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WORSTED STRETCH FABRIC AND PROCESS FOR MANUFACTURING SAME

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The present invention relates to worsted stretch fabric and novel procedures for preparing same.

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 certain unique improvements in the preparation of worsted stretch fabric. A more specific object is the provision of a process for preparing 100% worsted stretch fabric. Other objects will also be hereinafter apparent.

Broadly stated, the method for preparing a worsted stretch fabric according to the present invention comprises first preparing a worsted stretch yarn by plying or twisting together (*a*) one end of worsted yarn having a spun twist in the S direction and a yarn count and grade number within limits hereinafter defined and (*b*) another end of worsted yarn having essentially the same amount of twist as the first end but in the opposite or Z direction and a yarn count and grade number as indicated, the ply twist being in either the S or Z direction, depending upon the desired resultant twist direction. The ply twist should also be kept within specific limits and is usually equal to, or substantially equal to, the twist in the yarns before plying.

The plying operation is 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 15 grams, 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 ends are delivered to the final ply twisting guides. Thereafter, the twist in the worsted stretch yarn is stabilized by heat treatment, notably saturated steam at 65° C. to 77° C., until the twist is stabilized. Usually, this steam treatment takes from 30 to 60 minutes.

The thus stabilized stretch yarn is then used as the filling yarn and optionally as the warp yarn to weave a fabric of any desired pattern. During this weaving operation, the filling yarn and warp yarn are both kept under tension and a careful balance of picks and ends per inch is maintained as discussed hereinafter to give the desired product. The woven fabric is then subjected to appropriate finishing operations, e.g. scouring, in the completely relaxed state and under absolute temperature control.

The success of the invention is due, among other factors, to the use of carefully selected wools having a grade number and yarn count and degree of twist, both prior to and after plying, within the limits prescribed below. Another critical 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 features are all discussed in detail below.

Where the stretch yarn is used only as the filling yarn, the fabric will stretch only in the filling direction, i.e.

widthwise. If desired, the stretch worsted yarn of the invention may also be used for the warp, as indicated above, and in such event, the fabric will have stretch in both directions. However, it is preferred that the stretch yarn be used only as the filling yarn with conventional worsted yarn of substantially the same count and grade number as the warp to give a 100% worsted fabric which only stretches widthwise. The stretch can be controlled from 8 to 22% by adjusting construction and finish. It will be recognized that the degree of stretch can be varied as desired depending on the amount of reeding out, the type of weave, the yarn used and other finishing factors.

The invention permits the preparation of fabric constructions which vary rather substantially. However, as noted above, it is essential to have a certain balance between the number of picks and ends per inch and this is effected by insuring that a predetermined maximum is not exceeded for the sum of the average number of picks (filling threads per inch) and ends (warp threads per inch) sley. 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, which may also be called the maximum average loom fabric construction, may be determined for any particular type of weave and yarn count by the following formula:

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

wherein:

M is the maximum average loom 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.

The manner in which the above formula is used to determine the value of (M) is shown below using for purposes of illustration a so-called 2 x 2 weave (FIGURE 2, page 730 of "The Modern Textile Dicitionary," by George Linton). A weave of this type has four ends in a repeat of the pattern and two interlacings per end in the pattern. Using as the filling, a stretch worsted yarn having an equivalent worsted count of 30, the maximum sum of the average number of picks and ends per inch can be calculated as follows, the B value being 10% for this given fabric:

$$M=\left[\frac{(\sqrt{16800})(4)(1-.10)}{4+2}\right] \text{ times } 2=155.2$$

Thus, using warp and filling yarn of the type indicated for a 2 x 2 weave, the sum of the average picks and ends (or sley) per inch should not exceed a value of 155.2. This represents the maximum average loom fabric construction which will give a stretch fabric as contemplated herein and any number of picks and ends per inch may be used provided their sum is below the calculated maxi-

mum. Thus, the minimum average loom fabric construction may be any reasonable value which gives a usable fabric, usually not below 50% of the calculated value of the maximum loom fabric construction and will depend in any particular case on the type of product desired.

The worsted, pre-ply yarn used for the present invention must have a USDA wool grade number between 62 and 80. Thus, it has been found that the use of yarns having a grade outside this range will not give a desirable stretch product. Additionally, the pre-ply yarns which are utilized should have a worsted count between 40 and 80 in order to give the desired result. Particularly preferred yarns are those having a count around 60 and a grade number in the area of 80. As will be appreciated by those skilled in the art, an end of this preferred type of yarn would be referred to as "1/60's–80's wool."

As indicated heretofore, the success of the invention is also due to the use of worsted yarn which has been twisted a critical amount both before and after plying. The actual amount of twist will vary to some extent depending on the grade and count of the yarn as shown in the table below. However, speaking in general terms, the degree of twist for each yarn end before plying will fall within the range of 15 to 26 turns per inch in either the S or Z direction. A lower number of turns within the indicated range of 15 to 26 should be utilized as the count of the yarn is lowered within the range of 40 to 80. Additionally, the permissible variation in twist diminishes as a yarn of lower count is used. Thus, for example, the yarn twist should be within the range of 15 to 19 for a yarn count of 40, whereas yarn having an 80 count may be twisted over a wider range beginning at 17 and terminating at the upper limit of 26. The optimum for any particular situation can be readily determined using the following table which correlates the count, grade number, twist before plying (pre-ply twist) and ply twist for the yarns used herein:

TABLE

Count (Worsted count)	Wool Grade (USDA)	Pre-Ply Twist (turns per inch) S or Z	Ply-Twist (turns per) inch) S or Z
40–41	62's to 80's	15 to 19	15 to 19
42–43	66's to 80's	15 to 20	15 to 20
44–45	64's to 80's	15 to 20	15 to 20
46–47	64/70 to 80's	15 to 21	15 to 21
48–49	64/70 to 80's	15 to 21	15 to 21
50–51	70's to 80's	15 to 21	15 to 21
52–53	70's to 80's	16 to 21	16 to 21
54–55	70's to 80's	16 to 21	16 to 21
56–57	70's to 80's	16 to 22	16 to 21
58–59	70's to 80's	16 to 22	16 to 21
60–61	70's to 80's	16 to 22	16 to 21
62–63	70's to 80's	16 to 22	16 to 21
64–65	70's to 80's	16 to 22	16 to 21
66–67	80's	16 to 22	16 to 22
68–69	80's	16 to 22	16 to 22
70–71	80's	17 to 23	16 to 22
72–73	80's	17 to 23	16 to 22
74–75	80's	17 to 24	16 to 23
76–77	80's	17 to 25	17 to 24
78–79	80's	17 to 25	17 to 25
80	80's	17 to 26	17 to 25

It will be seen from the foregoing table that the operable range for the ply twist is about the same as the range for the pre-ply twist applied to the separate yarn ends. Thus, the ply twist can be varied from 15 to 25 turns per inch depending on the yarn count and grade number and it will be noted that, as the yarn count increases numerically, the permissible variation in the ply twist increases from a minimum of four turns at yarn count 40–41 to a maximum of eight turns at yarn count 80.

As will be apparent from the foregoing, the stretch worted yarn used as the filling yarn herein, and possibly also as the warp yarn, is prepared by plying one end of worsted yarn having a grade number, count and S or Z twist within the indicated ranges to a second end of worsted yarn which also has a grade number, count and spun twist within the limits indicated except that the twist in the second end is opposed to the twist in the first. Preferably, both yarns are identical in count and grade number and also have the same degree of spun twist. The ply twist applied to these two yarns may be either S or Z as desired and should be within the ranges indicated in the foregoing table. A tension of 5 to 15 grams should be kept on the yarns as they are being plied, as mentioned heretofore. The resulting plied or stretch worsted yarn should then be stabilized by means of steam (65° to 77° C., for 30 to 60 miutes) as discussed above. The thus stabilized product is then ready for use as the filling yarn and, if desired, the warp yarn in weaving a 100% worsted stretch fabric according to the invention.

Apart from the reeding out feature referred to above and the indicated limit in the total number of picks and ends, the fabric of the present invention may be woven using generally standard techniques and apparatus. After the weaving operation, however, it is essential that the resulting greige worsted fabric be finished, e.g. scoured, under conditions providing for complete fabric relaxation and absolute thermal control in each phase of the finishing operation. By thermal control, it is intended to mean that specific temperatures are applied for each phase of the finishing process.

In the usual case, the following finishing operations are carried out in the order indicated, the terminology utilized being standard in the trade as shown, for example, in "The Modern Textile Dictionary" by George Linton:

(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 under controlled temperature. This involves running the cloth into a series of hot water baths or bowls of increasingly higher temperature 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 ordinary shrinkage. 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 for the seven bowl Birch crab are the following:

	° C.
First bowl	43
Second bowl	54
Third bowl	71
Fourth bowl	82
Fifth bowl	93
Sixth bowl	93
Seventh bowl	32

(4) Tack. This is a standard type of operation for the purpose of protecting the material against damage in subsequent wet-finishing operations, e.g. scouring, etc.

(5) Scour. This may be done, for example, on a Dolly or full width washer using a high liquid level with no pressure or dragging on the material being scoured. The scouring agent should be non-alkaline, e.g. neutral or slightly acidic. Typically suitable scouring agents are the neutral nonionic detergents such as Adran 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 40–45° 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.

(6) De-tack.

(7) After de-tacking, the cloth is dry relaxed with about 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° 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.

(8) Screen. This operation involves a visual examination of the fabric to ascertain if the preceding processes met quality standards and to repair if necessary torn selvages, seams, etc., that might be more seriously damaged in subsequent operations.

(9) The fabric is then top steamed on an open steam table while in the completely relaxed state. Top steaming involves a treatment whereby the fabric is allowed to pass over an open steam table at 10–15 yards/minute at a saturated steam temperature of 100° C.

(10) The fabric is again tacked, dyed as desired under completely relaxed conditions and then de-tacked.

(11) Following the second de-tacking operation, the fabric is dry relaxed with overfeed as before, screened and sheared.

(12) The sheared fabric is then again subjected to top steam on an open steam table in the completely relaxed state. For some fabrics, a Yorkshire crabbing may be desirable at this stage. In any case, the next step is cold water shrinkage. In the latter operation, the fabric is immersed in a bath of cold water containing a wetting agent, at, for example, 32° C. This treatment is one of the final shrinkage steps.

(13) The finishing operation is continued by loop drying which is characterized by drying with warm air without tension at 115–125° C., preferably 123° C., at 20–25 yards/minute, preferably 20 yards per minute. The fabric is usually subjected to the above drying temperatures for approximately five minutes.

(14) The cold water shrinkage operation and loop drying procedures mentioned above are repeated.

(15) The final operation is semi-decating which consists of winding the fabric between a hard leader blanket on a perforated cylinder, steaming at, for example, 100° C., for five minutes and steam exhaustion for five minutes which serves to set the material and improve its appearance.

Some fabrics require full-decating in lieu of semi-decating. The former may be accomplished by autoclave pressure steaming at 10 p.s.i. for 3 minutes followed by 8 minutes cooling.

Most, if not all, of the above-noted finishing steps are known, in and of themselves, in the worsted fabric art. However, it is a characteristic requirement of the present process that the essential finishing operations, and notably those involving a liquid or drying treatment must be carried out with the fabric in a completely relaxed state and in sequences, temperatures and time cycles as described above.

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

Example 1

An end of 60's count worsted yarn having a USDA wool grade number of 80 (i.e. 1/60's 80's wool yarn) and a spun twist of 20 turns per inch in the Z direction was plied with an identical 1/60's 80's worsted yarn having a spun twist of 20 turns per inch in the S direction. The ply twist amounted to 20 turns in the Z direction. The plying operation was carried out with the two ends under tension (5 to 15 grams as mentioned heretofore).

The plied product was then stabilized by treatment with steam (saturated) at 75° C. for 60 minutes. The resulting worsted stretch yarn was then ready to use in the preparation of a worsted stretch fabric.

A fabric was then woven with stretch yarn prepared as above as the filling yarn in a 2 x 2 weave. The warp yarn was (two-ply) 2/60's 80's worsted yarn consisting of two pre-ply single ends of 1/60 80's wool 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.

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 stretch or plied yarn measured approximately 16240 yards per pound giving an equivalent count of about 29. Thus, the value M is calculated as follows, the value of B being 10%:

$$M=\left[\frac{(\sqrt{16240})(4)(1-.10)}{4+2}\right] \text{ times } 2=153$$

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 24.4% 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 10% farther apart than in 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 calculated value of 153 necessary to obtain optimum results.

After the weaving operation, the greige fabric was taken from the loom and finished as follows: batched with additional fabric made in the same way, flame singed, subjected to the Birch crab, tacked and scoured on the Dolly washer as mentioned heretofore. The fabric was then detacked, dry relaxed with overfeed, screened, top steamed on an open steam table in the completely relaxed state, again tacked, dyed, detacked, again dry relaxed with overfeed, screened, sheared and again subjected to top steaming in the completely relaxed state. Following this treatment, the fabric was subjected to cold water shrinkage, then loop dried, cold water shrinkage and loop dried again and semi-decated, all as heretofore described.

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 stability. The fabric returns to its original shape after being stretched and demonstrates no adverse changes after tailoring, wearing and repeated dry cleaning.

Example 2

Example 1 was repeated except that the warp yarn was replaced by the same stretch yarn as used in the filling. The resulting product had stretch in the warp direction as well as in the filling direction. Otherwise, the stretch and other properties of the fabric were essentially the same as the product of Example 1.

It will be appreciated that various modifications may be made in the invention described herein without deviating from the scope thereof as set forth in the appended claims wherein:

I claim:

1. The method of preparing a worsted stretch fabric which comprises providing an end of worsted yarn having a yarn count within the range of 40 to 80, a USDA wool grade number between 62 and 80 and a spun twist in the S direction of between 15 and 26 turns per inch, providing another end of worsted yarn having essentially the same yarn count, grade number and spun twist in the Z direction, twisting said two ends together by applying a ply twist in either the S or Z direction within the range of 15 and 25 turns per inch, stabilizing the twist in said yarn, thereafter weaving a fabric using said plied yarn at least as the filling yarn, the warp yarn being reeded out so that said filling yarn is provided space to bulk when the resulting fabric is finished.

2. The method of claim 1 wherein said fabric is finished in the completely relaxed condition.

3. The method of claim 1 wherein the plied yarn is also used for the warp.

4. The method of claim 1 wherein each end of pre-ply worsted yarn is a 60 count, 80 grade wool yarn.

5. The method of claim 1 wherein the warp yarn is also worsted and the resulting fabric is a 100% worsted stretch fabric.

6. The method of claim 1 wherein the sum of the average picks and ends per inch of the woven fabric is not greater than

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

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 the number of interlacings per end in the weave; and

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

7. The method of preparing a stretch fabric which comprises providing an end of worsted yarn having an appropriate yarn count and grade number and a spun twist in the S direction, providing another end of worsted yarn having essentially the same yarn count, grade number and spun twist in the Z direction, twisting said two ends together by applying a ply twist in either the S or Z direction substantially equal to the original number of turns in said ends before plying, thereafter weaving

a fabric using said plied yarn as the filling yarn with the warp yarn being reeded out so that said filling yarn is provided space to bulk when the resulting fabric is relaxed and thereafter finishing said fabric in the completely relaxed condition, the sum of the average picks and ends per inch of the woven fabric being not greater than

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

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.

8. The stretch worsted fabric prepared by the method of claim 1.

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CERTIFICATE OF CORRECTION

Patent No. 3,127,658 April 7, 1964

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, in the table, second column, opposite "42-43", for "66's to 80's" read -- 64's to 80's --; column 3, line 70, for "worted" read -- worsted --; column 4, line 10, for "miutes" read -- minutes --.

Signed and sealed this 20th day of October 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents