Nov. 26, 1968 R. S. MARTIN 3,412,547

ELASTIC COMPOSITE YARN AND PREPARATION THEREOF

Filed June 27, 1966

FIG. 1

FIG. 2

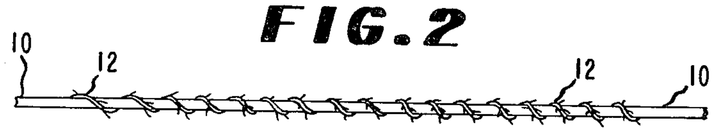
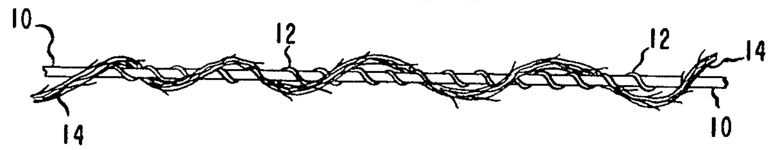


FIG. 3



INVENTOR
ROBERT S. MARTIN

BY [signature]

ATTORNEY

United States Patent Office

3,412,547
Patented Nov. 26, 1968

3,412,547
ELASTIC COMPOSITE YARN AND PREPARATION THEREOF

Robert S. Martin, Charlotte, N.C., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed June 27, 1966, Ser. No. 560,564
4 Claims. (Cl. 57—152)

ABSTRACT OF THE DISCLOSURE

Composite elastic yarns are prepared by core-spinning stretched continuous filaments of segmented elastomer with a sheath inelastic staple fiber having a shrinkability of at least 15%, heat setting the core-spun yarn to shrink the sheath fibers and plying the heat-set core-spun yarn with a second yarn of these inelastic staple fibers. These yarns, having the sheath fibers in shrunken engagement with the continuous filament core and interlocked therewith, are useful in fabrics made therefrom. These fabrics have limited stretch and low power, as well as good aesthetics and low pilling tendency, which is highly suitable for particular end uses, e.g., sweaters.

This invention relates generally to elastic core-spun yarns produced by core-spinning continuous filament elastic fibers and inelastic staple fibers at least part of which are high-shrinkage staple fibers.

Stretch-yarns and fabrics have been made heretofore from covered rubber threads and from both covered and non-covered synthetic elastomer threads such as the polyurethanes or spandex. Fabrics made up to this time have been made largely for support purposes such as girdles, swim suits and support hose, and the degree of stretch and the power have been too great for use in outerwear garments where there is a regard for aesthetics. Core-spun yarns made by spinning a continuous filament elastic fiber with inelastic staple fiber in the past have yielded fabrics with severe pilling properties. This is due to the fact that when the elastomeric fiber core contracts, the 100% low shrinkage staple fibers in the sheath are bulked and loosened so that the final fabrics fuzz and pill badly.

The primary object of the present invention is to provide elastic yarns and fabrics made therefrom having limited stretch and low power making them suitable for outerwear garments such as sweaters and suits. This invention also leads to fabrics having good aesthetics and low pilling tendency.

These and other objects are achieved in this invention in a core-spun yarn, and fabrics produced therefrom, the yarn being core-spun from continuous filament elastic spandex yarn and a roving of inelastic staple fibers that are high-shrinkage or of mixed shrinkage characteristics, the core-spun product being plied with another yarn of the inelastic staple fibers. The resulting yarns have low stretch-modulus and impart to fabrics made from them improved apparel quality.

The core-spinning of elastic and non-elastic fibers is taught in U.S. Patent 3,009,311 to Wang, and U.S. Patents 3,017,740 and 3,038,295 to Humphreys. However, in none of the prior art is it recognized that advantages in pill resistance, cover, regulation of stretch and power, and aesthetics can be obtained in the manner of the present discovery. The plying of core-spun yarns with yarns spun from high-shrinkage or mixed-shrinkage fibers has not been practiced heretofore.

When low-shirnkage inelastic fibers are core-spun with elastic fibers as in the prior art, the contraction of the elastic fibers creates slackness and loops in the inelastic sheath fibers and the loose fibers form fuzz and, eventually, pill because the staple fibers are not bound into the yarn in any way. Furthermore, the staple fibers in such prior yarns are easily displaced when the yarns are stretched and the elastic core yarn shows through to give a non-uniform appearance.

In one method of operation according to the present invention a yarn of continuous filament spandex fibers is core-spun with a roving of high-shrinkage or mixed-shrinkage fibers of acrylonitrile polymer, polyester or polyamide using conventional spinning equipment. The draft during this spinning is about 3.5 to 4.5 and a twist of about 6 to 20 Z turns per inch (2.3 to 8.0 turns per cm.) is applied. The yarn is then wound on a bobbin while maintaining the tension on the yarn. It is next heat-set sufficiently to prevent contraction when tension is removed. This yarn is then plied with another yarn spun from the same or different high- or mixed-shrinkage inelastic staple fibers with Z twist, the ply being twisted in the S direction. After the yarn is knit or woven into a fabric, the fabric is heated in a relaxed state to restore elasticity to the yarns. This heat relaxation may occur during dyeing and finishing.

By providing the yarns in this fashion, the mixed or high-shrinkage staple fibers are caused to shrink when the core-spun yarn is heat-set, and they become interlocked around the spandex core yarn. The staple fibers are firmly bound together upon shrinkage and this prevents pilling in the final fabric and also avoids bare spots where the core fiber would show through. By regulation of the spinning draft, twist, heat-setting time and temperature, and fiber deniers, it is possible to vary the fabric "hand" over a wide range. The degree of stretch and power of the product are variable within a range suitable for outerwear garments and these properties also are achieved in heat-setting the singles yarn under tension.

The product is shown in the attached drawing in which:

FIGURE 1 indicates a core-spun singles yarn as produced prior to heat-setting;

FIGURE 2 shows the yarn of FIGURE 1 after heat setting, with an indication of the inter-locking that occurs; and

FIGURE 3 shows the yarn after plying.

In FIGURE 1, the numeral **10** is the core yarn which is composed of spandex filaments. Surrounding it is a sheath yarn **12** formed of high or mixed shrinkage staple fibers. That core-spun yarn is heat set while held under spinning tension sufficiently to prevent contraction upon release of the tension. The heat setting causes the fibers of yarn **12** to shrink. This tightens yarn **12** around core **10** as shown in FIGURE 2. Thereafter, a product in FIGURE 3 is produced by plying a yarn **14** with the heat-set core-spun product.

As noted, yarns of the present invention include a continuous elastic filament core member. For the core component a segmented elastomer of the spandex type is employed. Spandex is the generic term for filaments composed of at least 85 percent of segmented polyurethane and further characterized by having segments of high-melting crystalline polymer alternating with segments of low-melting amorphous polymer. Segmented elastomers of this type and processes for preparing them in filamentary form are described in U.S. Patents 2,813,775, 2,813,776, 2,929,800, 2,929,801, 2,929,804, 2,953,839, 2,957,852, 3,097,192, 3,077,006; in British 779,054; and in French Patent 1,388,558 to which reference can be made for details.

The spandex core yarn generally comprises about 2 to 15 percent of the final yarn, with the actual amount used being determined by the denier of filaments employed and the yarn count produced therefrom. The elastic core yarn is in a stretched state during spinning and heat-setting, and thereafter is plied with another yarn of inelastic fiber. Consequently, the amount of elastomeric fiber in the final yarn is minimized. This is one way to obtain the low stretch-modulus desired. The amount of elastic yarn in the core-spun singles yarn for various elastic yarn deniers and for various core-spun singles yarn counts is shown in Table I below:

TABLE I

Yarn Count Worsted Count (W.C.)	Percent Elastic Fiber		
	40 Denier	70 Denier	140 Denier
1/18	2.5	4.5	7.0
1/24	3.3	6.0	9.3
1/36	5.0	9.0	14.0
1/45	6.2	11.3	17.5

The staple fibers suitable for use in this invention can be acrylic fibers, polyester fibers, polyamide fibers, or other fibers with boil-off shrinkage of at least 15%. The acrylic fibers are preferred because they can readily be prepared with high-shrinkage and they have wool-like properties which are desirable in view of the uses intended. High shrinkage can be obtained most conveniently by hot-stretching and breaking on the Turbo Stapler (Turbo Machine Co., Landsdale, Pa.). This yields staple fibers with up to 40% shrinkage if the "fiber setting" (relaxing) operation is omitted. Mixed-shrinkage fibers can be made by mixing relaxed and non-relaxed fibers. Such operations and the fibers indicated are well-known commercially and in the technical literature to which reference can be made.

The invention will be described further in conjunction with the following example in which the details are given by way of illustration.

Example I

An acrylic fiber tow of 470,000 denier is stretched and broken on a Turbo Stapler (Turbo Machine Co. of Lansdale, Pa.). In this operation the hot plates of the Turbo Stapler are at a temperature of 135° C. and the draft in the hot stretching is 1.5×. The resulting sliver is stuffer-box crimped and then passed through a further stretch-breaking operation in a Hood Doubler to break any long fibers. The resulting fibers have a boil-off shrinkage of 20%.

A second tow is similarly processed but is then relaxed to give fibers with less than 4% shrinkage. The relaxation is accomplished by placing the sliver in perforated cans in a pressure-eight container and subjecting the container alternately to vacuum and steam at 10 pound per sq. inch (0.7 kg./cm.^{2}) 116° C. for 4 minute intervals.

The relaxed sliver weighing 200 grains/yd. (14 grams/meter) and the unrelaxed sliver weighing 170 grains/yd. (11 grams/meter) are combined and pin drafted with six passes through the pin drafters. The resulting sliver weighing 60 grains/yd. (4 grams/meter) is spun on a roving frame to a 1 hank (142 den.) roving.

This roving is core-spun with a continuous filament 40-denier coalesced yarn of a segmented polyurethane made according to French Patent 1,388,558. In feeding the spandex, it is stretched 3.5× and the core-spun yarn is twisted 12.7 t.p.i. Z twist (5 t.p. cm.). The resulting singles yarn has a 1/40 worsted count (W.C.) (199 den.). This core-spun yarn is wound on a collapsible tube under the spinning tension and is heat-set in a steam chamber at 118° C. for 30 minutes. The retractive factor (defined hereinafter) for the heat set yarn is found to be 5.4%, its Lea product is 1116 and the worsted count is 1/32.4 (245 den.).

Another yarn is spun from the acrylic fiber roving by itself to a 1/36 W.C. (221 den.) having 12.0 t.p.i. (4.7 t.p. cm.) Z twist.

These two yarns are then plied with a twist of 6 S t.p.i. (2.3 t.p. cm.). The plied yarn is knit on a 12-cut Jacquard TA-4 knitting machine to give a fabric which, after finishing, has a count of 28 courses and 16 wales per inch (11 courses and 6.3 wales per cm.), and weighing 8 oz. per sq. yd. (268 grams per sq. meter).

Upon boil-off, the fabric shrinks 37% in length but none in width. When a 3-inch (7.6 cm.) belt 10-inches (25.4 cm.) long is stretched under a load of 30 pounds (13.6 kg.), the total stretch is 120% in the lengthwise test and 150% in the width. When tested for pilling in the Tumble Pill Test (ASTM D-1375) for 20 minutes, the rating is 3.7.

The above results are for plied yarns prepared from a spandex yarn and inelastic fibers of mixed-shrinkage with the core-spun yarn heat-set on a collapsible tube. Data for yarns and fabrics in which the inelastic fiber is varied and for heat-setting on collapsible tubes as well as on rigid bobbins are given in Tables II, III, IV and V.

Heat-setting of the core-spun singles yarn is done conveniently by placing the yarn packages in a container and alternately applying vacuum and steam. If the yarn is wound on a collapsible, spring loaded dye tube, it will shrink some during heat-setting and have greater extensibility than if heat-set on a rigid, non-collapsible perforated tube. Thus, the fabric aesthetics can be regulated by the choice of tube for the heat-setting operation. In addition different effects can be obtained by using high-shrinkage or mixed high- and low-shrinkage inelastic fiber in the two non-elastic yarns employed. The terms "high-shrinkage" and "mixed-shrinkage" apply only to the inelastic fibers in the yarns.

Regardless of the shrinkage character of the yarns, good pilling resistance is achieved with heat-setting on collapsible tubes or rigid bobbins. Similarly, no matter which yarn combination is used, a collapsible tube heat-set will result in good stitch clarity while a rigid bobbin will produce a slight boucle in stitch. With high shrinkage yarn in the plied yarn, a worsted "hand" is obtained with the tube or bobbin, with a "very worsted hand" resulting if the singles yarn also employs high shrinkage yarn. With mixed shrinkage yarn in the singles and ply, heat-setting on a collapsible tube results in a soft "hand" while that on a rigid bobbin produces a very soft "hand." With high shrinkage yarn in the singles and mixed shrinkage yarn in the ply, a moderately soft "hand" is experienced upon use of the collapsible tube and a soft "hand" with a rigid bobbin.

The heat-setting of the core-spun yarn (see U.S. Patent 3,017,740) is an important step in the present invention. The yarn is maintained under tension after spinning and is heat-set in the extended condition. The amount of tension, or stretch, at the time of heat-setting can be used to vary the degree of stretch and the stretch-modulus of the heat-set yarns and resulting fabrics. The temperature of heat-setting can vary from about 100° C. to 150° C. but is preferably about 110° C. to 130° C. because of the greater ease of obtaining uniform results in a reasonable time. At 118° C., heating time of 30 to 40 minutes is satisfactory. Longer or shorter times will serve for lower or higher temperature respectively. The following table shows the effect of time of heat-setting at 118° C. on the retraction of the core-spun yarn. The retractive factor is the percent shrankage noted when a skein of the yarn is boiled off. The core-spun yarns in Table II were spun with mixed-shrinkage in elastic fibers on a core yarn of spandex.

TABLE II

Heat-Setting Time (minutes)	Collapsible Tube			Rigid Bobbin		
	Retractive Factor (percent)	Yarn Count (W.C.)	Lea Product	Retractive Factor (percent)	Yarn Count (W.C.)	Lea Product
5	7.6	1/33.2	1,236	7.4	1/37.0	1,596
10	7.0	1/30.7	1,128	7.3	1/38.0	1,694
20	5.8	1/33.6	1,062	6.8	1/38.0	1,797
30	5.4	1/32.4	1,116	6.4	1/40.1	1,623
40	3.8	1/31.9	1,071	5.9	1/38.3	-------
Control [1]						1,844

[1] 1/40 W.C. yarn not heat-set.

It will be seen from this data that the yarn heat-set on a collapsible tube has shrunk to a heavier (lower count) yarn. The retractive factor gives an indication of the stretch that would be obtained in fabrics knit from these yarns. If the yarns were completely relaxed before heat-setting, the stretch would be too great to be satisfactory for outerwear garments. The lower Lea products for the yarn heat-set on the collapsible tube is a result of the bulking of the inelastic fibers when allowed to shrink on the tube.

The effects of heat-setting time and use of a collapsible tube or a rigid bobbin, on the shrinkage of fabrics, while varying the type inelastic yarn used, is shown in Table III below. In Table III the fabric stretch is measured by making a belt from a 3-inch wide strip of fabric with 10-inch length of fabric in the belt. This belt is then stretched on an Instron Tester up to a load of 30 pounds and the percent stretch recorded.

TABLE III

Type of Inelastic Fiber		Heat-Setting Time and Package (118° C.)	Stretch (percent at 10 pounds/inch load	
In Core-Spun Yarn	In Inelastic Yarn		Length	Width
Mixed-shrinkage	Mixed-shrinkage	5 min.—Rigid Bobbin.	205	270
Do	High-shrinkage	do	189	263
Do	Mixed-shrinkage	10 min.—Rigid Bobbin.	188	241
Do	High-shrinkage	do	175	273
Do	Mixed-shrinkage	20 min.—Rigid Bobbin.	149	178
Do	High-shrinkage	do	122	178
Do	Mixed-shrinkage	30 min.—Rigid Bobbin.	128	156
Do	High-shrinkage	do	120	150
Do	Mixed-shrinkage	40 min.—Rigid Bobbin.	91	138
Do	High-shrinkage	do	75	132
Do	Mixed-shrinkage	30 min.—Collapsible Tube.	120	150
Do	High-shrinkage	do	115	130

Table IV below gives a range of yarn counts and twists which have been found satisfactory for knit garments but does not indicate limits of twist and counts as each can be varied independently.

TABLE IV

Core-Spun Yarn		Non-Elastic Yarn		2-Ply Yarn, t.p.i. S
Yarn Count (W.C.)	Twist, t.p.i. Z	Count (W.C.)	Twist t.p.i. Z	
1/18	8.5	1/16	8.0	6
1/24	9.8	1/22	9.4	6
1/36	12.0	1/33	11.5	6
1/40	12.7	1/36	12.0	6
1/45	13.4	1/40	12.7	6

It has been found advantageous in some cases to twist the core-spun yarn and the inelastic fiber yarn in opposite directions and then twist the ply in the same direction as the core-spun yarn. This keeps the inelastic staple fibers closely wound around the elastic core-yarn and prevents the separation of the two as sometimes happens when the ply is twisted in a direction opposite the twist in the core-spun yarn.

If the ply is to be twisted in the same direction as the core-spun yarn, then the initial twist in the core-spun yarn should be less to allow for the additional twisting during plying. By operating in this way a balanced yarn will be obtained and the elastic core filaments will be completely and uniformly covered in the finished fabric.

The pilling resistance of fabrics prepared in accordance with the present invention is shown in Table V. The pilling resistance test used is ASTM method D-1375 described in ASTM Standards (1958) Part 10, page 510. The effect of heat-sealing time and package type on pill resistance is also shown. Pill testing ratings of 3 or above are considered satisfactory.

TABLE V

Inelastic Fiber Type	Heat-Setting Time (118° C.)	Pill Resistant Rating (20 Minutes Tumbling)
Mixed-shrinkage/mixed-shrinkage	Rigid Bobbin:	
	5 min	1.4
	10 min	2.9
	20 min	2.4
	30 min	2.9
	40 min	3.2
Mixed-shrinkage/high-shrinkage	Rigid Bobbin:	
	5 min	2.4
	10 min	1.7
	20 min	3.5
	30 min	3.3
	40 min	3.6
Mixed-shrinkage/mixed-shrinkage	Collapsible Tube:	
	5 min	3.5
	10 min	3.8
	20 min	3.4
	30 min	3.7
	40 min	3.9
Mixed-shrinkage/high-shrinkage	Collapsible Tube:	
	5 min	3.1
	10 min	2.9
	20 min	3.7
	30 min	3.8
	40 min	3.8

From Table V, it is evident that long heat-setting times and the use of a collapsible tube tend to contribute better pill resistance.

The ratios of high- to low-shrinkage fiber in the yarns can vary from about 25/75 to 100/0 to vary the bulk or tightness of the sheath fibers. A wide range of fiber deniers can be used both for the acrylic (or other type inelastic fiber) and the spandex fibers. The draft during spinning should be within the limits of 3.0 and 5.0 for most desirable aesthetics but 3.5 to 4.5 is preferred. It will be obvious that the draft and the twist can be varied to give lighter or heavier yarns and to give soft or harsh yarns.

By means of this invention knitters can knit garments to correct sizes and, hence, can spin yarns of desired count without having to allow for large dimensional change during dyeing and finishing.

While the invention has been described with certain details it will be appreciated that changes can be made without departing from its scope.

What is claimed is:

1. An elastic core-spun composite yarn comprising an initially stretched, uncrimped elastic continuous filament of a segmented elastomer and a sheath consisting of inelastic staple fibers having an initial shrinkability of at least 15 percent surrounding the filament, the sheath fibers being in shrunken engagement through the length thereof with the stretched filament and interlocked therewith, and a second yarn of substantially the same fibers as said sheath plied with said sheath-core yarn to provide a composite yarn.

2. A yarn in accordance with claim **1** in which said staple fibers are acrylic fibers.

3. A yarn in accordance with claim **2** in which the acrylic fibers comprise a blend of high shrinkage fibers and low shrinkage fibers, with at least 25 percent thereof being high shrinkage fibers.

4. A method comprising core-spinning an uncrimped, stretched continuous filament of a segmented elastomer and a sheath of inelastic staple fibers consisting of staple fiber having a shrinkability of at least 15 percent, heat setting the resulting core-spun yarn under substantially the tension of its formation to shrink the sheath fibers, and plying the heat-set core-spun yarn with a second yarn of said inelastic staple fibers to produce a composite yarn.

References Cited

UNITED STATES PATENTS

2,852,834	9/1958	Engelhard	57—163 XR
2,902,819	9/1959	Ross	57—152
3,115,745	12/1963	Lathem et al.	57—163
3,306,081	2/1967	Miles et al.	57—163 XR
3,315,328	4/1967	Ibrahim	57—163 XR

JOHN PETRAKES, *Primary Examiner.*