

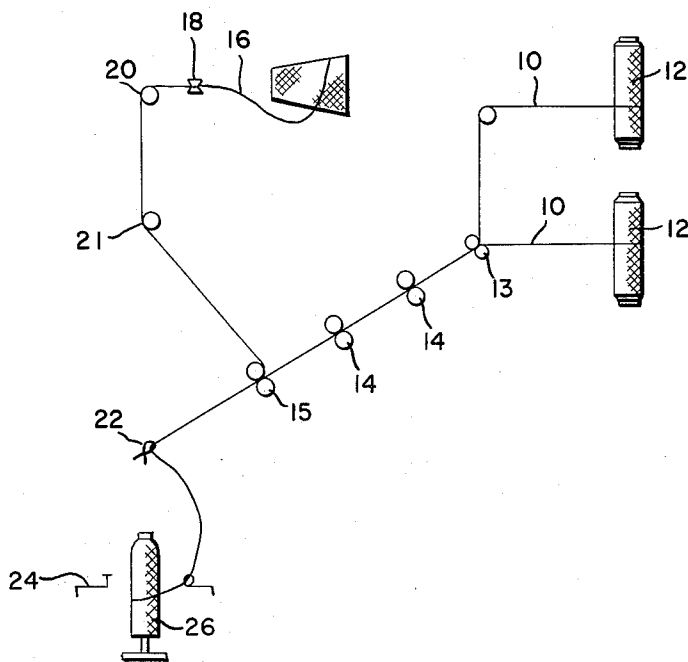
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C. R. HUMPHREYS

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PROCESS FOR CORE-SPINNING SMOOTH ELASTIC YARN

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1

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PROCESS FOR CORE-SPINNING SMOOTH ELASTIC YARN

Charles R. Humphreys, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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This invention relates generally to a process for making a smooth elastic yarn and, more particularly, to the production of such a yarn by core-spinning a sheath of staple fibers around a filament of a segmented elastomer. As used herein, the term "core-spinning" refers to the process of introducing a continuous filament to a conventional spinning or drafting frame together with one or more rovings of staple fibers to produce a composite yarn having the continuous filament as a core and the drafted rovings as a sheath.

In the past, rubber filaments have been covered with a sheath for a variety of reasons among which are appearance, improved hand, protection against light, perspiration and grease, and for the purpose of controlling the stretch of the composite yarn.

Commercial core-spun yarns, incorporating highly pre-twisted rubber cores and oppositely twisted sheaths of staple fibers, are known. The pre-twisting and handling of the rubber core is an expensive operation, since twists of approximately 100 turns per inch are necessary. Furthermore, the process is a delicate one since the torque exerted by the twisted core must exactly balance the torque resulting from the twist in the sheath fibers in order to produce a composite yarn which will be free of "twist liveliness", i.e., one which will not spontaneously kink. Such a balanced smooth elastic yarn is marketed by the U.S. Rubber Company under the trademark "Laton."

Those skilled in the art are familiar with the difficulties involved in the use of a pre-twisted core and have proposed various solutions of the problem. One such proposal is disclosed by Foster in U.S. Patent No. 2,804,745. In producing a core-spun yarn, Foster uses a thermoplastic sheath which is heat-shrunk upon the core. However, a moderately high degree of pre-twist in the core is still required. In producing a core-spun yarn having a rubber core, no way has yet been found to avoid the necessity of balancing the torque of the sheath by pre-twisting the core. A further disadvantage is that rubber core yarns are not available in a denier of less than about 300 which factor imposes a rather severe limitation on the use of such yarns.

A smooth elastic yarn may also be prepared by wrapping two pre-spun yarns of staple fibers in opposite directions around an untwisted rubber core. Such a product, wherein the torques of the oppositely wrapped sheaths are counter-balanced, is marketed by the U.S. Rubber Company under the trademark "Lastex". This is not a core-spun product.

The most important object of the present invention is to provide a simple and inexpensive process for the production of smooth elastic yarns by a core-spinning technique.

Another important object of the invention is the pro-

2

vision of a process of core-spinning by which a balanced composite yarn may be produced without the need of pre-twisting the core.

Another object of the invention is to provide a process of producing smooth covered elastic yarns of fine denier.

With these and other objects in view, the process of this invention includes generally the steps of core-spinning a sheath of drafted staple fibers on a stretched, continuous filament of a segmented elastomer, permitting partial contraction of the stretched composite yarn, heating the yarn at a temperature less than the degradation temperature of the core filament and, finally, cooling the composite yarn at the same length at which it was heated. The result of the heat treatment steps is that the twist liveliness of the composite yarn is destroyed. By controlling the critical factor of twist multiplier, using a segmented elastomer instead of rubber and incorporating the steps incident to heat treatment, smooth elastic yarn may be prepared inexpensively in an otherwise conventional core-spinning process. The process is applicable to practically all ring-and-traveler spinning frames in use today and necessitates only a small investment in tension devices.

The drawing is a schematic representation of a spinning frame which has been adapted for use in producing the core-spun yarn of the present invention.

In the drawing, the numeral 10 designates rovings which are led from packages 12 through the back pair 13 of drafting rolls, intermediate pairs 14 and the front pair 15. A twist-free, continuous filament structure 16 of a segmented elastomer passes through a tension device 18, over guide 20 and a positioning guide 21, and, along with rovings 10, through the front rolls 15. The filament structure 16 which is illustrated in the drawing can be either a monofilament or a plurality of continuous filaments. Between the tension device 18 and the front rolls 15, filamentary structure 16 is positively tensioned and then entered in the stretched condition at the nip of the front rolls at the same location as the rovings 10. From the rolls 15, the drafted rovings 10 and filament 16 travel through guide 22 to the traveler of ring twister 24. The operations in spinning are normal except that the tension on filament 16 below the front rolls 15 must be sufficient to retain substantially the same percentage elongation below the rolls as above. This may be accomplished by the use of heavier than normal travelers on ring twister 24. In traveling through ring twister 24, the drafted rovings 10 are spun in the normal manner about filament 16 to produce a core-spun yarn which is wound on bobbin 26 in the stretched condition.

The next step in the process is to unwind a length of the stretched composite yarn from bobbin 26 and permit partial contraction thereof. Preferably, this contraction is arrested just before the appearance of twist loops, which is usually at about 40-60% of the as-spun length. The appearance of twist loops is due to the unbalancing torque existing in the composite yarn and this in turn is related to the amount of twist applied to the composite yarn by the ring twister 24.

The term "twist multiplier," as used hereinafter, is a factor which relates the twist in turns per inch (t.p.i.)

to the cotton count of yarn being spun. In cotton spinning systems, the formula used is:

$$\text{t.p.i.} = \text{twist multiplier} \times \sqrt{\text{cotton count}}$$

converting this formula into units of denier,

$$\text{twist multiplier} = \frac{\text{t.p.i.} \times \sqrt{\text{denier}}}{73}$$

Unless otherwise specified herein, the term "denier" refers to the as-spun composite elastic yarn in its stretched condition.

It has been found that where a twist multiplier of less than about 4 is employed, the sheath fibers tend to bulk before twist loops appear, as the composite yarn is permitted to contract. Accordingly, it is imperative that a twist multiplier of 4 or more be employed in the core-spinning steps if a smooth yarn is to be produced. A process of core-spinning bulky, elastic yarns, wherein twist multipliers of less than 4 are employed, is disclosed in my copending application Ser. No. 782,744, filed December 24, 1958.

After the stretched composite yarn has been partially contracted, as indicated above, the next step is the application of heat. The duration and temperature of this heating step depend upon the particular segmented elastomer chosen for the core and upon the presence or absence of other chemical substances therein, such as plasticizers or solvents. Ordinarily, temperatures between 100° C. and 150° C. are preferred. The upper limit of 150° C. may be exceeded if the time of exposure to the high temperature is shortened to avoid degradation of the elastomer. It is important to note that the heating step does not shrink the sheath fibers on the core, nor does it fuse the sheath to the core. The step of permitting partial contraction may be carried out either at room temperature or at elevated temperatures, and it may precede or be simultaneous with the heating step. The composite yarn is retained and held at its partially contracted length for the duration of the heating step and thereafter until cooled below 70° C. Preferably, the yarn is held at this length until it has cooled to room temperature. The result of the heating and cooling treatment is that, when released, the yarn no longer has any tendency to contract but is still elastic in extension. Another way of expressing this phenomenon is to state that the twist liveliness of the composite yarn has been destroyed. The time of treatment at the elevated temperature must be sufficient for this effect to be produced. Generally, it will be in the order of 10-60 minutes at temperatures ranging from 100° C. to about 150° C.

In addition to the critical factor of twist multiplier, there are certain other variables which must be considered in carrying out the instant process, such as the percentage elongation of the core and the core content of the composite yarn as it is wound on bobbin 26. For example, it is apparent that the amount of stretch to be applied in the core-spinning steps will depend on the percentage elongation desired in the finished yarn. Furthermore, when twist multipliers in the range of 4.0-4.6 are used, the core content should be greater than 40% by weight, in order to avoid any tendency toward bulking of the sheath fibers. With higher twist multipliers the core content can be reduced to 30% by weight or lower. As the core content is reduced toward the lower limits, the extent to which the stretched composite yarn may be permitted to contract before the appearance of twist loops is also reduced. The only criticality in this respect is that the core content of the as-spun composite yarn be sufficient to insure that, as the yarn is permitted to contract before heating, twist loops will appear before the occurrence of any sheath bulking. As noted previously,

the extent of contraction is generally between 40% and 60% of the as-spun length.

Heat may be supplied to the partially contracted core-spun yarn by any suitable means, such as by treatment with a hot gas or a liquid, infrared radiation, ultrasonic energy, dielectric heating, and the like. The only requirement is that the heating medium be subject to control so that the temperature will not be carried beyond the elastomer degradation point.

Any textile fiber available in staple form may be used in the rovings 10, including the natural fibers cotton and wool, and the synthetic fibers rayon staple, nylon staple, polyacrylonitrile staple, polyethylene terephthalate staple, and the like. Any staple length which may be used in a conventional ring-spinning process is also suitable for the process of the present invention.

The term "segmented elastomer," as used herein, refers to a synthetic elastomeric polymer made of segments of a high-melting, crystalline polymer alternating with segments of a low-melting, amorphous polymer. A wide variety of suitable segmented elastomers exists. The crystalline, high-melting segment may be derived from a urea polymer, urethane polymer, amide polymer, bis-ureylene polymer or polyester, for example. The low-melting, amorphous segment may be derived from an ester polymer, an ether polymer, or a hydrocarbon polymer, for example. Segmented elastomers of this type together with a process for obtaining them in filamentary form are described in U.S. Patents No. 2,813,775 and 2,813,776. Suitable polyether-polyester segmented polymers are also described in British Patent No. 779,054. The preferred segmented elastomers are those containing a bis-ureylene segment alternating with segments of a low-melting polyether or polyester. These preferred elastomers as well as a process for their preparation are more fully described in copending application Ser. No. 709,445, filed January 17, 1958. Generally speaking, such segmented elastomers, wherein the low-melting polymer has a melting point below 50° C. and a molecular weight above about 600 and which contain from 10 to 40% of the high-melting segment derived from a polymer melting above 200° C., will have elongations over 150%, tensile recoveries over 90% and stress decays less than 20%.

In addition to the fact that smooth elastic core-spun yarns may be produced from a twist-free core, there are other noteworthy advantages in the use of segmented elastomers as against rubber in the core-spinning process of the present invention. For example, the segmented elastomers may be spun in deniers well below 20 to yield filaments having exceptional elastic properties. By the use of such fine denier continuous filament cores, very fine smooth elastic yarns may be prepared. Since the segmented elastomers can be dyed simultaneously with the sheath fibers, the problem of "grinning" (the unsightly effect produced when a rubber core-spun yarn is stretched, allowing the rubber core to show through the sheath) is easily overcome. The possible uses for these composite yarns are thereby increased. Moreover, they are more resistant than rubber core-spun yarns to oils, perspiration, grease, and the like. Furthermore, core-spun yarns containing segmented elastomer cores exhibit much more uniform work recovery and stress decay characteristics over the entire stretch range when compared with rubber core-spun yarns.

The table which follows is a compilation of comparative data for several composite yarns, all of which were produced on conventional spinning frames similar to that which is illustrated in the drawing. It should be noted in advance that the yarn of comparative Example 6 was spun using a twist multiplier below the critical limit of 4 and that this yarn exhibited high bulk characteristics.

Ex. No.	Core, Original Denier	Sheath			Composite Yarn					Heat Treatment		
		Fiber	Staple Length	Cotton Count	T.p.i.	Twist Multi- plier	Percent Core	Denier Ex- tended	Maxi- mum Stretch, percent	Time (Min.)	Temp. (° C.)	Medium
1.	297	Cotton	Combed Supima	44. 4/1	26	5.0	34	203	155	10	115	Steam.
2.	300	do.	do.	40. 2/1	20	4.5	47	274	70	10	115	Do.
3.	289	Polyacrylo- nitrile.	1½"	38. 7/1	20	4.4	46	265	125	15	150	Air.
4.	403	do.	1½"	38. 7/1	20	5.7	63	441	82	15	150	Do.
5.	580	do.	1½"	38. 7/1	20	6.5	70	585	88	15	150	Do.
6.	300	do.	2½"	39/1	20	3.8	37.5	195	178	None	-----	Do.

The column headed "Maximum Stretch" refers to the maximum extensibility of the composite yarn after the indicated amount of heat treatment.

In each of the above examples, the preferred poly(bis-ureylene/ether) segmented elastomer was used for the core. This core elastomer was prepared as described in Example 1 of copending application Ser. No. 709,445, filed January 17, 1958.

With the exception of Example 6, the composite yarn of each of the examples had a smooth sheath of staple fibers and exhibited essentially no bulk characteristics.

As noted previously, the core-spun yarns of the present invention exhibit more uniform work recovery and stresses decay characteristics than do rubber core-spun yarns. In this respect, the yarn of Example 1 showed work recovery values of 74.1-77.5% and stress decay values of 4.6-18.4% over the range of 25-125% stretch. In contrast to these rather uniform values, a "Laton" yarn showed work recovery values of 30.6-85.1% and stress decay values of 1.5-30% over the same range. For purposes of comparison, the yarns in Examples 1 and 2 and a "Laton" sample were dyed to a dark blue shade. When extended, the rubber core yarn "grinned" badly whereas the yarns containing a segmented elastomer core did not visibly "grin."

The smooth elastic core-spun yarns prepared in accordance with this invention are useful in woven, knitted, and non-woven fabrics for use in universal fitting apparel (socks, polo shirts, underwear, bathing suits, gloves, elastic cuffs, sweaters, waistbands, suits, coats, dresses, skirts, action sportswear, leotard-type outerwear, and accessories such as tapes, webbings and other woven, non-woven or knit apparel fabrics), household products (form-fitting upholstery, slip covers, sheets, carpets, mattress coverings, and narrow tapes and webbings for a wide variety of uses), industrial products (transportation upholstery, woven and non-woven felts, tapes and webbings for varied applications), and medical products (surgical bandages, supports, elastic dressings, surgical stockings, and splint tapes). Other inherent uses and advantages will occur readily to those skilled in the art and the extent of the invention is accordingly intended to be limited only by the scope of the appended claims.

I claim:

1. A process of spinning smooth elastic yarn comprising the steps of: drafting at least one roving of staple fibers; stretching at least one continuous filament of a segmented elastomer to increase its length substantially; gathering the drafted roving and the stretched filament; twisting the filament and roving, using a twist multiplier of more than about 4.4, to produce a composite yarn having the filament as a core and the roving as a sheath; permitting appreciable contraction of the composite yarn from its initially stretched condition; heating the composite yarn at a temperature less than the degradation temperature of the core; and cooling the composite yarn

at a length substantially equal to the length at which it was heated.

2. A process of spinning smooth elastic yarn comprising the steps of: core-spinning a sheath of drafted staple fibers on a substantially stretched core consisting of at least one filament of a segmented elastomer by twisting, using a twist multiplier of more than about 4.4; permitting appreciable contraction of the composite yarn and therefore of the core; heating the yarn at a temperature and for a period of time less than the time-temperature relationship at which the core starts to degrade; and cooling the composite yarn at a length substantially equal to the length at which it was heated.

3. The process of claim 2 wherein the core, before the twisting step, is essentially twist-free.

4. The process of claim 3 wherein the segmented elastomer has bis-ureylene segments alternating with segments of a low-melting polyether.

5. The process of claim 4 in which the composite yarn is permitted to contract, before the heating step, to 40-60% of its as-spun length.

6. The process of claim 5 in which the cooling step is carried to below 70° C.

7. The process of claim 2 wherein the heating step is carried out at substantially 150° C. for about 15 minutes.

8. A process of spinning smooth elastic yarn comprising the steps of: drafting at least one roving of staple fibers; stretching a twist-free filament of a segmented elastomer to increase its length substantially; twisting the filament and drafted roving, using a twist multiplier of more than about 4.4, to produce a composite yarn having the filament as a core and the roving as a sheath; permitting appreciable contraction of the yarn to and retaining it stretched at a fraction of its as-spun length; heating the yarn at a temperature of more than 100° C. but less than the degradation temperature of the core for at least 10 minutes; and cooling the yarn to a temperature of less than 70° C. at a length substantially equal to the length at which it was heated.

9. The process of claim 8 wherein the composite yarn is permitted to contract to between 40% and 60% of the as-spun length before heating.

10. The process of claim 8 wherein the core consists of a segmented elastomer having bis-ureylene segments alternating with segments of a low-melting polyether.

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