Nov. 10, 1964 D. R. STRACHAN 3,156,607

LOBED FILAMENT

Filed May 31, 1961

FIG. 1

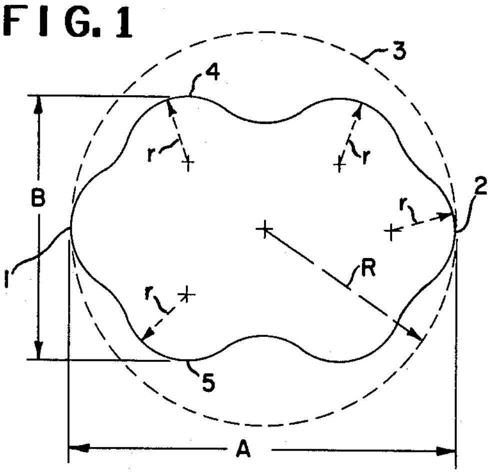


FIG. 2

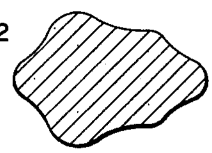


FIG. 4

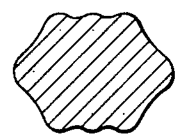


FIG. 3

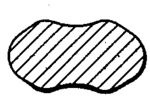


FIG. 5

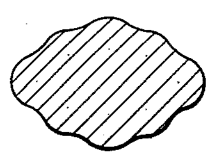


FIG. 6

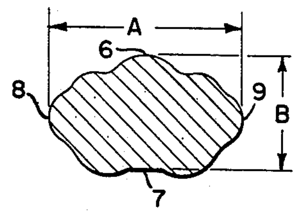


FIG. 7

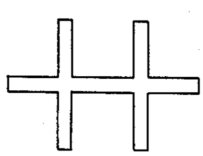


FIG. 8

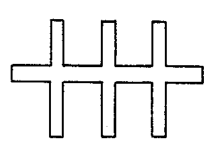
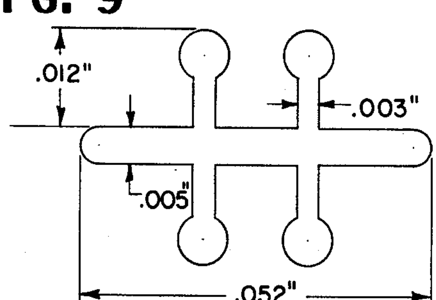


FIG. 9



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3,156,607
LOBED FILAMENT

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This invention relates to novel synthetic fibers and filaments having a unique combination of improved optical and physical properties. More particularly, the invention relates to filaments having certain oblong cross-sectional configurations which are especially useful in continuous filament form in fine denier hosiery and in staple fiber form in suiting.

Textile filaments having a wide variety of cross-sectional configurations have been prepared. These cross sections include ribbons, dumbbell or dogbone shapes, cruciform, crenulated, and Y shapes which exhibit various properties when incorporated in textile goods. However, none of the known cross-sectional configurations provide a combination of uniform optical properties with physical properties essential for the textile uses within the scope of this invention, in particular, physical properties which provide resistance to picking and resistance to twist runback during processing.

It is, therefore, an object of this invention to provide novel synthetic textile filaments which have been improved processability in textile manufacturing operations as well as improved optical properties. A more specific object is to provide textile filaments which can be knit into hosiery which exhibits a uniform, distortion-free surface. Another object is to provide monofilaments which, when knit into hosiery, exhibit uniform reflectance. Still another object is to provide filaments which exhibit a combination of low twist runback and high pick resistance during processing and low optical flash in finished textile goods. A still further object is to provide staple yarns having a combination of good pilling resistance and low sparkle which are particularly desirable in suiting materials.

These and other objects will become more apparent from the following detailed description and accompanying drawings in which:

FIGURES 1 to 6 are enlarged views of cross sections of filaments of the present invention; and

FIGURES 7 to 9 are enlarged views of orifices of spinnerets suitable for producing the filaments within the scope of this invention.

The objects of this invention are accomplished by providing a textile filament having a substantially uniform, oblong cross section along its length, the cross section having a major to minor axis ratio within the range 1.3 to 1.8, a tip radius ratio within the range 0.15 to 0.6, and from six to eight lobes interconnected by smooth continuous lines which define the periphery of the cross section, the lobes with their interconnecting lines being arranged about the periphery of the cross section to provide symmetry about at least one of the axes.

Referring now to FIGURE 1 of the drawing, the cross section illustrated has six lobes and is symmetrical about a major axis X and a minor axis Y. For purposes of this invention, the dimension A is defined by the distance between the extremities of the two most distant points 1 and 2 of the cross section. The tips of the most distant lobes lie on the arc of a circle 3 which circumscribes the cross section and has a radius R. The dimension A is equal to 2R. The minor dimension B is measured perpendicularly to the major axis and is defined by the greatest dimension from the tip of one lobe on one side of the major axis to the tip of a lobe, or side, of the cross section on the opposite side of the major axis. As illustrated in

FIG. 1, this distance is measured between points 4 and 5. The major to minor axis ratio is determined by the ratio A/B, i.e., the ratio of the major dimension to the minor dimension of the cross section.

The major to minor axis ratio A/B can be readily determined for each of FIGS. 2 to 6 by following the aforementioned procedure. With particular reference to FIG. 6, the minor dimension B will, of course, be determined by measuring the distance between point 6 at the extremity of the lobe protruding the greatest distance from the major axis and point 7 opposite point 6 and on the line perpendicular to the major axis which extends to the opposite side of the cross section. The major dimension A is measured along the major axis between points 8 and 9.

Referring again to FIGURE 1, the tips of the lobes are essentially arcs of circles. In further defining the cross sections, reference may be made to the ratio of the radius of the circular tip r to the radius of the circle which circumscribes the cross section R. The ratio r/R will be referred to as the tip radius ratio. Since the radii of these tips may be the same or may be different, the tip radius ratios may be the same or different for a given cross section. In FIG. 1, each of the tip radius ratios are the same; however, in FIGS. 2 through 6 the ratios vary. It is essential, however, that the combination of radii and interconnecting lines be such that the cross section is symmetrical about at least one of the axes and that the tip radius ratios each be within the range 0.15 to 0.6 as will be discussed more fully later herein.

As illustrated in FIGURES 1 to 6, each of the lobes is connected to an adjacent lobe by smooth continuous lines. These connecting lines may be straight or curved. When the lines are concave, they may be either arcs of circles or combinations of straight and curved lines which are free from abrupt changes in direction.

The filaments of this invention may be prepared by extruding a synthetic filament-forming polymeric composition through spinneret orifices having configurations similar to those shown in FIGS. 7 to 9. By adjusting the lengths of the slots of the orifices and positioning them accurately with respect to each other, it is possible to maintain excellent control of the cross-sectional configuration. For example, the orifice shown in FIG. 7 will provide cross sections having six lobes, and the orifice in FIG. 8 will provide eight lobes. The value of the tip radius ratios may be controlled by varying the width of the slots or, as illustrated in FIG. 9, by providing circular apertures at the extremities of the slots. The smaller slot widths provide cross sections having lower tip radius ratios. Combs et al., in their copending application Serial No. 88,894, filed March 13, 1961, now Patent No. 3,109,195, illustrate spinneret orifices in their FIGURES 5 and 10, and describe spinning conditions which may be used in controlling the cross-sectional shape.

The viscosity of the polymer and the spinning conditions must, of course, be varied, depending on the polymeric composition being spun. In melt spinning processes, the polymer viscosity should be sufficiently high to permit rapid quenching and solidification of the thread line. For example, with polyhexamethylene adipamide, the relative viscosity may be between 25 and 42 as measured according to the procedure set forth in U.S. Patent 2,385,890.

The necessity for providing cross sections having the aforementioned limitations becomes apparent in view of the fact that when the major to minor axis ratio is less than 1.3, knitted fabrics, particularly hosiery, develop excessive picks and snags. In the manufacturing process, the distorted stitches which arise when individual loops in the fabric are snagged by adjacent fabrics or other objects are referred to as "picks." In a normal textile operation, many hours of labor are required to straighten such fabrics and remove the distorted areas by working the fabric to loosen the distorted portions. By maintaining the major to minor axis ratio within the aforementioned range, and particularly in the range from about 1.4 to 1.7, the knitted goods is relatively free from picks and snags. The quality of the fiber related to this processing improvement is referred to as "pick resistance."

In certain types of knitted goods, especially in sheer hosiery, it is undesirable to have a flashy appearance. By providing filaments with cross sections according to this invention having from six to eight lobes, the return of light by reflectance and the objectionable non-uniform light deflectance observed in other filament cross-section configurations is virtually eliminated. The undesirable patches or flashy type of sparkle of certain cross sections is avoided by maintaining the tip radius ratios below about 0.6. The excessive dull or chalky appearance of other filament cross sections is avoided by maintaining this ratio above 0.15.

By maintaining the major to minor axis ratio within the aforementioned limits, in addition to improving pick resistance, twist runback is avoided. In filaments having a high major to minor axis ratio, an undesirable and non-uniform twist is generated during processing of monofilament yarns, especially on hosiery knitting machines. If there is any twist at all in the original packaged yarn, or if the yarn is removed over the end of the package, a twist develops which is transmitted back along the thread line as the filaments run over the thread guides. When considerable torque has been generated, the twisted portion jumps over the guide and twist kinks are accidentally knitted into the fabric, distorting it, and giving a short length of one course containing a triple thread. Twist runback is substantially avoided by maintaining the major to minor axis ratio within the limits previously described. Preferably, the ratio is less than 1.7.

When utilizing synthetic polymer yarns in staple fiber form, particularly in suiting materials, pilling is a problem. By maintaining the major to minor axis ratio of filaments within the range of the present invention, preferably higher than 1.4, the resistance of staple fiber yarn to pilling is greatly enhanced. Due to the novel cross-sectional configuration, the ability of the fibers of this invention to cable together or wind around one another with the attendant formation of pills or fluff balls is significantly retarded.

The following examples further illustrate the present invention.

EXAMPLE I

Polyhexamethylene adipamide having a relative viscosity in the flake of 38 is spun using the apparatus described in Waltz U.S. Patent 2,571,975. The polymer contains 0.3% by weight of titanium dioxide delusterant. The grid and melt pool temperature is maintained at 291° C. and the molten polymer is blanketed with steam. A spinneret having ten orifices of the type shown in FIGURE 9 is used. The molten fiber is quenched in air moving at 150 cubic feet per minute. The ten monofilaments are separated and wound up at 461 yards per minute. The fiber has a spun denier of 60–66. After spinning, the yarn is drawn to a draw ratio of 4.4 to 4.6 using a 3/16 inch ceramic draw pin. The drawn denier is 15. This drawn monofilament has a break elongation of about 27%.

By using spinnerets with slightly different orifice dimensions, monofilaments with other specific hexalobal oblong cross sections are obtained. For example, when the length of the main slot is increased, a higher major to minor axis ratio, A/B ratio, is obtained. Table 1 shows the A/B ratio for a number of samples, each of which is spun from a slightly different spinneret orifice.

From each type of monofilament, hosiery is knitted. In addition, a round monofilament is knitted into hosiery. The hosiery is dyed, boarded, and handled using the normal procedures for hosiery manufacture. The pick resistance of the hosiery is judged after turning the samples inside out four times, using the same operator for each test. After this operation, the hosiery is examined and the number of picks per hose is determined. The results of the test are shown in Table 1.

During the process of knitting, some of the hosiery developed twist kinks due to twist runback as the filaments are pulled over thread guides. The number of twist kinks per hose is determined. Data are recorded in Table 1. The number of twist kinks is not excessive in any of the filaments having an A/B ratio less than 1.8.

Table 1

EFFECT OF A/B RATIO ON HOSIERY PROPERTIES

A/B Ratio	r/R Ratio	Picks/ Hose [1]	Twist Kinks/Hose	Intensity of Light Flashes
1.00	Round	15.5	0.0	Low.
1.30	0.7	13.9	1.0	Moderate.
1.47	0.6	7.1	1.6	Do.
1.68	0.5	5.5	3.5	Do.
2.97	0.3	1.3	Very high	Severe.

[1] After turning inside out four times.

Examination of the various samples of hosiery, using a single light source, reveals obvious differences in the optical properties. Hosiery from round filaments gives flashes of light having very low intensity. The filaments having cross sections with A/B ratios of 1.30, 1.47, and 1.68 have flashes of light of moderate intensity. On the other hand, the sample with a very high A/B ratio of 2.97 has severe pinpoints of light reflecting from the surface. Even though all the hosiery are knitted with the same construction, the sample having an A/B ratio of 2.97 is less sheer that the others, particularly when viewed from a low angle relative to the plane of the fabric, and is not acceptable for uses where transparency is desired.

This experiment illustrates the unusual combination of properties which can be obtained with fibers having major to minor axis ratios in the range 1.3 to 1.8. It is most unusual to find a single hosiery yarn having a low degree of twist runback, a high pick resistance, a low degree of flashiness, and a high degree of sheerness.

EXAMPLE II

The unusual optical properties of hexalobal oblong cross sections compared to elliptical cross sections is demonstrated by wrapping monofilament yarn samples on black cards and comparing them when lighted with a single source of light. The samples are examined with the axis of view perpendicular to the fiber axis and forming an angle of about 10° with the plane of the card. The light source is held in the viewer's hand, and the axis of the light beam falling on the card is approximately parallel to the axis of view.

Table 2

POLYHEXAMETHYLENE ADIPAMIDE MONOFILAMENTS

Sample No.	Type of Cross Section	A/B Ratio	r/R Ratio	Denier/ Filament
1	Hexalobal	1.71	0.24	15
2	Elliptical	1.75	0.46	15
3	Round	1.00	---------	15

Table 2 shows cross-sectional measurements for hexalobal oblong filaments, elliptical filaments, and round filament yarns which are viewed on cars. Monofilament yarns are twisted on a twenty-inch Precision Twist Tester (Alfred Sutor Co., New York 10, New York) to the following twist levels: 0, 5, 10, 20, 40, and 100 Z turns per inch. Several cards are prepared with all three types of filament on each card, the twist level being constant for the filaments on each card. At any given level of twist, the six-lobed oblong cross-section yarns exhibit a more regular and more subdued luster than the smooth elliptical yarns. The elliptical yarns exhibit appreciable sparkle which makes them undesirable where maximum transparency is desired. This sparkle is nonuniform and patchy in appearance.

Hosiery is prepared from the untwisted six-lobed fiber, from the smooth elliptical fiber, and from round fiber. The twist runback is not objectionable in knitting for any of these three yarns. However, difficulties in knitting are encountered with a fourth yarn having a smooth elliptical cross section with a major to minor axis ratio of 2.0. Hosiery prepared with the smooth ellipse and the hexalobal cross section has the desirable sheerness of hosiery from round yarn, but the hosiery prepared from the smooth ellipse exhibits an undesirable optical flash. In examining the hosiery from elliptical yarns closely, it is found that pinpoint flashes are coming from points of concentrated twist in the filaments. The intensity of these flashing points of light is greatly reduced in the hexalobal oblong cross section and a very pleasing effect is obtained.

EXAMPLE III

Polyethylene terephthalate having 0.3% titanium dioxide delusterant and a relative viscosity of 30 ± 2 (as measured in a mixture of two parts phenol to 5 parts trichlorophenol) is melted and pumped through a spinning block held at 295° C. The molten polymer is then filtered through a sand pack (described by Hull et al. in U.S. Patent 2,266,362), and extruded through a 300-hole spinneret. Using a spinneret capillary shape similar to FIGURE 7 and quenching the resultant filaments with a 70° F. air flow of 200 cubic feet per minute, a spun fiber having the cross section of FIGURE 3 is obtained. The ratio of A/B under these conditions is 1.6. This filament ratio can be altered by changing the quench air flow. For example, increasing the flow to 300 cubic feet per minute produces a filament ratio of 1.8. Corresponding decreases lower this value. These ratios are altered by changing spinning temperature, polymer viscosity, and throughput per hole of spinneret. In this example, 300 filaments per spinneret are spun at 1500 yards per minute to produce 9-denier per filament spun fibers. The resultant bundle is combined to form a 30,000 denier tow which is subsequently drawn to three times its original length by known methods as in a 95° C. water bath. After crimping in a stuffing box, the tow is cut into staple two and one-half inches in length. By conventional procedures the staple is opened, picked, and carded. It then passes through the processes of gilling, roving, spinning, and winding. The yarn is woven into a 2 x 2 suiting twill. After finishing, i.e., crabbing, scouring, dyeing, heat setting, and decating, the fabric is tested in RTPT (Random Tumble Pilling Test) for sixty minutes (ASTM D1375–59T—Method E). It has a subjective rating of 4, being almost free from pills (1=severe, 3=moderate, 5=no pilling). The fabric is also free from objectionable glitter in contrast to ribbon fibers of high filament ratios which show intense light spots in the presence of high intensity, directional light.

A fiber is similarly prepared from a round-hole spinneret and carried by indentical processes through to fabric having the same weight in ounces per square yard. This fabric pills objectionably, giving a RTPT rating of 1.0.

In addition to those polymers described in the examples, a wide variety of other polymers may be utilized in preparing filaments according to the present invention. Preferably, the melt-spinnable polymers are used since greater control of the filament cross-sectional configuration can be attained in melt spinning as compared to dry or wet spinning. Illustrative of the various polymers which may be used are the polyamides, such as polyhexamethylene adipamide and polyepsiloncaprolactam; polyesters, such as polyethylene terephthalate, or copolymers derived from ethylene glycol, terephthalic acid, and up to 15 mol percent of some other dibasic acid, cellulose triacetate and other meltable cellulose derivatives. In addition, plasticized melt-spinnable fibers such as acrylonitrile or copolymers containing at least 85% acrylonitrile may be utilized. Specific examples of polyesters which can be spun into filaments with odd cross section by the use of this invention are poly(ethylene-2,6-naphthalate); poly(tetrachloro diphenylol propane isophthalate); the polyester reaction product of ethylene glycol, terephthalic acid and bibenzoic acid, or the polyester of ethylene glycol, terephthalic acid, and up to 15 mol percent of hexahydroterephthalic acid, or the polyester derived from ethylene glycol, terephthalic acid, and up to 2 mol percent sulfoisophthalic acid. Among the polyamides which can be used are the polyamide from bis(p-aminocyclohexyl)methane and azelaic acid; the block copolymer from poly(hexamethylene adipamide) and poly(hexamethylene isophthalamide); poly(hexamethylene adipamide) containing a phenol formaldehyde resin; and poly(m-xylylene adipamide), to name a few. In addition, odd cross-section fibers may be spun from the polyamides listed in U.S. Patents 2,071,250, 2,071,251, 2,071,253, 2,130,523, 2,130,948, 2,190,770, 2,252,555, 2,252,557, 2,374,137, 2,465,150, and 2,465,319.

In preparing the filaments of the present invention, various additives may be included in the polymeric compositions. In general, when a delustering agent, such as titanium dioxide, is utilized in the melt-spinnable polymers, the amounts should be less than about 1% in order to avoid excessive dullness.

Fibers with the cross-section configuration specified in this invention are useful for a wide variety of textile products. They may be used to advantage in all sorts of woven materials including hosiery, lingerie, and other light-weight knit structures. They are useful as feed yarns for a large number of bulking processes such as the well-known stuffer box crimping process, the jet bulking process of Breen and Lauterbach described in U.S. application Serial No. 698,103, the torque jet process described in Breen and Sussman U.S. application Serial No. 810,671, and the various false twist crimping techniques. The crimped product prepared by any of these processes may be used in sweaters, upholstery, carpets, underwear, shirting materials, blouses, dress fabrics, and suiting materials. The crimped product may also be cut up into staple and recombined in the form of a staple yarn. These yarns, of course, are useful for preparing suiting materials, sweaters, upholstery fabrics, and a wide variety of bulky textile materials. The multifilament yarns may, of course, also be used without crimping to give shirt and blouse materials, dress materials, and fine, lightweight fabrics.

As many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not to be limited to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. A continuous textile filament having a substantially uniform oblong cross section along its length prepared from a synthetic fiber-forming polymer, said cross section having a major to minor axis ratio within the range 1.3 to 1.8, tip radius ratios within the range 0.15 to 0.6, and from six to eight lobes interconnected by smooth continuous lines which define its periphery, said lobes and said interconnecting lines being arranged about the periphery of said cross section to provide symmetry about at least one of said axes.

2. The filament of claim 1 wherein said major to minor axis ratio is in the range from 1.4 to 1.7.

3. The filament of claim 1 wherein said polymer is a polyamide.

4. The filament of claim 1 wherein said polymer is a polyester.

5. The filament of claim 1 having a denier from 1 to 20.

6. A filament of claim 1 which is symmetrical about both of said axes.

7. A filament of claim 6 having six lobes.

8. A continuous textile filament having a substantially uniform oblong cross section along its length prepared from a synthetic fiber-forming polymer comprised of from six to eight lobes interconnected by smooth continuous lines which define its periphery, said cross sections having a major to minor axis ratio within the range 1.3 to 1.8 and tip radius ratios within the range 0.15 to 0.6, said lobes and interconnecting lines being arranged about the periphery of said cross section to provide symmetry about at least one of said axes.

9. The filament of claim 8 wherein said major to minor axis ratio is in the rane from 1.4 to 1.7.

10. The filament of claim 8 having a denier from 1 to 20.

11. A filament of claim 8 which is symmetrical about both of said axes.

12. A filament of claim 11 having six lobes.

References Cited in the file of this patent

Bohringer et al.: Faserforschung und Textiltechnik 6 (1955), Heft 5, "Synthetiche Faserstoffe mit profiliertem Querschnitt," East German publication, pages 199–203, page 202 only applied.