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J. L. EDWARDS ETAL 3,174,271

VARIABLE DENIER MULTIFILAMENT YARN HAVING RANDOM SLUBS
IN A BROAD DISTRIBUTION OF SIZES

Filed June 3, 1963

2 Sheets-Sheet 1

FIG. 1

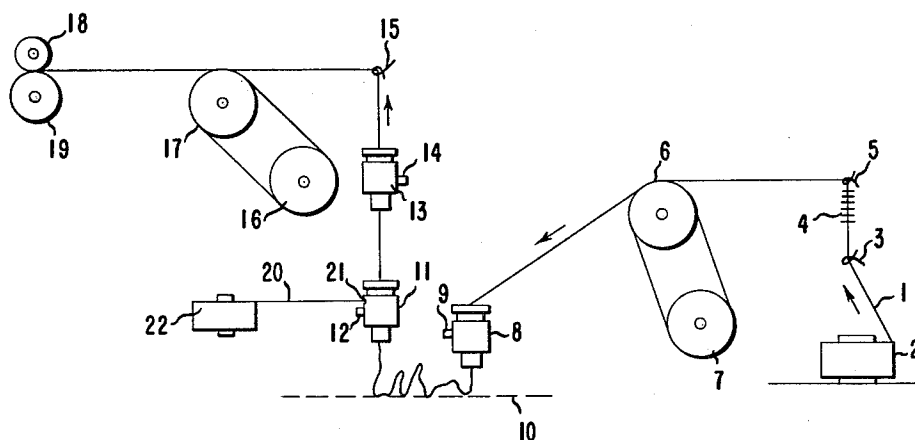


FIG. 2



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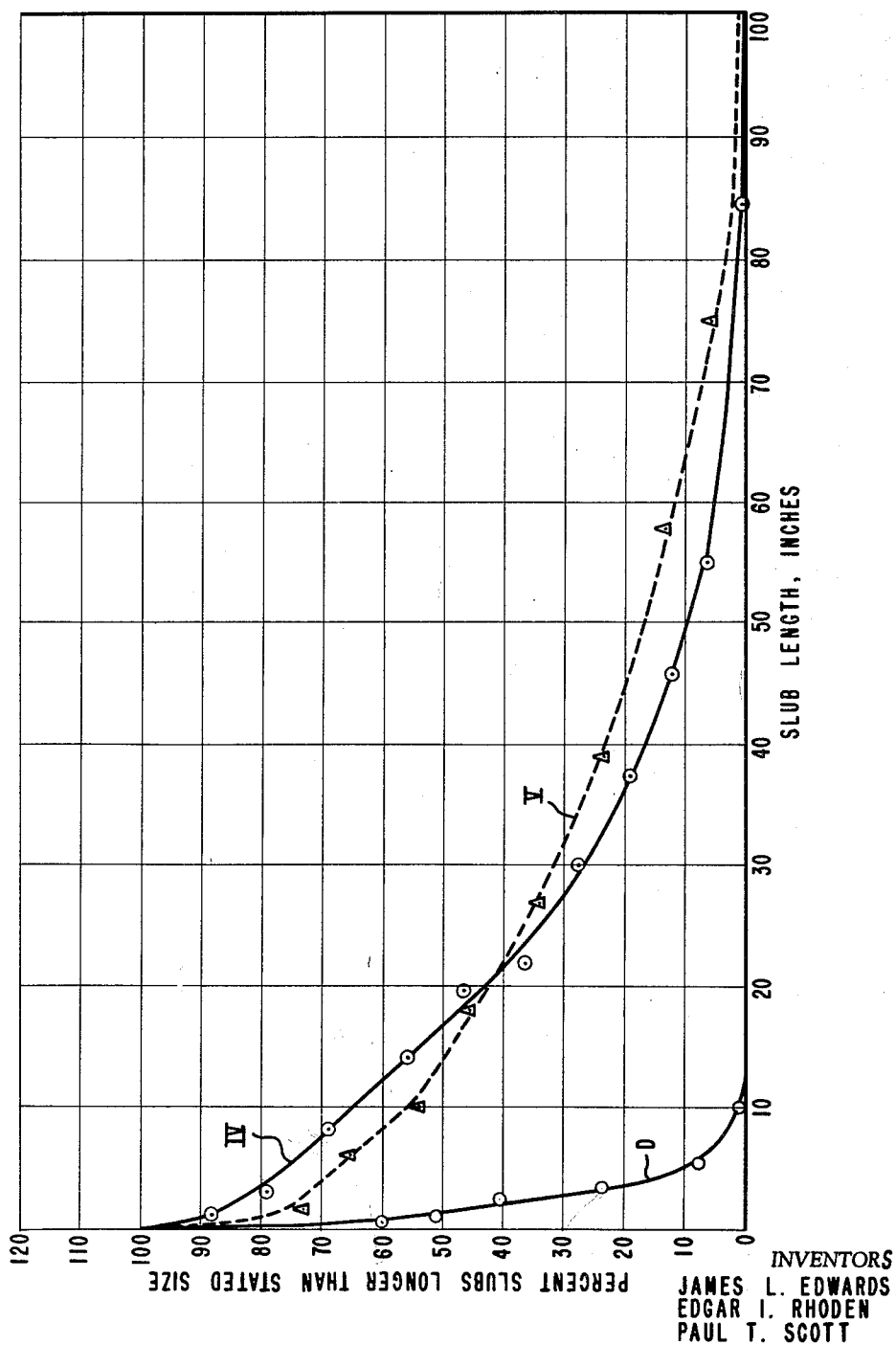
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2 Sheets-Sheet 2

FIG. 3



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VARIABLE DENIER MULTIFILAMENT YARN HAVING RANDOM SLUBS IN A BROAD DISTRIBUTION OF SIZES

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10 Claims. (Cl. 57—140)

This invention relates to new and novel slub yarn products. Processes for making them are claimed in my co-pending application Serial No. 161,221, filed December 21, 1961, now Patent No. 3,116,589 issued January 7, 1964, of which this is a continuation-in-part.

Slub yarns are well known to the prior art and are characterized by variations in cross-section along the length of the yarn. Such yarns have been made from continuous filaments, from staple fibers and from mixtures of continuous filament yarns in which tufts have been incorporated, i.e., by twisting, into the continuous filament structure. When made into fabric, such yarns provide a decorative effect of slubs distributed throughout the surface of the fabric.

For some purposes, it is desirable to produce yarns having large variations in denier, particularly, with the large denier segments continuing for a considerable length along the yarn in order to obtain novel effects in fabrics for such purposes as casement fabrics, draperies, dress goods, upholstery fabrics, and the like. One of the most satisfactory yarns for such purposes in the past has been that obtained from imperfect, freak, or double cocoons, or from cocoons of uncultivated silkworms which form imperfect silk threads. These silk yarns, called doupioni silk, are irregular and carry slubs of a thickened nature of a considerable length in an irregular fashion.

It is an object of the present invention to provide a novel continuous-filament slub yarn which has unusually long and thick slubs. Other objects will become apparent from the specification and claims.

In accordance with the present invention, there is provided a variable denier multifilament yarn comprising portions of a substantially uniform base denier and an average of at least 50 slubs, per 1000 yards of yarn, of continuous synthetic filaments looped upon themselves and consolidated into the yarn by filament entanglement, the slubs being of random size and distribution along the yarn. The slubs are of random length, averaging at least 10 inches in length, and the random slub lengths are such that about 10% to 30% of the slubs have lengths greater than twice the average. The average denier ratio is at least 3.0 and about 5% to 65% of the slubs have a segment with a denier ratio of at least 10.

The term "slub" as used herein should be distinguished from "nubs" or other relatively minor enlargements. In order to provide a precise basis for the numerical evaluations, a slub is defined as a readily discernable bulked portion having a length of at least 0.25 inch. Smaller enlargements on the base denier of a yarn are difficult to count or evaluate, and are not relevant to the present invention.

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The slub yarns of this invention are highly desirable for the purposes indicated because of broad distribution of slub sizes which includes unusually long and thick slubs, with at least 10% of the slubs having a length twice the average and at least 5% having a segment with a denier ratio of at least 10. The slubs consist of loops of the feed yarn which are entangled with themselves by an intermingling of filaments. Due to the formation of snarls and knots the slubs are extremely stable and are not pulled out. Attempts to pull out the slubs result in yarn breakage with no discernible change in slub size. The major portion of the bulk of the slub is due to yarn loops or folds. A relatively small portion of slub bulk is due to individual filaments, or to small groups of filaments, which serve, for the most part, to anchor and stabilize the yarn loops or folds.

In a preferred process for preparing these novel slub yarns, continuous filament yarn is continuously fed to a supply jet from a suitable source, such as a spinning position or a supply package, and forwarded by the jet in a high velocity stream of compressible fluid to impinge at an angle against a screen. The essential function of this jet is to open up the yarn bundle. Jets suitable for this purpose are disclosed by A. L. Breen in U.S. Patent Nos. 2,783,609, 2,852,906 and 2,869,967. A second jet directs a high velocity stream of compressible fluid against the screen adjacent to the stream from the feed jet. This creates a zone of turbulence between the two streams which causes the yarn bundle to open and also to fold back on itself. The yarn becomes entangled, initiating the formation of slubs. The yarn is then withdrawn from the surface at a rate at least 5% less than the feed rate. The loops or folds of the entangled yarn mass are consolidated into slubs by withdrawing the yarn through the slub jet stream in a direction which is countercurrent to the stream. The turbulent flow in the jet causes the filaments to intermingle and entangle the folds or loops to form stable slubs which are random in length and thickness. The jet used to consolidate the slubs may be similar to the feed jet, but interlacing jets of the type disclosed by Bunting et al. in U.S. Patent No. 2,985,995 are preferable. The interlacing action in this jet consolidates the slub by further filament entanglement. Consolidation of the slubs in the yarn is completed by a third jet located after the slubbing jet to twist protruding loops or ends about the yarn. Torque jets of the type disclosed by Breen et al. in U.S. Patents 2,997,837 and 3,009,309 are suitable for this purpose.

When a carrier yarn is used, the carrier can be introduced at either the feed, slub, or torque jet. Preferably, the carrier yarn is introduced at the slub jet, particularly when the slub jet is of the interlacing type. Generally, it is desirable to have the carrier yarn and the slub yarn combined so that they are not readily separable and will, therefore, process as a unit in subsequent operations such as weaving. For special purposes, it may be desirable to use a slub yarn as a carrier yarn.

The drawings will facilitate understanding the invention.

FIGURE 1 is a diagrammatic representation of a preferred embodiment of process and apparatus for preparation of the yarn of this invention.

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FIGURE 2 is an enlarged view of one form of slub. FIGURE 3 is a plot comparing the distribution of slub sizes in yarns of Examples IV and V with those of a prior slub yarn D.

Referring to FIGURE 1, substantially 0 twist multifilament yarn 1 is withdrawn from supply package 2 through pigtail guide 3, tension gate 4, and guide 5 by feed rolls 6 and 7, the yarn passing a sufficient number of times around the pair of rolls to provide positive control of the feed rate. The yarn then passes through feed jet 8 and is forwarded to screen 10 by air introduced into the jet through fitting 9 to form a high velocity stream. The yarn is struck against the screen at an angle of about 90° by the air which passes through the screen. A slub jet 1 of the interlacing type is supplied with air under pressure through fitting 12 to form a high velocity stream which is also directed perpendicularly against the screen to impinge on the screen adjacent to the other stream from the feed jet. The turbulence created between the two streams causes the yarn to twist, loop, and entangle on itself. The yarn passes from the screen through slub jet 11 and through a torque jet 13, supplied with air under pressure through fitting 14, then over pigtail guide 15 to takeup rolls 16 and 17. The take-up rolls are similar to feed rolls 6 and 7 but are operated at a slower speed to withdraw the yarn from the screen at a suitable rate for the desired slub formation. As the yarn is pulled through the slub jet, the slubs are consolidated in the yarn by intermingling of the folds and filaments of the slubs and base yarn bundle. The slubs are even more firmly consolidated as the yarn passes through the torque jet. The slub yarn then passes from the takeup rolls to a conventional windup, such as a package 18 surface driven by roll 19. Preferably, a carrier yarn 20 is used and is fed into slub jet 11, through an opening 21 in the side of the jet, from a supply package 22.

FIGURE 3 is a plot of the distribution of the length of the slubs in the yarn produced as shown in Examples IV and V and also, for comparison, a slub yarn of the prior art exemplified by Sample D. FIGURE 3 graphically shows the preponderance of long slubs in the yarns of this invention.

The novel slub yarns of this invention are characterized by a broad range of slub lengths and thicknesses which are distributed at random along the length of the yarn. The corresponding random location of slubs in fabric woven from the yarn is a distinct advantage. The average length of the slubs and the number of long slubs will vary with processing conditions. The yarns may contain as many as 1200 and as few as 50 slubs per 1000 yards of yarn with an average slub length ranging from 10 to 25 inches or more. In determining the number of slubs in a sample of yarn, only those enlargements having a length 0.25 inch or greater are counted as a slub. In general, in order to achieve the most pleasing fabrics, it is desirable to have a relatively small total number of slubs, i.e., about 60-150 slubs per 1000 yards of yarn, and that the slubs be relatively long, i.e., with an average slub length of about 15-25 inches. Preferably, the yarn will contain between 1 and 10 slubs longer than 75 inches per 1000 yards of yarn. If there are too many slubs longer than 75 inches in the yarn, the fabric will have a striped effect, and, for many uses, it may be desirable that there be only from 1 to 5 slubs longer than 75 inches per 1000 yards of yarn.

Thick, heavy slubs are desirable for increased fabric contrast. The measure of slub thickness used herein is the denier ratio. By "denier ratio" is meant the ratio of the denier of the slub to the denier of the base yarn.

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When a carrier yarn is used, "base" yarn means the combination of slub yarn plus carrier yarn. The average denier ratio is determined by measuring the denier ratio of all the slubs in a sample of yarn of a given length and calculating the average. Because of the random nature of the slubs, the sample should be at least 1500 yards in length. In general, the yarns of this invention do not have slubs whose denier is uniform throughout their length. Hence, an average value is used for the denier ratio of a given slub.

Since it is the relatively thick sections of a slub, i.e., the segments having a denier ratio of 10 to 15 and more, that contribute most to fabric contrast, the percentage of slubs having a segment with a high denier ratio is also used to characterize the slub yarns of this invention. For most uses, the average denier ratio will be between 3 and 6. Preferably, 15% to 45% of the slubs will have segments with a denier ratio of at least 10.

Any synthetic continuous filament yarn can be used to make the novel products described above. The materials from which the yarns are made include all the fiber-forming polyamides such as 6 nylon, 66 nylon, and 6-10 nylon. The polyester yarns are all usefully and include polyesters of terephthalic acid or isophthalic acid and a lower glycol, e.g., poly(ethylene terephthalate), and poly(hexahydro-p-xylylene terephthalate). Another sub-class of these general chemical classes are the spontaneously elongatable yarns. These are particularly interesting for novelty effects in the lower ranges of overfeed and especially if a heated fluid is used in the supply jet and/or the slubbing jet. Other conventional classes of fiber-forming materials include regenerated cellulose, the cellulose esters and the acrylic, vinyl, and vinylidene polymers, as well as the many suitable fiber-forming copolymers of any of these groups.

Preferably, the yarn to be treated is a continuous multifilament yarn at 0 twist. It may be desirable, however, for special effects or for specific end uses to use a pretwisted yarn or to add a pretwisted yarn as a carrier yarn.

The feed yarns can also include monofil or twist-lively yarns. These are difficult to handle and slub effectively, but they can be included for unusual results.

When a carrier yarn of a different polymer type than that of the feed yarn is used, cross-dyeing effects can be achieved.

Suitable process conditions are illustrated in the examples of Table I. The coherency factor given in Table II is determined by the hook-drop test described in detail starting in column 20 of Bunting et al. U.S. Patent No. 2,985,995. The base yarn of these new slub yarns has a coherency factor of at least 20 and the slub portions have a coherency factor of at least 20% greater than that of the base yarn. Thus, the ratio of the coherency factor of the slub portions to that of the base yarn is at least 1.2 to 1. Base yarn coherency factors are frequently greater than the 60 to 90 shown in Table II and can run as high as 200 to 400. The slub coherency factor will usually be 100 to 300 and can run as high as 400 to 900.

Under the heading "Yarn Treated," 70/50/0 indicates a 70-denier yarn of 50 filaments and 0 twist. The angles given refer to the angle at which the supply jet fluid is directed against the screen. This angle may be from substantially 0 to 90°. The process is likewise operable with slub jet angles over this broad range, although the examples illustrate operation with the slub jet arranged to direct fluid perpendicular to the screen. The characteristics of the novel slub yarn products obtained are shown in Table II. The products are entirely random in appearance with slubs in a wide range of lengths, thicknesses, and frequencies.

TABLE I
Examples of process conditions

Example No.	Yarn Treated	Yarn Speed (YPM)		Supply Jet		Slub Jet		(Distances in Inches)			
		Feed Rate	Wind-up	Pressure (p.s.i.g.)	Temp. (° C.)	Pressure (p.s.i.g.)	Temp. (° C.)	Supply Jet to Screen	Slub Jet to Screen	Jet Separation	Angle of Supply Jet, Degrees
I-----	300/150/0 polyethylene terephthalate.	950	783	20	20	100	20	2½	2	5	43
II-----	100/68/0 polyethylene terephthalate.	950	763	5-10	20	30	20	2¼	2½	5	90
III-----	70/50/0 polyethylene ¹ terephthalate.	900	750	6	20	60	20	2¼	1¾	4¾	76

¹ In Example III a 40/27/0 carrier yarn of polyethylene terephthalate is fed separately at 750 yards per minute to the entrance of the slub jet and the combined yarns are passed from the slub jet through a torque jet supplied with 60 p.s.i.g. air at 20° C.

TABLE II
Characterization of slub yarn products of Table I

Example No.	1	2	3
Average Slub Length, inches	11.1	21.8	11.5
Slubs/1,000 Yards	110	110	150
Average Denier Ratio	3.5	3.3	4.6
Percent of Slubs Having a Length Greater than—			
1 inch	57	80.3	59.7
5 inches	33	57.5	34.7
10 inches	17	40	25
22.2 inches	12		
23.0 inches			11
43.6 inches		23	
Longest Slub in Samples Analyzed, inches	111	176	126
Base Yarn Coherency Factor	90	63	200
Slub Coherency Factor	165	102	300

For comparison with the yarns of this invention the following previously known slub yarns are characterized in Table III:

A. A typical doupioni silk (a natural product).

B. An intermittently textured yarn of the type disclosed by Grisct in U.S. Patent 2,874,444 and Field in U.S. Patent 2,931,090 (both assigned to the assignee of the present application), using a carrier yarn to stabilize the slubs.

C. A slub yarn produced by spinning viscose and forming slubs in the coagulating bath as disclosed by R. Woodell in Example I and Table I of U.S. Patent 3,042,482 (assigned to the assignee of the present application).

D. A slub yarn produced by intermittently bulking a preformed polyester yarn in a liquid bath by a modification of the above disclosed in British Patent 902,642 (granted November 28, 1962, to the assignee of the present application).

TABLE III

Slub Characterization Parameters	Sample A Doupioni Silk	Sample B Intermittently Textured Yarn	Sample C Slubbed in Viscose Process	Sample D Intermittently Bulk in a Liquid Bath
Average Slub Length, inches	7.7	4.2	0.5	2.6
Slubs/1,000 Yards	350	4,350	4,380	1,170
Average Denier Ratio	6	3.5	4	1.6-2.4
Percent of Slubs Having a Length Greater Than—				
1 inch	52	96	6	40.5
5 inches	36	11	0	9.6
10 inches	25	1	0	1.0
25 inches	12	0	0	0
Percent of Slubs Having a Segment with a Denier Ratio of at Least 15	26	0	0	0

EXAMPLE IV

Apparatus similar to that shown in FIGURE 1 is used to prepare a slub yarn from 100-denier, 68-filament, zero-twist yarn of a copolyester prepared from ethylene glycol and a 98/12 mixture of terephthalic/5-(sodium sulfo)-

isophthalic acids. The feed jet is mounted vertically and 0.75 inch above the horizontal screen. The slub jet is mounted vertically 1.75 inches above the screen and 5 inches horizontal distance from the feed jet. A torque jet is used after the slub jet to consolidate the slubs. Air pressures for the feed, slub, and torque jets are 9, 40, and 60 p.s.i.g., respectively. The yarn is fed to the feed jet at 900 yards per minute and withdrawn from the torque jet at 741 yards per minute. A 40-denier, 27-filament, zero-twist carrier yarn of the same copolyester used for the feed yarn is fed to the slub jet at 741 yards per minute. In this example, processing conditions are selected to give a yarn having a relatively small number of slubs with a high average slub length. Such yarns are a preferred embodiment of the present invention. The characteristics of the slub yarn obtained are given in Table IV.

EXAMPLE V

A 100-denier, 34-filament, zero-twist 66 nylon is used to prepare a slub yarn as in Example IV except that a carrier yarn is not used. The characteristics of the slub yarn obtained are given in Table IV.

TABLE IV

Example No.	IV	V
Yarn Treated	¹ 100/60/0	² 100/34/0
Carrier Yarn	¹ 40/27/0	None
Average Slub Length (inches)	21.9	24.8
Slubs/1,000 yards	83	72
Average Denier Ratio	4.0	5.3
Percent of Slubs Having a Length Greater Than—		
5 inches	73	68
10 inches	63	55
25 inches	38	38.5
50 inches	20	24.6
100 inches	1.7	3.4
Percent of Slubs Having a Segment with a Denier Ratio of at least 14	10	35

¹ Copolyester.

² 66-nylon.

In Examples VI through IX, various slub yarns are prepared as in Example IV except that a carrier yarn is used only in Example VII. The average slub length in these examples is about 25 inches. The preponderance of long and thick slubs is shown by the data in Table V.

TABLE V

Example No.-----	VI	VII	VIII	IX
Yarn Treated-----	¹ 150/40/0	² 100/34/0	² 70/30/0	³ 200/80/0
Carrier Yarn-----	None	⁴ 40/27/0	None	None
Slubs/1,000 yards-----	119	60	65	111
Percentage of slubs Having a Length of--				
25-50 inches-----	24.6	12.2	12.4	17.1
50-100 inches-----	7.3	18.8	13.4	15.0
Greater than 100 in-----	4.5	5.5	8.3	5.4
Percentage of Slubs Having a Segment with a Denier Ratio of at Least x:				
Percentage-----	29	28.7	16.5	65
x-----	14.3	21.0	29.6	10
Average Denier Ratio-----				4.7
Average Slub Length (inches)-----				23

¹ Cel acetate.
² 66-nylon.
³ Acrylic.
⁴ Copolyester.

EXAMPLE X

Apparatus similar to that shown in FIGURE 1 is used to prepare a slub yarn from 200-denier, 136-filament zero-twist of the same copolyester used in Example IV. The feed jet and the slub jet are both mounted vertically 0.75 inch above the horizontal screen with a 5-inch horizontal distance between the jets. A torque jet is used after the slub jet to consolidate the slubs. Air pressures for the feed, slub, and torque jets are 9, 60, and 60 p.s.i.g., respectively. The yarn is delivered to the feed jet at 900 yards per minute and withdrawn from the torque jet at 764 yards per minute. A 70-denier, 50-filament, zero-twist yarn of the same polyester used for the feed yarn is fed to the slub jet at 764 yards per minute. In this example, processing conditions are selected to give a yarn with a relatively small number of slubs with a high average slub length and reduced slub thickness. Such yarns represent a compromise between contrast and ease of handling in subsequent textile operations, particularly when they are used as the warp yarn in weaving. The characteristics of the slub yarn obtained are given in Table VI.

TABLE VI

Yarn treated-----	200/136/0 copolyester.
Carrier yarn-----	70/50/0 copolyester.
Average slub length (inches) --	19.7.
No. of slubs/1000 yards-----	87.
Average denier ratio-----	3.8.
Percent of slubs having a length greater than 39.4 inches-----	17%.
Percent of slubs having a segment with a denier ratio greater than 10-----	6%.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

We claim:

1. A variable denier multifilament yarn comprising portions of a substantially uniform base denier and an

average of at least 50 slubs per 1000 yards of yarn, of continuous synthetic filaments looped upon themselves and consolidated into the yarn by filament entanglement, the slubs being of random size and distribution along the yarn, the average slub length being at least 10 inches, about 10% to 30% of the slubs having lengths greater than twice the average, the slubs having an average denier ratio of at least 3.0, and about 5% to 65% of the slubs having a segment with a denier ratio of at least 10.

2. A yarn as defined in claim 1 wherein said slubs average about 60 to 150 slubs per 1000 yards of yarn.

3. A yarn as defined in claim 1 wherein said slubs have an avreage length of about 15 to 25 inches.

4. A yarn as defined in claim 1 wherein there are between 1 and 10 slubs longer than 75 inches per 1000 yards of yarn.

5. A yarn as defined in claim 1 wherein said slubs have an average denier ratio between 3 and 6.

6. A yarn as defined in claim 1 wherein said base denier portions of the yarn has a coherency factor of at least 20 and said slub portions have a coherency factor at least 20% greater than that of the base denier portions.

7. A yarn as defined in claim 6 wherein the slub coherency factor is 100 to 300.

8. A yarn as defined in claim 1 which includes a carrier yarn.

9. A yarn as defined in claim 1 plied with an unslubbed carrier yarn.

10. A yarn as defined in claim 1 plied with up to an equal weight of unslubbed carrier yarn.

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MERVIN STEIN, Primary Examiner.