks of filling per inch and number of ends per inch of warp should not exceed the maximum set. This maximum will vary depending on the yarn count and type of weave, but a definite value can be calculated for any specific circumstance and should not be exceeded if a satisfactory stretch fabric is to be obtained. This maximum set, which may also be called the maximum average greige fabric construction, may be determined for any particular type of weave and yarn count by the following formula:

$$M=\frac{(\sqrt{X})(Y)(1-B)}{Y+H}\times 2$$

wherein

M is the maximum average greige fabric construction or maximum average of the sum of the picks and ends per inch;

X is the yards per pound determined by multiplying the equivalent count of the stretch filling yarn by 560 (worsted hank);

Y is the number of ends in a repeat of the pattern;

N is the number of interlacings per end in the weave, interlacings being defined as the number of intertwinings or crossings that one end of the weave makes with the filling in one repeat of the pattern; and

B is the percent warp contraction depending upon weave and picks per inch. This value is obtained by subtracting the length of the greige woven material from the length of the dressed or beamed material. In other words, if the greige material has a length of 90 yards and the beamed or wound length of warp yarn on the loom beam is 100 yards, the warp contraction (B) is 10% or .10 in the above formula.

As will be apparent, this formula is used to determine the value of M, the latter being the sum of the average ends and picks per inch. This represents the maximum average greige fabric construction which will give a stretch fabric and this total should not be exceeded. Thus, the minimum average greige fabric construction may be any reasonable value usually not below 50% of the calculated value of the maximum greige fabric construction. It is important to increase the reed spread (width of the unwoven warp ends) for stretch fabrics over conventional fabrics which decreases the filling beat-up allowing more air space for the filling yarn to contract. Where the stretch yarn is used only as the filling yarn, the fabric will stretch only in the filling direction, that is, widthwise. If desired, the stretch yarn used may be also used for the warp, and in this case, the fabric will have stretch in both directions. The stretch can be controlled from 8–65% in filling by adjusting yarn and cloth construction and finish. It is recognized that the degree of stretch can be varied as desired depending upon the amount of reeding out, type weave, general construction, type yarn and finishing factors.

Standard equipment and apparatus may be used in processing and weaving the stretch yarn according to the present invention. However, to insure a quality product, it is important to maintain careful tension control. Thus, for example, if multiple shuttles are used, care must be taken to be certain that the shuttles are balanced both in weight and filling tensions. Other techniques which are recognized in the art as essential for high quality goods, e.g. careful selection of the yarns utilized, should also be observed in the weaving operation as well as in the yarn preparation.

After the weaving operation, it is necessary that the fabric be finished under carefully controlled conditions since the quality of the resulting stretch fabric can be greatly influenced by the finishing techniques. The finishing conditions which are ultimately selected will vary depending on the nature of the yarn and fabric but, in any event, it is important that the fabric be kept in a completely relaxed or stretch-free state with absolute thermal control in each phase of the finishing operation. By thermal control, it is intended to mean maintenance of the specific temperatures applied in each phase of the finishing process.

Various preferred finishing operations for several different types of fabrics are set forth below along with specific working examples for the purpose of illustrating the invention.

100% NONTHERMOPLASTIC FABRICS

The following operations or routings are employed in finishing a woven 100% nonthermoplastic stretch fabric according to the present invention, the terminology utilized being standard in the trade as shown, for example, in "The Modern Textile Dictionary," by George Linton:

STEPS

(1) Batching, i.e., putting together different quantities of woven material which are to be processed together.

(2) Singe—The woven fabric being passed over a series of gas jets or hot plates to remove protruding fibers.

(3) Birch crab—This involves running the cloth into a series of hot water baths or bowls of increasingly higher temperatures with cooling in the final water bath or bowl. The purpose of this operation is to set the yarns in the material and to prevent excessive shrinkage. The operation also removes any sizing material which might be applied to the warp yarn during slashing to improve weaving characteristics. In the case of a seven bowl Birch crab, the speed of the fabric is preferably about 30 yards per minute and usually within the range of 25 to 35 yards per minute depending on the type of fabric. Typical operating temperatures as an example for the seven bowl Birch crab are the following:

	° C.
First bowl	49
Second bowl	60
Third bowl	71
Fourth bowl	77
Fifth bowl	82
Sixth bowl	82
Seventh bowl	34

(4) Yorkshire crab—This involves setting the fabric in hot (94° C.) water usually for five to fifteen minutes, preferably about ten minutes. Temperature and timing of the treatment can be varied depending upon the degree of setting desired.

(5) Tacking—This step is optional and is a standard type of operation for the purpose of protecting the material against damage in subsequent wet-finishing operations, e.g. scouring, etc.

(6) Dolly or full width washer scour—This may be done, for example, on a Dolly or full width washer using a high liquid level so that there is no pressure or dragging on the material being scoured. It has been found that for best results the scouring agent should be non-alkaline, e.g. neutral or slightly acidic. Typically suitable scouring agents are the neutral nonionic detergents such as "Adrian C." Usually the scouring is carried out at 40°–60° C. for from 25 to 45 minutes, preferably about 50° C. for 30 minutes, followed by rinsing with water at a lower temperature in the range of 30°–45° C. for about the same length of time. The use of a non-alkaline scouring agent with the fabric in a loose, relaxed condition during scouring represents another finishing step which is peculiar to the success of the present invention. This operation as well as the other phases of finishing permit dimensional shrinkage without excessive structural shrinkage thus insuring a fabric of optimum stretch and recovery properties.

(7) Detack—This is optional and involves opening the cloth back up to open width if step (5) has been employed.

(8) Drying—The cloth is dried relaxed with up to 10% overfeed. The purpose of the overfeed is to avoid any possible tension on the cloth, thus insuring complete relaxation. The operation is carried out at 105° C. to 115° C. preferably 110° C., at a fabric speed of 20–25 yards per minute until the fabric is dry. This drying operation is carried out at lower temperatures and slower speeds than used for conventional fabrics in view of the necessity of overfeeding to keep the fabric in the relaxed state.

(9) Warm water padding—The cloth is padded in warm water (typically at 55° C.) by feeding the cloth from a relaxed state (example: from a free fold position) into the water pad. The purpose of this padding operation is to get as much dimensional shrinkage as possible in the cloth.

(10)–(14)—The cloth is then subjected to drying, warm water padding, drying, warm water padding and drying as in steps (8) and (9) respectively. The last padding and drying steps are optional and may be omitted if desired.

(15) The fabric is then again tacked, if necessary, followed by:

(16) Dyeing—In this step, the fabric should be dyed in as completely relaxed condition as possible, using a high liquid level to reduce tension. The fabric is then detacked if previously tacked.

(17) Drying—This step is carried out in the same fashion as step (8) above.

(18) Shearing—The degree of shearing depends upon the desired character of fabric leaving more or less cover on fabric.

(19) Cold water shrinking—The sheared fabric is immersed in a bath of cold water containing a wetting agent at, for example, about 27°–32° C. This treatment is one of the final shrinkage steps and it is essential to use cold water (e.g. water below about 35° C.).

(20) Loop drying—The cloth is dried with air without tension at 130°–140° C., preferably 135° C., at 20–25 yards per minute, preferably 20 yards per minute. The fabric is usually subjected to the above drying temperatures for approximately five minutes.

(21)–(22)—The cold water shrinking and loop drying operations may be repeated if desired followed by:

(23) Full decate—The fabric is fed to the decater from a free fold position to obtain best results. This process involves steaming the fabric (on a rigid roll to minimize shrinkage) in an autoclave. Typically, this operation may involve the use of steam at 10 p.s.i. for 3 minutes followed by 8 minutes cooling although other time, temperature and pressure conditions may also be used depending on the fabric.

Most, if not all, of the above noted finishing steps are known, in and of themselves, in the finishing art. Some of these finishing operations may be omitted and/or modified depending on the fabric. In any event, it is preferred that the above finishing operations be utilized in the manner indicated and, as noted heretofore, it is important that those operations which involve a liquid or drying treatment be carried out with the fabric in a completely relaxed state insofar as possible using essentially the steps, sequence, temperatures and time cycles as described above.

BLEND FABRICS

The following operations are normally employed in finishing a stretch woven fabric containing a blend yarn as heretofore described.

Steps (1′), (2′) and (3′): Batch, singe and Birch crab, respectively, as before except that somewhat different temperatures are used for the Birch crab operation. Thus, typical operating temperatures for the Birch crab are:

	° C.
First bowl	49
Second bowl	60
Third bowl	71
Fourth bowl	82
Fifth bowl	94
Sixth bowl	94
Seventh bowl	34

Step (4′): Drying as in step (8) for the 100% nonthermoplastic fabric.

Step (5′): Full decating—as in step (23) for the 100% nonthermoplastic fabric.

Step (6′): Relaxed boil—This is a very important step and consists of a scour at the boil in a nonionic detergent in, for example, the dye kettle, in a relaxed state for at least 30 minutes. The purpose of this operation is to accentuate the memory characteristics of the thermoplastic portion of the fabric.

Step (7'): Dyeing—as in step (16) for the 100% non-thermoplastic fabric.

Step (8'): Drying—as in step (4').

Step (9'): Shearing—as before.

Step (10'): Heat setting—This may be done in a dryer (e.g. a Famatex Dryer) under dry heat setting conditions such as 160°–170° C. in a relaxed condition.

Steps (11') and (12'): Cold water shrinking and loop drying, respectively, as before and these steps are preferably repeated.

Step (13'): Full decating—as before.

The invention is further illustrated, but not limited, by the following example:

Example I.—An end of 50's count worsted yarn having a USDA wool grade of 70's (i.e. 1/50's 70's wool yarn) and spun twist of 18 turns per inch in the S direction was plied with an identical 1/50's 70's worsted yarn having a spun twist of 18 turns per inch in the S direction. The ply twist amounted to 12 turns in the S direction. The plying operation was carried out with the two ends under controlled tension (i.e. a constant tension of 10 grams).

The plied product was then stabilized by treatment with saturated steam (dry bulb 80°–90° C. and wet bulb 70°–80° C.) at 80°–90° C. for 60 minutes. This ply yarn (identified as 2/50's 18S×12S) was then thermally processed as previously described using the apparatus shown in the drawing. In particular, the plied yarn was processed through the false twisting apparatus at a speed of 21 linear yards per minute. The temperature of the heater element was kept at 220° C. and the yarn was exposed to heat for 2.2 seconds per linear inch. While in the heated state, 46 turns per inch in the Z direction were imparted to the plied yarn by the spindle rotating at 34,000 r.p.m.

The thus thermally processed stretch yarn was collected on the takeup package and then was ready to use in the preparation of a worsted stretch fabric. A fabric was woven using this stretch yarn as the filling yarn in a 1×1 weave. The warp yarn was (two-ply) 2/50's 70's worsted yarn consisting of two pre-ply single ends of 1/50 70's worsted yarn with a spun twist of 18 turns per inch in the Z direction, both ends of which were plied together in the S direction with 17 turns per inch not thermally processed, i.e. a conventional yarn.

Before weaving, the maximum figure for the sum of the average picks and ends per inch was calculated using the formula given heretofore. Because of the twist therein, the plied yarn measured approximately 14,000 yards per pound worsted count giving an equivalent count of about 25's. As described before, the warp was reeded out to conform with the amount of stretch and finish width desired. For the correct construction of the fabric, the basic weaving construction formula is as previously described:

$$M=\frac{(\sqrt{14,000})(2)(1-.09)}{2+2}\times 2=108 \text{ maximun set}$$

The fabric was woven with the warp yarns reeded out sufficiently to permit the filling yarn to bulk when the fabric was relax finished. This caused the fabric to narrow approximately 26.5% in width when finished. This means that the fabric when taut would stretch out a substantially equivalent amount from the relaxed state. The reeding out used in this example meant that the warp ends were spaced from 8 to 12% farther apart than a similar non-stretch type of fabric. The reeding out also helped maintain the total number of picks and ends per inch below the maximum calculation value of 108.

After the weaving operation, the greige fabric was taken from the loom and finished as follows: batched with additional fabric made in the same manner, flame singed, Birch crabbed, Yorkshire crabbed, tacked, Dolly washed, detacked, dried, warm water padded, dried, warm water padded, dried, warm water padded, dried, dyed, dried, sheared, cold water shrunk, loop dried, cold water shrunk, loop dried and full decated all in the manner described above.

The thus finished fabric comprised a highly attractive 100% worsted fabric possessing inherent stretch characteristics in the filling direction. Clothing made from this fabric is characterized by comfort and a very desirable freedom of movement without distorting shape of garment with increased crease resistant qualities. The fabric has an excellent recovery after being stretched and demonstrates no adverse changes after tailoring, wearing and repeated dry cleaning.

Example II.—An end of 60 count worsted system composed of the following intermingled blend, 47% 70's USDA wool, 53% 3 denier T–64 Dacron and spun 20 turns per inch in the Z direction was plied with another identical end of the same blend 18 turns per inch in the S direction. The plying operation was carried out with the two ends under controlled tension (i.e a constant tension of 15 grams).

The plied product was then stabilized by treatment with steam (saturated) at 80° C.–90° C. for 60 minutes. The stabilized yarn (experssed as 2/60's 20Z×18S) was then thermally processed in the manner outlined in Example I using the apparatus illustrated in the drawing discussed above.

A fabric was then woven with stretch yarn prepared as above as the filling yarn in a 1×1 weave. The warp yarn was (two-ply) 2/60's composed of the following blend: 47% 70's USDA wool, 53% 3 denier T–64 Dacron consisting of two pre-ply single ends of 1/60 (of same blend) yarn with a spun twist of 20 turns per inch in the Z direction, both ends of which were plied together in the S direction with 18 turns per inch. The warp yarn was conventional and was not thermally processed by the false twist method or given any equivalent treatment.

Before weaving, the maximum figure for the sum of the average picks and ends per inch was calculated using the formula given heretofore. Because of the twist therein, the plied yarn measured approximately 16,800 yards per pound worsted count giving an equivalent count of about 30's. As described before, the warp has been reeded out to conform with amount of stretch and finish width desired. For the correct construction of the fabric, the basic weaving construction formula is as previously described:

$$M=\frac{(\sqrt{16,800})(2)(1-.09)}{2+2}\times 2=118 \text{ maximum set}$$

The fabric was woven with the warp yarns reeded out sufficiently to permit the filling yarn to bulk when the fabric was relax finished. This caused the fabric to narrow approximately 26% in the width when finished. This means that the fabric when taut would stretch out a substantially equivalent amount from the relaxed state. The reeding out used in this example meant that the warp ends were spaced from 8 to 12% farther apart than a similar non-stretch type of fabric. The reeding out also helped maintain the total number of picks and ends per inch below the maximum calculation value of 118 necessary to obtain optimum results.

After the weaving operation, the greige fabric was finished as follows: batched with additional fabric made in the same manner, singed, Birch crabbed, dried, full decated, relaxed boiled, dyed, dried, sheared, heat set, cold water shunk, loop dried, cold water shrunk, loop dried, full decated, in the manner referred to above.

The thus finished wool/polyester fabric was highly attractive, possessing inherent stretch characteristics in the filling direction. Clothing made from this fabric is characterized by comfort and a very desirable freedom of movement. The fabric has an excellent recovery to its original shape after being stretched and demonstrates no adverse changes after tailoring, wearing and repeated dry cleaning.

Example III.—Example II was repeated except that, instead of using two ends of spun blend for the stretch yarn, one such end was used with a 100% nonthermoplastic spun yarn as used in Example I. The resulting fabric had excellent stretch characteristics in the filling direction and was otherwise satisfactory.

Various modifications may be made in the procedures described above. For example, when using a blend of 65% Dacron polyester fibers and 35% cotton fibers in the preparation of a stretch blend yarn as aforesaid, the plied yarn comprising two or more ends of the indicated blend, may be either (a) package dyed (typically at 127° C. for one hour), coned and thermally processed on the false twisting apparatus as described above or (b) first thermally processed, then wound to dye tubes, dyed using temperature and time conditions which will not upset the crimp in the yarn and wound to cone. The dyed stretch yarn obtained by either of these procedures may be used as filling yarn and, if desired, warp yarn to weave any desired fabric pattern. The resulting fabric may be finished in the following manner to give a yarn-dyed stretch product: shearing; desizing in a rope washer (e.g. washing at 93° C. for 15 minutes followed by hot rinse at 71° C. and cold rinse); drying on tenter (typically at 175° C. in relaxed width at 70–80 yards per minute); pad finishing, washing and drying in normal fashion, dry singeing and sanforizing.

To prepare piece dye fabric instead of yarn dyed fabric using a blend of polyester and cotton as described, the plied yarn may be first processed on the false twist equipment as before followed by winding on a cone, quilling, weaving, shearing, desizing as above, beck dyeing without any tension on the cloth in the filling direction and then drying, pad finishing, washing, drying again, singeing and sanforizing as before.

The quility of the woven product will depend on the quality and nature of the staple fibers in the spun yarn. Thus, for example, in the case of yarns containing wool fibers, the fibers should desirably have a USDA wool grade number between about 50's and 80's and worsted yarns, before plying, should have a yarn count of the order of 10's to 80's. An end of this type of yarn, using 60's count, can be identified as "1/60's–80's wool" in the accepted terminology of the art.

While the invention has been illustrated above using one or two ends of spun yarn, more than two ends (e.g. 3, 4 or 5) may be used with equivalent results. Other modifications may also be made in the invention described herein without deviating from the scope thereof as set forth in the appended claims wherein we claim:

1. A process for preparing a stretch fabric which comprises (1) providing a yarn comprising at least one end of staple spun yarn selected from the group consisting of:

(a) staple spun yarns made up entirely of wool fibers; and

(b) staple spun yarns made up of an intimate blend of thermoplastic and nonthermoplastic staple fibers;

(2) making the thus provided yarn into a stretch yarn by mechanically false twisting the same with rotating mechanical parts and heat treatment in a dry condition, the wool and nonthermoplastic fibers in said staple spun yarns retaining their nonthermoplastic characteristics and being free from any wetting and chemical treatment, prior to and during said mechanical false twisting and heat treatment, which would render the same functionally thermoplastic for the mechanical false twisting and heat treatment; (3) weaving a fabric using said stretchable yarn at least as the filling yarn, the warp yarn being reeded out so that said filling yarn is provided with space to bulk when the resulting fabric is finished; and (4) finishing said fabric in the relaxed condition.

2. The stretch fabric obtained by the process of claim **1**.

3. The process of claim **1** wherein the sum of the average picks and ends per inch of the woven fabric before finishing is not greater than the value determined by the formula:

$$M=\left[\frac{(\sqrt{x})}{y+n}(y)(1-B)\right]\text{times } 2$$

wherein

M is the maximum sum of the average of the picks and ends per inch;

x is the yards per pound determined by multiplying the equivalent count of the filling yarn by 560;

y is the number of ends in a repeat of the pattern

n is the number of interlacings per end in the weave; and

B is the percent warp contraction depending on the weave and picks per inch.

4. The process of claim **1** wherein said stretch yarn comprising at least one end of staple spun yarn made up of an intimate blend of thermoplastic and nonthermoplastic staple fibers.

5. The stretch fabric obtained by the process of claim **4**.

6. The process of claim **4** wherein the fabric is finished by setting in hot water; decating, aqueous scouring at the boil, drying, dryheat setting, cold water shrinking, drying and decating; all of said finishing steps being carried out with the fabric in a relaxed condition.

7. The stretch fabric obtained by the process of claim **4** wherein the blend comprises wool and polyester fibers.

8. The process of claim **4** wherein said stretch yarn comprises plied ends of staple spun yarn, each of said ends being made up of an intimate blend of thermoplastic and nonthermoplastic staple fibers.

9. The stretch fabric obtained by the process of claim **8**.

10. The process of claim **1** wherein said stretch yarn comprises a single end.

11. The stretch fabric obtained by the process of claim **10**.

12. The process of claim **1** wherein said stretch yarn comprises an end made up entirely of wool fibers.

13. The stretch fabric obtained by the process of claim **12**.

14. The process of claim **1** wherein said finishing step comprises treating said fabric in a heated aqueous medium and then drying in the relaxed condition.

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