July 13, 1965 D. W. RAYNOLDS ETAL 3,194,002

MULTIFILAMENT YARN OF NON-REGULAR CROSS SECTION

Filed July 25, 1962

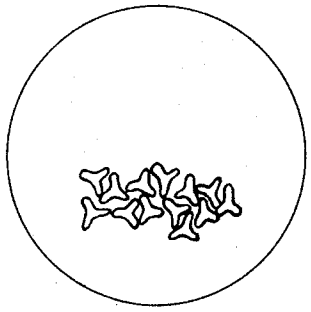


FIG. 1.

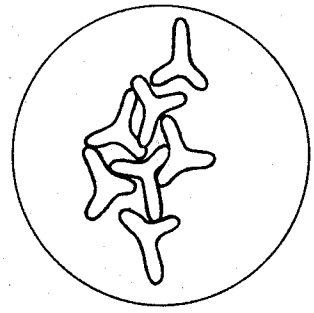


FIG. 2.

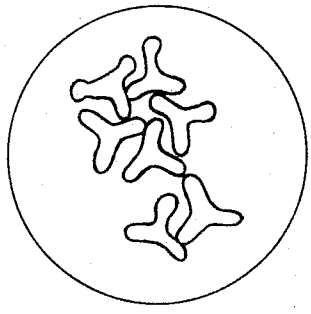


FIG. 3.

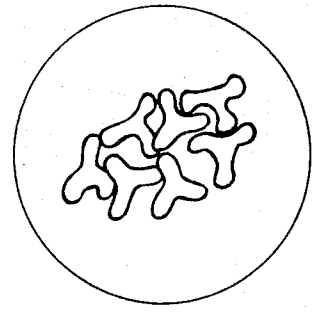


FIG. 4.

DAVID W. RAYNOLDS
FRANK W. ABERNATHY
ARTHUR S. SMITH
INVENTORS

BY R. Frank Smith
Harold N. Powell
ATTORNEYS

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MULTIFILAMENT YARN OF NON-REGULAR CROSS SECTION

David W. Raynolds and Arthur S. Smith, Kingsport, Tenn., and Frank W. Abernathy, Framingham, Mass., assignors to Eastman Kodak Company, Rochester, N.Y., a corporation of New Jersey

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This application is a continuation-in-part of our earlier application Serial No. 476,142, filed December 20, 1954, now abandoned. Disclosed therein are a number of methods of manufacturing fine denier multifilaments, novel yarns therefrom and articles such as rugs made from such yarn. In the present invention we have found how our methods have natural application to and may be further extended for the manufacture of a wider range of novel multifilament special cross-section yarns and articles therefrom.

This invention relates to the manufacture of multifilament yarn made up of filaments having a predetermined cross-section whereby the yarn has sufficient flexibility for good processing and yet also has increased cover, stiffness and other improved properties. More particularly, this invention relates to multifilament yarn product as such and rugs or the like fabricated articles made from the multifilament yarn.

In the prior art a number of processes and apparatuses have been provided for the production of man-made filaments of certain cross-sections. Generally, these prior art cross-sections fall within the classification of round or cloverleaf cross-sections (see Patents Nos. 2,000,047 and 2,000,048) or for flat or rectangular cross-section (see Patent No. 1,964,159).

It has also been proposed in the prior art to make relatively large monofilaments of X or Y cross section (U.S. Patent No. 2,637,893), such monofilaments being utilized for brushes. Such large monofilaments as required for brushes may be likened to steel rods which have rigidity and stiffness. In contrast thereto, in the present invention we are dealing with fine denier multifilaments which may perhaps be likened to wire rope which has greater flexibility, utility and strength. In addition when our multifilaments are woven into an article as cloth or rugs they have additional different characteristics not found in the wire rope-rod analogy aforementioned.

Accordingly, it is believed apparent that the development of novel multifilament yarns of small denier filaments, which yarns have a wide field of utility and which permit the production of better rugs and the like articles, represents a highly desirable result. After extended investigation and further application of our original invention we have discovered such type multifilament yarn and certain improved processes for the production thereof.

An object of the present invention is to provide multifilament yarns with an increased cover, bulk and stiffness as compared to prior art fibers. Another object of this invention is to provide multifilament yarns wherein the filaments making up the yarns have increased surface area as compared to the above discussed filaments known heretofore in this art. Still another object is to provide multifilament yarn made up of Y-shaped, or modified Y-shaped cross-section filaments of small flexible denier of the nature hereinafter described.

Another object is to provide continuous filament multifilament yarn made from a plurality of relatively small, flexible filaments having Y-shaped or modified Y-shaped cross-sections.

Again another object is to provide new and novel yarn products as rugs, having a crisp feel, less apparent soiling, improved covering power and luster containing such Y-shaped or modified Y-shaped cross-section multifilament yarns.

Other objects will appear hereinafter.

In the broader aspects of our invention of making a new multifilament yarn made up of a large number of small denier, flexible filaments having a Y-type cross-section the processes and apparatus shown in our Patent No. 2,829,027 may be used and detailed reference may be made to such patent. Or, the processes and apparatuses disclosed in said parent application Serial No. 476,142, now abandoned, of which the present application is a continuation-in-part may be used. Hence, for the purposes of the present invention, the following process description will suffice.

The multifilament yarn may be formed by forcing a suitable spinning composition through a spinnerette having a plurality of equilateral triangular shaped forming orifices therein or other non-circular orifices as will be described and curing the resulting filaments in a spinning cabinet under controlled conditions of temperature while subjecting the filaments to drafting. The temperature of the spinning composition, when dry spinning is being carried out, and its rate of extrusion are also controlled for optimum results.

Under preferred conditions of spinning composition, temperature, extrusion, curing and drafting, the filaments as they leave the (non-circular) equilateral triangular orifices temporarily assume a triangular cross-sectional shape. However, in accordance with a surprising feature of our process, by suitable control of the extrusion rate, the drafting rate and curing temperature, there will be a change in the filament cross-sections from triangular to a Y-shaped type cross-section. Under preferred ranges of operation, and as will be described in detail further on in this specification, the "legs" of the Y-shaped cross-section filament can be made substantially equal in length and of substantially uniform shape. Also the angles between adjacent legs of the Y may be made substantially equal.

In general, spinnerettes having a plurality of very small equilateral triangular orifices may be employed with any suitable spinning cabinet to produce multifilament flexible yarn to be used in making the products described herein. The Y-shaped type cross-section filaments can be prepared in accordance with our invention within a wide range of spinning, drafting and other conditions as is described hereinafter.

Another interesting feature of our invention is the discovery that the multifilament yarn produced in accordance with our invention through a plurality of equilateral type triangular orifices have a more perfect Y-shaped cross-section than is obtainable when a spinnerette having Y-shaped cross-section orifices is employed. However, in accordance with an important feature of the present invention we have discovered the following: Polymeric spinning compositions, such as a composition containing a substantial amount of poly acrylonitrile or other polymeric component may be extruded through a Y-shaped orifice rather than triangular. The Y-shape may be symmetrical or unsymmetrical or other tripodal shape. However, when using such tripodal shape, as contrasted to trangular, we have found that the orifice should be somewhat oversized as compared with the size (denier) of the multifilament yarn to be produced. In brief, in oversized Y type filament is first extruded and then the oversized Y filament is drafted down to the desired size.

As previously indicated above, we have found that the Y-type cross-section multifilament yarns of our invention of small denier filaments have the proper and sufficient flexibility for textile fibers yet provides more cover, bulk and stiffness than obtained from the yarns

from filaments of the various round and round-like cross-sections heretofore known in this art. By small denier we mean a D./F. of not greater than 30. There are also a number of other benefits from our multifilament yarn as will be set forth hereinafter.

This appears due to the intermeshing, internally entangling or twisting of the legs of the Y of the individual filaments in the filament bundle so that each is reinforced by the other and the filament bundle has a resultant stiffness greater than the normal cross-section filament of equivalent denier because of the change in surface area distribution. It is noted that a circle taking in the three tips of the legs of the Y will be greater in diameter than one taking in the lobes of the well-known cloverleaf type of cross-section. This larger "circle" is, therefore, the effective area of the Y-shaped cross-section and explains the increased cover, bulkiness and the like of our novel Y-type multifilament yarn. By the small denier filaments of the present invention we obtain the flexibility and other advantages without rigidity and stiffness of monofilaments.

While the filaments extruded from equilateral triangular spinnerette orifices, and further processed in accordance with our invention, are preferred for most purposes, we have also discovered that employing triangular non-circular spinnerette orifices having angles other than equilateral, the spinning conditions being substantially similar to those employed with spinnerettes having equilateral triangular orifices, also will give filaments having bulk and stiffness measurements greater than filaments extruded from round orifices, but less than those extruded through equilateral triangular orifices.

We have also found that control of the bulkiness and stiffness of such filaments can be achieved while employing similar spinning conditions by employing, in the spinnerette, orifices which are derived from equilateral triangles. Such modified orifice perhaps can be described as an equilateral triangle, the corners of which are filled in and rounded off, the remaining straight sides being of equal length.

For assistance in a further understanding of the above described flexible yarn comprised of at least 7 relatively small non-circular cross-section filaments of a total denier of less than 6250, reference is made to the attached drawing forming a part of this application.

In such drawing, FIG. 1 is a reproduction of an actual photomicrograph depicting the cross-section of a flexible yarn of the present invention comprised of several relatively symmetrical Y cross-section intermeshed small denier filaments.

FIG. 2 is another reproduction of an actual photomicrograph depicting a yarn cross-section of the present invention in which the filaments making up the yarn may have a leg or lobe several percent longer than the other legs or lobes of the filament cross-section.

FIG. 3 is another reproduction of an actual photomicrograph depicting another yarn construction in accordance with the present invention comprised of filaments of a modified Y cross-section wherein the legs or lobes may be of slightly different lengths and shapes.

FIG. 4 is still another reproduction of a photomicrograph depicting a yarn construction comprised of filaments of Y cross-section but wherein the legs or lobes are more lobular or curvaceous than some of the other yarns described herein. Further information concerning these yarns illustrated in the drawing as well as other types of similar non-circular cross-section yarns will be had from data appearing in the several tables which follow exemplified by some of the yarns tabulated under spinnerettes listed as odd triangular.

The present invention will be further understood by reference to the following examples of our invention which are set forth for illustrating certain preferred embodiments.

For assistance in a consideration of the examples, if such is desired, reference may be made to the apparatus shown in our Patent No. 2,829,027 referred to above. In carrying out the processes of the following examples, the apparatus as shown in our patent just mentioned may be used either with a spinnerette having a plurality of small triangular orifices as shown in the patent or with the substitution of spinnerettes having a plurality of oversized Y-type orifices as mentioned above.

EXAMPLE 1

A spinning solution consisting of 26.5% cellulose acetate, 1.25% titanium dioxide, based on the weight of the cellulose acetate, 1.75% water and the remainder being the solvent, acetone was spun into the ultimately formed Y-shaped cross-section filaments of 55 denier using the apparatus and its general operation as described in our Patent No. 2,829,027. The spinnerette had 13 equilateral triangular orifices therein to give a multifilament yarn. The conditions of operation are shown in Table I where they are identified as No. 1.

Table I

No.	Denier per strand	No. filaments per strand	Extrusion speed, meters/min.	Candle filter temp., °C.	Extrusion temp., °C.	Top air flow, c.f.m.	Bottom air flow, c.f.m.	Top air inlet temp., °C.	Bottom air inlet temp., °C.	Spinnerette orifice	Draft
1	55	13	500	65	62	500	500	70	85	0.067	1.10
2	75	19	500	62	62	500	500	70	85	0.067	1.10
3	150	38	500	65	61	800	800	70	85	0.067	1.10
4	150	7	211	65	----------	500	500	60	90	0.155	1.22
5	55	36	500	58	----------	500	500	60	85	0.047	1.43
6	75	49	500	58	----------	500	500	60	85	0.047	1.48
7	300	7	100	65	----------	1,500	1,500	60	90	0.220	1.03

In this table the air flow in cubic feet per minute is calculated for one hundred spinning cabinets. The figures under the spinnerette orifice column represent one side of the equilateral triangle. The extrusion speed in meters per minute represents the rate at which the spinning solution is forced out of the spinnerette. This, in cooperation with the draft rate enables the filaments to change from the initial triangular cross-section to the Y-shaped cross-section while properly drying.

Draft may be described as the ratio of the linear velocity of wind-up of the filaments to the linear velocity of extrusion of the spinning solution. More specifically, the draft herein is the ratio of the linear velocity at which the filaments are wound onto and off the godet roll of a spinning cabinet to the calculated average linear velocity at which the quantity of spinning solution necessary to the formation of any one of the plurality of filaments comprising the multifilament yarn wound onto and off the godet roll is extruded through any one of the plurality of orifices in the spinnerette employed in the spinning operation, the velocities being expressed in the same units of distance per unit time. For example, if the filaments are wound up at the godet roll at the same linear velocity that the spinning solution is extruded from the spinnerette,

the draft is 1.0 thus signifying that the linear speed of wind-up is 100% of the extrusion speed. Similarly, if the filaments are wound up or withdrawn from the cabinet at the godet roll at a linear speed 50% greater than the speed of extrusion, the draft is 1.5 and so on.

Other columns of Table I are more or less self-explanatory when considered in connection with the drawings of our Patent No. 2,829,027 and the related description. Temperatures in the curing zone averaging from 40 to 90° C. are usable.

EXAMPLE 2

The cellulose acetate spinning solution of Example 1 was spun into a multifilament yarn of Y-shaped cross-section filaments of 150 denier per strand. The spinnerette had 38 equilateral triangular orifices. The above described spinning equipment was used with the operating conditions shown as No. 3 in Table I.

EXAMPLE 3

This example is for illustrating the operation of this invention as referred to above of spinning through an oversize Y orifice to obtain an oversized Y-type filament. We prefer that the ratio of the width of the arms of the Y to the length of the arms be within the following range 2:1 to 20:1. This oversized filament is then drafted and otherwise processed as will be apparent from the further description.

In this example the spinning composition converted into the multifilament yarn was a modified acrylonitrile material. It contained approximately 50% poly-acrylonitrile together with other constituents such as vinylidene chloride, isopropylacrylamide and the like. Further details on such spinning composition may be had by reference to U.S. Patent No. 2,811,409 of our co-workers. The exact polymeric composition is not a limitation on the process as other polymeric compositions may be employed.

The spinning composition had a relatively high viscosity and was extruded at 100 m./m. through a Y-shaped orifice, the legs of which were equally spaced and had the dimensions of 0.025 x 0.10 mm. Filaments with cross-sections approximating a Y shape but somewhat oversized were obtained. The filaments after spinning were then drafted 6/1 in a heated zone beyond the extrusion zone subsequently subjected to a relaxing treatment of 15%. This relaxing treatment was also performed in a heated zone. This modified the filaments to a more rounded shape after the drafting and relaxing.

The drafting in the extrusion step may be as low as .25 and as high as 1.5. We have found that the higher draft gives somewhat better Y-type cross-sections.

The advantages and utility of our multifilament flexible yarn comprised of filaments of non-circular drafted Y cross-section are manifold. The processes of manufacturing such filaments may be more rapid than a comparable process for producing the round or cloverleaf cross-sections. This is the situation whether such filaments are solvent spun or melt spun. In either instance there is a faster curing or cooling rate with the non-circular filaments of the present invention. The filaments as produced have a higher luster.

The filaments of Example 3 have a slower apparent soil rate. This is advantageous when such multifilament yarns are made into products exemplified by rugs and other articles of manufacture which frequently come in contact with soil. The filaments after production, as in Example 3, may be readily processed by known procedures exemplified by bulking, lofting or texturizing. Such are procedures wherein multifilament yarns are fed through an air jet and subjected to treatment with air, steam or other similar gaseous fluid or subject to false twist and heat setting or the like. We have found that the Y cross-section polymeric multifilament yarns of Example 3 process faster and better by bulking than the regular round or cloverleaf filaments. This improvement is to the extent of the order of 19% faster and the resultant product had 14% more strength as well as 10% more stretch.

While the above example has been described using the spinning composition containing poly-acrylonitrile as a polymeric constituent, the present invention has applicability to a variety of other polymeric yarn spinning compositons. Multifilament yarn of the character described herein when applied to polypropylene and nylon tends to eliminate to a substantial extent the greasy or slick synthetic hand of such synthetic fibers. In the instance of cellulose acetate filament forming compositions as referred to in Example 1 and certain of the other examples the resultant cellulose acetate filaments have a crisper hand.

EXAMPLE 4

In this example the spinning composition was a graft polymer principally of acrylonitrile and a copolymer of acrylonitrile and N-methyl-metha-acrylamide which was dissolved in dimethyl formamide to form a solution of relatively high viscosity. After filtration to provide a clear solution, the solution was extruded using a spinning draft of about 1.5 at 100 m./m. through: (1) a triangular orifice; (2) a Y shaped orifice, the arms of which were equally spaced and had the dimensions of 0.025 x 0.10 mm.; (3) a shaped orifice made of three circular holes, 0.05 mm. in diameter, whose circumference was tangent to each of the other holes. Filaments with cross-sections approximating a Y or tripodal shape but somewhat elongated were obtained. The filaments were then drafted 6:1 in a heated zone of 250–300° C. and then allowed to shrink 15% in a stabilization operation conducted in a heated zone of 250–300° C. The yarns of this example were 100 denier—30 filaments and 150 denier—40 filaments and had strengths of 2.1–2.6 grams per denier and elongations of 25.0–32.0%.

The Y shaped orifice gave an increase in bulk of about 22% over that from yarn with a circular cross-section with increased stiffness of approximately 11% using the heart-loop stiffness test. These yarns produced a fabric with more cover, a fuller hand, a crisper feel and optical sparkle than obtainable from yarns spun from a circular orifice.

As apparent from the foregoing we have found that satisfactory Y-shaped type cross-section filaments can be prepared under a broad range of composition, spinning and drafting conditions. A primary requisite for optimum Y-shaped cross-section yarn through triangular orifices as for acetate is that the spinning drafting should be above 1.0 and preferably within the range of 1.0 to 1.6. However, somewhat deformed Y-shaped cross-section filaments may be obtained using spinning drafts of 0.7 to 1.0.

The temperatures listed in Table I are temperatures employed to produce a quality product with a particular cellulose ester-acetone solution. These temperatures may vary somewhat. Changes in cellulose ester composition or changes in cellulose ester to acetone ratios or changes to other polymeric compositions may require some changes in these temperatures.

We have also found that our spinning process employing spinnerrettes having equilateral triangular orifices operates very well over a range of deniers per filament of 1.5 to 30.

That the cover and bulk of the Y-shaped cross-section yarn is greater than the cloverleaf or regular cross-section fiber of equivalent denier is shown clearly in the following Table II where comparisons of equivalent samples of regular and Y-shaped cross-section yarn made from the same spinning compositions are set forth.

Table II

BULK TESTS ON REGULAR AND Y SECTION CONTINUOUS FILAMENT YARNS

Yarn	Bulk factor	Specific volume, cu. in./lb.	Percent difference
Regular 55/13/.3	163.7	34.5	30.5
Y 55/13/.3	214.1	45.1	
Regular 55/36/.3	155.2	32.7	37.3
Y 55/36/.3	214.0	44.9	
Regular 75/19/.3	164.9	34.7	30.3
Y 75/19/.3	213.8	45.2	
Regular 75/49/.3	158.0	33.3	29.6
Y 75/49/.3	205.5	43.2	
Regular 150/7/.3	149.5	31.5	41.0
Y 150/7/.3	210.5	44.4	
Regular 150/38/.3	154.1	32.4	36.8
Y 150/38/.3	210.4	44.3	
Regular 300/7/.3	158.0	33.2	33.4
Y 300/7/.3	211.0	44.3	

In Table II the numerical expressions 55/13/.3 and the like represent continuous filament yarn in terms of total denier, filament count, and twist. For example, 55/13/.3 designates a continuous filament yarn having a total denier of 55 made up of 13 filaments and having 0.3 turn per inch of twist. The denier per filament of such a yarn is the total denier divided by the number of filaments. In this example 55 divided by 13 equals approximately 4 denier per filament.

The data in Table II are determined by a test which we have developed in which yarn is wound under a specified tension until it fills a spool of a known volume. The amount of yarn required to fill this volume is weighed. From this weight the "Bulk Factor" and "Specific Volume" are calculated. The "Bulk Factor" is calculated by the following formula:

(Volume of Spool × Density of Fibers ÷ Weight of Yarn to Fill Spool) × 100 = Bulk Factor

This formula expresses the bulk as a percentage ratio of the space occupied by the yarn to the space which would be occupied by solid material from which the yarn is made.

The "Specific Volume" is determined by converting the weight of yarn on the spool to cubic inches per pound.

The column shown as "Percent Difference" expresses as a percentage, the percentage difference between the bulk factor, or the specific volume, in the regular and Y-shaped cross-section yarn. It will be noted that in continuous filament yarn the Y-shaped cross-section yarn has from 29.6 to 41.0% more bulk than regular yarn. This difference can be seen visually when comparing the skeins from which these data were obtained.

Similar data are shown in Table III relative to staple fiber yarn made from regular and Y-shaped cross-section fibers of the same cellulose ester composition.

Table III

BULK TESTS ON REGULAR AND Y SECTIONS STAPLE RIBERS

Yarn	Bulk factor	Specific volume, cu. in./lb.	Percent difference
Regular 20/1, 2 D/F, 2"	282.0	59.2	38.3
Y 20/1, 2 D/F, 2"	389.0	81.9	
Regular 20/1, 3 D/F, 2"	262.0	55.2	54.2
Y 20/1, 3 D/F, 2"	405.0	85.0	
Regular 12/1, 5 D/F, 2"	267.5	56.3	37.4
Y 12/1, 5 D/F, 2"	368.0	77.4	

In Table III the staple fiber yarns are designated by their cotton count and their ply. For example, 20/1 designates a staple fiber yarn made up of a single end, which is 20's cotton count. This table also shows the denier per filament (2 D./F.) etc. and the staple length of the fibers (2") etc., from which the staple yarns are spun. The bulk factor and specific volume are determined as described above in connection with Table II. It will be evident that with samples of yarn of the same composition, denier and length and varying only in cross-section, i.e. between regular and Y section, that the Y section staple has from 37.4 to 54.2% more bulk.

The luster of the Y-shaped cross-section yarn is appreciably greater than that of the regular or clover-leaf cross-section of equivalent denier and composition. Luster is measured by means of a photo-electric cell. The filaments are wound in a parallel manner around a flat piece of cardboard or other similar flat surface. Light reflected off these panels to the photo-electric cell imparts a potential which is translated into a numerical luster level. On comparative tests the clover-leaf panel of filaments record 0.77 volt whereas the Y-shaped cross-section filaments of the same denier record 0.83 volt.

EXAMPLE 5

Rugs and carpets were prepared from multifilament Y-shaped cross-section polymeric yarn alone and with other fibers, rayon, nylon, wool, etc. The bulk and stiffness properties of the Y-shaped fibers permit the construction of rugs of improved design.

In further detail loop pile carpets were tufted from round cross section, 3:1 Y cross section, and 5:1 Y cross section polypropylene yarns. The carpeting was identified as ct–1306. Staple yarns were processed from 4" staple into 2.5/3 cotton counts with 2.1 TIPZ in the single, and 2.7 TPIZ in the ply. Results of D./F. checks and specific volume tests on the yarns were as follows.

CT–1306	1	2	3
Cross section	Round	3:1Y	5:1Y
D./F	19	16	19
Specific volume (in.³/lb.)	83	92	99

The 3:1, 5:1 refers to orifice design wherein the length of the arm or leg of the Y to the width is in the ratio indicated.

The 3 staple yarns were tufted together in bands on a 5/32" gauge Cobble Brothers tufting machine, into 25 oz./yd.² level, and high-low loop pile constructions. After tufting it was observed that the Y cross section samples had higher luster, an unusual sparkle, better hand, and cover than the regular cross section sample. Floor test performance was comparable for the 3 samples except that the Y section samples showed a definite improvement in soil resistance over the regular cross section sample.

It is estimated that fibers made with a Y cross section are about 20% stiffer than fibers made with a round cross section. This increased stiffness is believed to contribute to the greater bulk, better hand and increased cover noted in carpets tufted from Y cross section yarns.

The operation of our process is now described in connection with the production of less uniform Y-shaped cross-section filaments through spinnerettes having triangular orifices other than equilateral.

A spinning solution of the composition described in Example 1 was spun through the individual spinnerettes which have triangular orifices other than equilateral.

The cross-sections of some the filaments were of a modified Y-shape having substantially no center leg. Comtrasted to this some cross-sections were obtained which have a long center leg which are little more than twice the length of the other two legs which are of similar size. Cross-sections were obtained which are somewhat intermediate between those just referred to and may be described as of a Y shape having a center leg somewhat longer than the other two legs which are symmetrical. The angle between the other two legs is greater than in the case of the cross-section just mentioned. A cross-section was obtained which is somewhat like that just mentioned except that the center leg is now half as long as the other two symmetrical legs. A cross-section was

obtained which approaches that of a true Y-cross-section in that the center leg is about the length and size of the other two legs but the angles between the legs are not quite equal.

The spinning conditions and the characteristics of these resulting modified Y cross-section filaments (non-symmetrical Y) are tabulated in Table IV where they are compared to fibers spun through spinnerettes having a plurality of the preferred equilateral triangle orifices. The increase in bulk of the fibers spun through these modified triangular orifices over the prior art fibers, as well as the variance in bulk between the fibers produced from the various triangular orifices is also apparent in Table IV.

While these yarns were spun as 150 denier, 7 filament, 20 D./F., they can be prepared as both filament and staple yarns in other deniers and filament counts. For example, for the multifilament yarns of the present invention we would keep above 7 filaments but usually not more than 20 D./F. For tricot around 13 filaments is used. For dress goods we have found that the 19 to 38 filament range is useful. For drapery and upholstery we would go to 200–250 filament range in combination with 15–25 D./F. However for rugs we would prefer around the 80–100 filament range. As may be observed from multiplying the 25 D./F. with, for example, the 250 filaments referred to, the total denier of our new yarn does not exceed 6250.

Yarn was spun from each of the odd triangular-shaped orifices at both 65° and 70° C. candle filter temperatures. At this particular spinning draft 1.25, these yarns would not spin when a candle filter temperature above 70° C. was employed. The data show that slightly increased stretch values were obtained by employing the 70° C. extrusion temperature. Data also show that yarns obtained from the odd triangular orifices have less strength than those of uniform Y-shaped cross-section obtained from the equilateral triangular orifices. Percent stretch for Nos. 50750 and 70753 yarns which have cross-sections very similar to the uniform Y-shaped cross-sections yarn was about the same as the latter, while stretch for the other types of cross-section is about 3% lower.

Although each of the yarns shown in Table IV showed an increase in bulk over the regular cross-section, none showed an improvement in bulk over the uniform Y-shaped cross-section yarn. Values, however, for Nos. 50750 and 50753 were comparable therewith.

Each yarn shown in Table IV was woven as filling yarn for preparing a small satin fabric. The yarn spun from the 120°, 30°, 30° triangle showed a slight scintillating effect. The other types of yarn displayed about the same fabric appearance as that made when employing a spinnerette having the equilateral triangle orifices.

As the Y becomes more rounded the shear strength appears to improve slightly according to the twistability and Walker abrasion tests. It appears that these changes in Y-shaped cross-section from the more perfect Y-shaped cross-section give not only a slight improvement in strength and stretch but a reduction in waste and fly in staple processing. The gain in this respect is obtained at some expense of lessening the bulk as is apparent in Table V. The fraction X referred to in Table V refers to the length of the sides of the equilateral triangle which is removed from each apex of the triangle in rounding off the apices of the spinnerette when proceeding with the rounded structure just referred to. For example, 1/6 means that the apices were rounded off 1/6 of the length back on the side or length of the triangle. Hence considering that it is rounded off on each end, the overall length of a side of the triangle would be reduced 2/6 or 1/3 of the length.

We have further found that the rounding of the corners of the triangular orifice causes the ends of the Y-shaped filament to become rounded and this effect becomes greater as more of the corner is removed.

Table V

No.	50045	50047	50048	50049	50050
Cross section	Reg.	Y	1/6X	1/3X	1/2X
Denier/filament	150	150	150	150	150
Jet size	7.10	7.155	7.161	7.164	7.169
			1/6X	1/3X	1/2X
Spin speed	300	300	300	300	300
Bottom air temp	85	85	85	85	85
Candle filter temp	65	65	65	65	65
Draft	1.0	1.0	1.0	1.0	1.0
Denier	148	144	148	147	146
Elongation, percent stretch:					
Suter wet	46.6	45.6	47.0	47.7	48.2
Suter dry	37.3	36.8	38.0	39.0	38.7
Suter loop	11.8	3.5	5.0	4.1	4.7
Suter knot	18.4	14.1	15.5	17.9	16.2
Strength G/D:					
Suter wet	.63	.63	.63	.64	.63
Suter dry	1.19	1.20	1.19	1.19	1.20
Suter loop	.80	.61	.64	.62	.67
Suter knot	1.0	.73	.77	.77	.93
Walker abrasion	26	1	2	2.5	3.3
Twistability	42.5	37.6	38.2	40.6	41.2
Bulk increase, percent	0	32.0	24.0	22.6	19.0

While particular emphasis has been made to employing cellulose acetate spinning solutions, our process will also operate satisfactorily with other single and mixed organic acid esters such as those containing 2 to 4 carbon atoms or other polymeric compositions as referred to above.

We have noted that multifilament yarns composed of Y-shaped cross-section and modified Y-shaped cross-section filaments are much stiffer and more resilient than similar multifilament yarns having normal or cloverleaf cross-sections. The effect on stiffness of cross-sectional

Table IV

PHYSICAL PROPERTIES OF YARNS SPUN FROM VARIOUS TYPES OF TRIANGULAR HOLE SPINNERETTES

No.	50741	50741	50744	50744	50747	50747	50750	50750	50753	50753	51214
Candle filter temp., ° C.	65	70	65	70	65	70	65	70	65	70	65
Jet:											
No. holes	7	7	7	7	7	7	7	7	7	7	7
Hole type	Odd triangular		Odd triangular		Odd triangular		Odd triangular		Odd triangular		Equilateral triangular
Equiv. diameter	.110	.110	.110	.110	.110	.110	.110	.110	.110	.110	.115
Degrees in angles	120-30-30	120-30-30	24-78-78	24-78-78	78-60-42	78-60-42	84-48-48	84-48-48	48-66-66	48-66-66	60-60-60
Spin. draft	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.32
Spin. speed meters/min.	300	300	300	300	300	300	300	300	300	300	300
Bottom air temp., ° C.	85	85	85	85	85	85	85	85	85	85	85
Denier	151	149	148	148	150	147	151	154	149	150	144
Dry, C/D	1.10	1.09	1.02	1.02	1.13	1.14	1.11	1.11	1.10	1.13	1.20
Dry, percent stretch	33.0	34.0	30.0	30.4	33.0	36.4	36.0	36.2	35.5	37.0	36.8
Wet, C/D	0.62	.62	0.58	.57	0.61	0.64	.63	.63	.63	0.65	.63
Wet, percent stretch	43.0	45.0	39.4	40.2	42.5	45.9	45.7	48.2	46.0	48.5	45.6
LPS, C/D	1.30	1.35	1.25	1.20	1.27	1.27	1.28	1.27	1.27	1.26	
LPS, percent stretch	30.0	30.5	28.0	28.0	30.0	31.8	29.7	34.0	31.0	33.2	
Luster	73		77		77	78	76	76	77	78	30
Bulk factor	178.06		184.53		186.63		192.66		196.78		196.73
Specific volume, cu. in./lb.	37.395		38.75		39.195		40.46		41.328		41.75
Bulk increase over regular cross-section-approx., percent	80		25		26		30		33		30

shape can be estimated by comparing moments of inertia of fibers having different shapes but the same cross-sectional area. By this method we have determined that Y-shaped cross-section multifilament yarns are approximately 60% stiffer than regular filaments of equal size. Furthermore, we have found that when a plurality of Y-shaped cross-section filaments are collected in a bundle as in a yarn strand or in a batting, a greatly increased resilience or stiffness is noted which is more than would be expected from the increase in stiffness of individual fibers. We attribute this effect to the interlocking or tongue and groove mingling of the legs of the Y-shaped cross-section filaments making up the mass of fibers. This interlocking of fibers causes much greater resistance to interfiber slippage than can be obtained in a bundle of normal filaments. Thus the aggregate stiffness of a bundle of Y-shaped cross-section filaments is much greater than the sum of the stiffnesses of the individual fibers.

The inherent properties of cellulose acetate fibers of the Y-shaped cross-section described herein are such that they offer numerous desirable properties in both woven and knitted fabrics. In such fabrics as ninons, marquisettes, and voiles, the Y-shaped cross-section fibers produce fabrics having desirable crispness and stiffness which are usually obtained only by special processing techniques or by special finishing. In flat fabrics, such as taffetas, twills and satins, the increased bulk of the Y-shaped cross-section fibers produce fabrics having greater cover and thickness for a given weight of material. On the other hand there is the possibility of using less material to produce fabrics of the same cover and thickness thereby decreasing the cost. This characteristic is particularly important in certain fabrics, for example, satins and twills. Loom finished taffetas have a crisper feel when made from Y-shaped cross-section yarns.

Knitted fabrics from yarns with Y-shaped cross-sections exhibit increased body and hand which make them more desirable for certain uses such as sport shirts, men's ties, and dress goods. Yarns spun from staple fibers of Y-shaped cross-section exhibit increase in bulk and stiffness as do the filament yarns. In addition, fabrics from these yarns have a wool-like feel or hand. In all of the fabrics which have been produced from cellulose acetate fibers of the Y-shaped cross-section fabric properties have been obtained which are desirable and which are not obtained in cellulose acetate fibers of regular cross-section.

While the filaments produced from the various spinnerette orifices vary in cross-section, the individual filaments from a single spinnerette all have substantially the same cross-section. The angles between the legs of the Y will be consistently the same or consistently different depending on the particular spinnerette employed.

Although this invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention as described hereinabove, and as defined in the appended claims.

We claim:

1. As a new article of manufacture a rug essentially comprised of yarns of man-made fibers, the rug being particularly characterized in that a substantial portion of said yarns making up the rug are multifilament yarns of at least 80 filaments and of a denier per filament of less than 25 and a total denier of less than 6250, said filaments making up the multifilament yarn having a Y-shaped cross-section, the several filaments being of a sufficiently small size to be flexible but the legs of the Y of the individual filaments being intermeshed with the legs of other individual filaments so that each is reinforced by the other thereby imparting crush resistance to the rug, and the filaments exhibiting a slower apparent rate of soiling.

2. The rug of claim 1 wherein a substantial portion of the yarn making up the rug is comprised of a polymeric composition containing at least one of the constituents, cellulose ester, poly-acrylonitrile, polyamide, polyester and polyolefin, and whereby the Y-shaped cross section of the filaments eliminates or minimizes the greasy or slick synthetic hand of the filaments.

3. As an article of manufacture a fabric comprised of yarn of man-made fibers, the fabric being particularly characterized in that a substantial portion of said yarn making up the fabric is multifilament yarn of at least 75 filaments and a denier per filament of greater than 8 but less than 30, said filaments making up the multifilament yarn having a Y-shaped cross section, the filaments being of a sufficiently small size to be flexible but the legs of the Y of the individual filaments being intermeshed with the legs of other individual filaments so that each is reinforced by the other thereby imparting greater body and hand to the fabric and the yarn exhibiting a greater cover.

4. A textile yarn comprised of at least 7 relatively small non-circular cross-section filaments of a denier per filament less than 20 and a total denier less than 6250, the filaments making up the yarn consisting of filaments of a synthetic polymer having an essentially uniform cross-section along their length, said cross-section consisting of 3 integrally joined, substantially symmetrical lobes, said cross-section having a tip radius ratio and an arm angle such that said tips of the individual filaments contact other filments in the yarn to reinforce each other and therefore impart improved cover and crush resistance to the yarn as compared with a similar yarn made up of filaments of round cross-section, said small non-circular filaments of the instant yarn having a tensile strength of less than 150 grams per denier in order to impart softness and flexibility to the yarn and in order to avoid stiffness associated with monofils.

5. The yarns of claim 4 wherein the polymer comprising the filaments is cellulose acetate.

6. As a new article of manufacture the multifilament yarn of claim 4 wherein the filaments of said yarn are closely associated together by internally entangling, said filaments having a Y-shaped cross-section, whereby the yarn while substantially as flexible as conventional yarn exhibits of the order of 37 to 54% more bulk than regular yarn of the same number of filaments, denier, and entanglement.

7. A manufactured article from the group consisting of fabrics and rugs, said article being characterized in that it is essentially comprised of a textile yarn as defined in claim 4.

8. The yarn of claim 4 wherein one of the lobes may be of a different length and shape than the other lobes.

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MERVIN STEIN, *Primary Examiner.*

RUSSELL C. MADER, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,194,002 July 13, 1965

David W. Raynolds et al.

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 2, line 63, for "trangular" read -- triangular --; columns 3 and 4, Table I, last column, lines 6 and 7 thereof, for "1.48" and "1.03", respectively, read -- 1.43 -- and -- 1.08 --, respectively; column 7, Table III, in the heading, for "RIBERS" read -- FIBERS --; column 8, lines 63 and 64, for "Comtrasted" read -- Contrasted --; columns 9 and 10, Table IV, last column, lines 17, 18, 19 and 20, for "30" read -- 75 --, "196.73" read -- 196.70 --, "41.75" read -- 41.30 --, and "30" read -- 33 --, respectively.

Signed and sealed this 26th day of July 1966.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents