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(54) **Self crimping yarn, process for producing a self crimping yarn, and textured yarn having a wool-like hand.**

(57) A self-crimping continuous-filament yarn comprises latent-crimp filaments having a periodic variation in denier greater than  $\pm 15\%$  about a mean value combined with filaments having a lower shrinkage than the latent-crimp filaments. Each of the latent-crimp filaments is made by converging two individual molten streams (fig. 5) travelling at different velocities and quenching the resulting combined streams to form a combined filament. The lower-shrinkage filaments are spun simultaneously and both kinds of filaments are withdrawn at a common spinning speed in excess of 2200 meters per minute. On developing the crimp there is produced a novel yarn having high bulk and a wool-like hand comprising developed crimp filaments having a periodic variation in denier greater than  $\pm 15\%$  about a mean value combined with longer filaments protruding from the yarn in loops.

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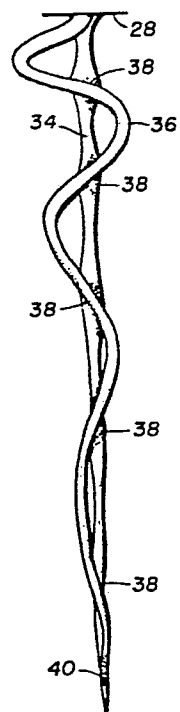


FIG. 5.

SELF CRIMPING YARN, PROCESS FOR PRODUCING A SELF CRIMPING  
YARN, AND TEXTURED YARN HAVING A WOOL-LIKE HAND

The invention relates to the art of melt-spun synthetic yarns and processes for their production, and more particularly to such yarns which combine high bulk with a wool-like hand.

It is known to produce somewhat bulky yarns by combining filaments with different shrinkages into a yarn, then shrinking so that the resulting longer filaments protrude in loops from the yarn. This may be done by spinning the filaments from different polymers, as in Reese U.S. patent 3,444,681, or by spinning from different filament cross-sections from a common polymer, as typified by several patents. Such known yarns ordinarily do not have high bulk, nor do fabrics made therefrom ordinarily provide a hand similar to that of wool, combining an initial crispness on light touch with softness on more firm compression.

These and other difficulties of the prior art are avoided by the present invention, which provides novel and useful processes and improved yarn products.

According to a first major aspect of the invention, there is provided a process for producing a self-crimping yarn comprising first and second types of filaments, the process comprising spinning the first type of filaments by generating first and second individual streams of molten polymer of fiber-forming molecular weight, the individual streams travelling at different velocities; converging the individual streams side-by-side to form a combined stream; and quenching the combined stream to form a combined filament;

spinning the second type of filaments by extruding a third stream of molten polymer of fiber-forming molecular weight from an orifice selected to give a filament with lower shrinkage than said combined filament, at a given common  
5 spinning speed; and quenching the third stream into a filament; withdrawing the filaments from the streams at the given common spinning speed in excess of 2200 meters per minute; and combining the filaments into a yarn.'

According to another aspect, each of the streams is  
10 of polyester polymer.

According to another aspect, the spinning speed is selected such that the yarn has a shrinkage below 20%.

According to another aspect, the spinning speed is selected such that the yarn has a shrinkage below 8%.

According to another major aspect of the invention,  
15 there is provided a multifilament yarn comprising first and second classes of filaments, each of the first class of filaments having a periodic variation in denier of greater than  $\pm 15\%$  about a mean value and possessing latent crimp;  
20 each of the second class of filaments having lower shrinkage than the shrinkage of the filaments of the first class.

According to another aspect, each of the second class of filaments has a denier larger than the average denier of the first class of filaments.

According to another major aspect of the invention,  
25 there is provided a multifilament yarn comprising first and second classes of filaments; each of the filaments of the first class having a periodic variation in denier of greater than  $\pm 15\%$  about a mean value and possessing developed crimp;  
30 each of the filaments of the second class being longer than the filaments of the first class whereby the filaments of the second class protrude from the yarn in loops.

According to another aspect, each of the second class of filaments has a denier larger than the average denier  
35 of the first class of filaments.

These and other aspects of the invention will in part appear hereinafter and will in part appear hereinafter in the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a vertical sectional view of a spinneret orifice;

FIGURE 2 is a bottom plan view of the FIGURE 1 orifice, looking up;

5        FIGURE 3 is a graph of shrinkage versus spinning speed used in explaining the principles upon which certain aspects of the invention are based;

FIGURE 4 is a cross-sectional view of a filament according to certain aspects of the invention;

10       FIGURE 5 is a side elevation view of the molten streams issuing from the FIGURE 1 spinneret according to certain aspects of the invention;

FIGURE 6 is a graph illustrating the variation in denier along a representative filament according to certain aspects of the invention; and -

15       FIGURE 7 is a graph illustrating the distribution of the fluctuations illustrated in FIGURE 5 for a representative multiple orifice spinneret according to certain aspects of the invention.

20       The invention will be specifically exemplified using polyester polymer, it being understood that certain aspects of the invention are applicable to the class of melt-spinnable polymers generally. "Polyester" as used herein means fiber-forming polymers at least 85% by weight of which is formable by reacting a dihydric alcohol with terephthalic acid.

25       Polyester typically is formed either by direct esterification of ethylene glycol with terephthalic acid, or by ester interchange between ethylene glycol and dimethylterephthalate.

FIGURES 1 and 2 illustrate the preferred embodiment of a spinneret design which can be employed for obtaining the first type of filaments according to the invention. The spinneret includes a large counterbore 20 formed in the upper surface 21 of spinneret plate 22. Small counterbore 24 is formed in the bottom of and at one side of large counterbore 20. A large capillary 26 extends from the bottom of large counterbore 20 at the side opposite small counterbore 24, and connects the bottom of large counterbore 20 with the lower surface 28 of plate 22. Small capillary 30 connects the bottom of counterbore 24 with surface 28. Capillaries 26 and

30 are each inclined four degrees from the vertical, and thus have an included angle of eight degrees. Counterbore 20 has a diameter of 0.113 inch (2.87 mm.), while counterbore 24 has a diameter of 0.052 inch (1.32 mm.). Capillary 26 has a diameter of 0.016 inch (0.406 mm.) and a length of 0.146 inch (3.71 mm.), while capillary 30 has a diameter of 0.009 inch (0.229 mm.) and a length of 0.032 inch (0.813 mm.). Land 32 separates capillaries 26 and 30 as they emerge at surface 28, and has a width of 0.0043 inch (0.109 mm.). Plate 22 has a thickness of 0.554 inch (14.07 mm.). Capillaries 26 and 30 together with counterbores 20 and 24 constitute a combined orifice for spinning various novel and useful filaments according to the invention, as will be more particularly described hereinafter.

FIGURE 3 is a graph showing how polyester filament shrinkage varies with spinning speed for two illustrative cases of jet stretch. The curve in dotted lines shows that the shrinkage falls from about 65% at 3400 ypm (about 3100 mpm) to about 5% at 5000 ypm (about 4500 mpm) when using spinneret capillaries having diameters of 0.063 inch (1.6 mm.) and when simultaneously spinning 34 such filaments to be false-twist draw-textured to yield a textured yarn having 150 denier. The solid curve shows that the shrinkage drops off at higher speeds when using spinneret capillaries having diameters of 0.015 inch (0.38 mm.) when similarly simultaneously spinning 34 such filaments to be false-twist draw-textured to yield a textured yarn having 150 denier. Using different capillary diameters produces a family of curves between, to the left, and to the right of those illustrated. The curves also can be shifted (for a given capillary diameter) by varying the polymer throughput. In other words, the curves can be shifted by varying the jet stretch, which is the ratio of yarn speed just after solidification to average speed of molten polymer in the capillary. It is thus possible to provide a combined orifice for spinning a composite filament of a single polymer wherein one side of the filament has a much higher shrinkage than the other side. This is done by selecting the individual capillaries to give different jet stretches, and also selecting the spinning

speed within the range wherein an individual filament quenched from one of the individual streams would have a shrinkage at least ten percentage points higher than that of an individual filament quenched from the other of the individual streams. Under the spinning conditions illustrated in FIGURE 3, at a spinning speed of 5000 yards per minute the individual streams would have shrinkages differing by about 25 percentage points. Combining these molten streams into a side-by-side configuration results in a highly crimped filament in its as-spun form, without the necessity of drawing the yarn to develop the crimp. Such combining may be done using a spinneret design similar to that disclosed in FIGURE 1, or the spinneret may merge the two streams at or just prior to emergence of the streams from surface 28. In any event, the two streams merge substantially coincident with the face of the spinneret according to this aspect of the invention.

Advantageously, the spinneret is so designed that one of the individual streams has a velocity in its capillary between 2.0 and 7 times (preferably between 3.5 and 5.5 times) the velocity of the other of the streams in its capillary. Further advantages are obtained when the faster of the two streams has a smaller cross-sectional area than the slower of the streams, particularly in degree of crimp and spinning stability. Productivity is increased when the spinning speed is selected such that the combined filament has a shrinkage less than 30%, and is maximized when the shrinkage is less than 10%.

Further aspects of the invention, applicable to melt-spinnable polymers as a class, are achievable by use of spinnerets wherein the streams intersect outside the spinneret. As a specific example, molten polyester polymer of normal textile molecular weight is metered at a temperature of 290°C. through a spinneret having 34 combined orifices as above specifically disclosed. The polymer throughput is adjusted to produce filaments of 4 average denier per filament at a spinning speed of 5200 yards per minute, the molten streams being conventionally quenched into filaments by transversely directed quenching air.

Under these spinning conditions a remarkable phenomenon occurs, as illustrated in FIGURE 5. Due to the geometry of the spinneret construction, the polymer flowing through the smaller capillaries 30 has a higher velocity than that flowing through the larger capillaries. The speeds and momenta of the paired streams issuing from each combined orifice and the angle at which the streams converge outside the spinneret are such that the slower streams 34 travel in substantially straight lines after the points at which the paired streams first touch and attach, while each of the smaller and faster of the streams 36 forms sinuous loops back and forth between successive points of attachment 38 with its associated larger streams. This action can be readily observed using a stroboscopic light directed onto the stream immediately below the spinneret face 28. As the molten streams accelerate away from the spinneret, the slower stream attenuates between the points of attachment 38 and the loops of the faster stream become straightened until the faster stream is brought into continuous contact with the slower stream. The slower stream attenuates more between than at the points of first attachment, so that the resulting combined stream has a cross-section which is larger at the points of first attachment than in the regions between these points. The resulting combined stream is then further attenuated somewhat until it is solidified into a filament 40 by the transverse quench air.

Each solidified filament 40 has non-round cross-sectional areas which vary repetitively along its length, and, after being heated while under low tension, has variable pitch S-twisted and Z-twisted helically coiled sections, the sections being less tightly coiled in regions of large cross-sectional area than in regions of small cross-sectional area. As illustrated qualitatively in FIGURE 6, when using the above spinning conditions, the filament cross-sectional area repetitively varies at a repetition rate of about one per meter, although this can be varied by modifying the spinning conditions and the geometry of the spinneret passages.

Due to minor differences between combined orifices, temperature gradations across the spinneret, and other like

deviations from exactly the same treatment for each pair of streams, a multiple orifice spinneret will typically provide somewhat different repetition rates among the several resulting streams and filaments. An example of this is qualitatively shown in FIGURE 7, wherein is shown that various orifices produce somewhat different repetition rates as determined by stroboscopic examination of the combined streams just below the spinneret face. The repetition rate is proportional to the stroboscope frequency bringing about apparent cessation (or freezing) of movement of the thick and thin regions of the filament. A number of such frequencies are plotted along the horizontal axis of Figure 7, and on the vertical axis are plotted the number of orifices giving filaments wherein such freezing was observed, at each given stroboscope frequency. In the resulting multifilament yarn, the filaments have non-round cross-sections which vary by more than  $\pm 10\%$  along the length of the filaments, and alternating S-twisted and Z-twisted helically crimped sections being out of phase from filament to filament.

For certain effects, it is advantageous that the filaments vary repetitively along their lengths by more than  $\pm 25\%$  (preferably more than  $\pm 30\%$ ) in cross-sectional area. The effects are particularly pronounced when the yarn has a Uster unevenness of at least  $2.5\%U$ . The Uster measurement is made using the Uster Evenness Tester, Model C, together with integrator ITG-101 for this instrument. The yarn speed is 182.8 meters per minute (200 ypm), the service selector is set on normal, and the sensitivity selector is set to  $12.5\%$ . The  $\% U$  is read from the integrator after a sample run time of 5 minutes.

Shrinkage is determined by the method disclosed in this paragraph. Generally speaking, a sample yarn's initial length  $L_0$  is determined while the yarn is under a tension of 0.1 grams per denier. The yarn is then subjected to a tension of 0.0025 grams per denier and placed in an oven at  $120^\circ\text{C}$ . for five minutes. The yarn is then removed from the oven, again subjected to a tension of 0.1 grams per denier and its length  $L_2$  determined. Shrinkage percentage equals.

$$\frac{L_0 - L_2}{L_0} \times 100$$

The second class of filaments may be spun from spinneret orifices selected such that, at the given common spinning speed, the filaments of the first class will have a higher shrinkage than those of the second class.

5           As a specific example, molten polyethylene terephthalate polymer of normal molecular weight for textile apparel yarns is extruded simultaneously through two spinnerets, one of which contains 34 combined orifices as above described and the other of which contains 34 round  
10 orifices having diameters of 0.009 inch (0.229 mm.). The extrusion rates are selected such that each resulting class of 34 filaments has a denier of 77 at a winding or spinning speed of 5600 ypm (about 5100 meters per minute). The  
15 68 molten streams are quenched into filaments by transversely directed moving air, and the 68 filaments are converged into a common yarn bundle and wound on a bobbin at 5600 ypm as a yarn having a denier of 154.

The yarn is heated to 150°C. while under low tension to develop the latent crimp in those filaments of the  
20 first class and to develop the shrinkage differences between the two classes of filaments. Those filaments of the first class, collected separately, have a shrinkage of 10.6%, while those of the second class, collected separately, have a shrinkage of 4.5%. The combined yarn has a shrinkage of  
25 6.3%. Each filament of the first class has a periodic variation in denier from approximately one denier to approximately four denier, while the filaments of the second class protrude in relatively large loops from the yarn bundle.

To produce a more wool-like hand, the denier per  
30 filament of the filaments of the second class can be increased, the range of about 5-9 dpf being particularly suitable.

What is claimed is:

1. A process for producing a self-crimping yarn comprising first and second types of filaments, characterized by:

- 5 a. spinning said first type of filaments by  
(1) generating first and second individual streams of molten polymer of fiber-forming molecular weight, said individual streams travelling at different velocities;  
10 (2) converging said individual streams side-by-side to form a combined stream; and  
(3) quenching said combined stream to form  
15 a combined filament;
- b. spinning said second type of filaments by  
(1) extruding a third stream of molten polymer of fiber-forming molecular weight from an orifice selected to give  
20 a filament with lower shrinkage than said combined filament at a given common spinning speed; and  
(2) quenching said third stream into a filament;
- 25 c. withdrawing said filaments from said streams at said given common spinning speed in excess of 2200 meters per minute; and  
d. combining said filaments into a yarn.

2. The process of claim 1, characterized in that  
30 each of said streams is of polyester polymer.

3. The process of claim 2, characterized in that said spinning speed is selected such that said yarn has a shrinkage below 20%.

4. The process of claim 3, characterized in that  
35 said spinning speed is selected such that said yarn has a shrinkage below 8%.

5. The process of claim 1, characterized in that said spinning speed is between 5000 and 6000 yards per minute, and wherein each of said first type of filaments is polyester.

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6. A multifilament yarn comprising first and second classes of filaments characterized by;

- a. each of said first class of filaments having a periodic variation in denier greater than  $\pm 15\%$  about a mean value and possessing latent crimp;
- b. each of said second class of filaments having lower shrinkage than the shrinkage of said filaments of said first class.

7. The yarn of claim 6 characterized in that each of said second class of filaments has a denier larger than the average denier of said first class of filaments.

8. The yarn of claim 6 characterized in that said first class of filaments are polyester.

9. A multifilament yarn comprising first and second classes of filaments characterized by;

- a. each of the filaments of said first class having a periodic variation in denier of greater than  $\pm 15\%$  about a mean value and possessing a developed crimp;
- b. each of the filaments of said second class being longer than said filaments of said first class whereby said filaments of said second class protrude from said yarn in loops.

10. The yarn of claim 9 characterized in that each of said second class of filaments has a denier larger than the average denier of said first class of filaments.

11. The yarn of claim 9 characterized in that said first class of filaments are polyester.

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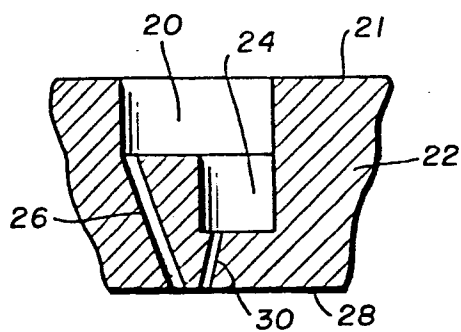


FIG. 1.

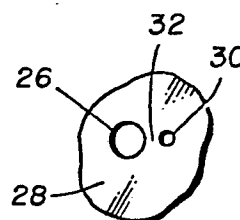


FIG. 2.

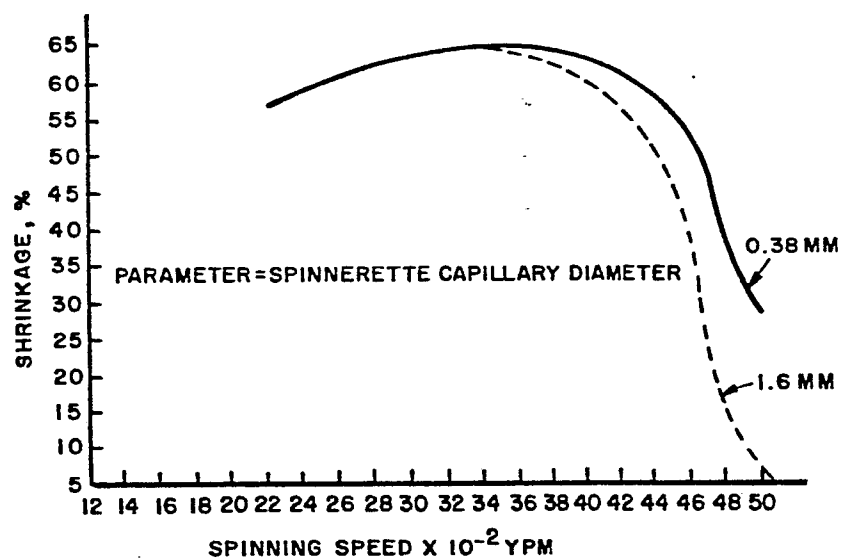


FIG. 3.



FIG. 4

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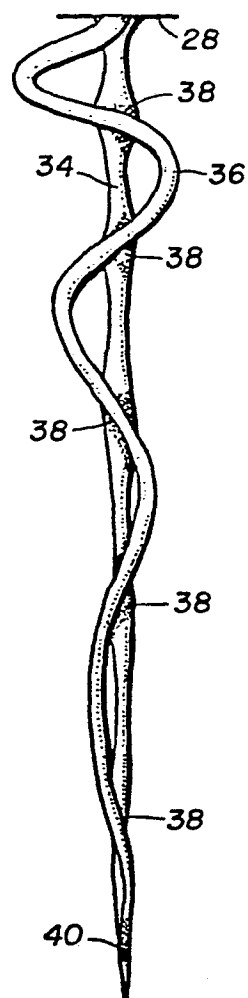


FIG. 5.

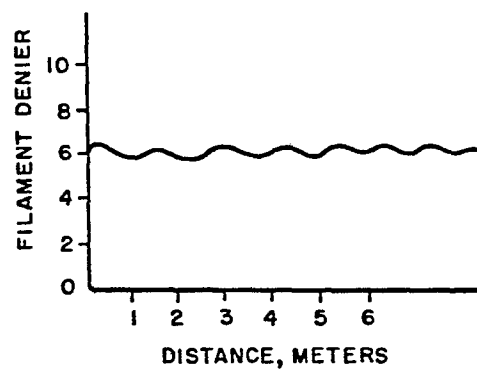


FIG. 6.

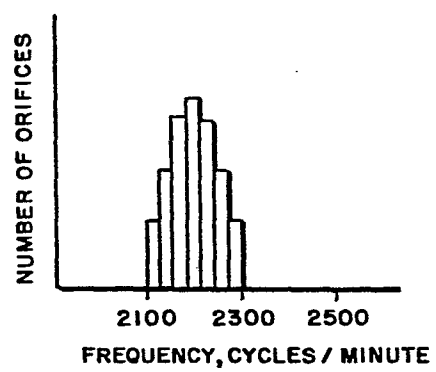


FIG. 7.



European Patent  
Office

# EUROPEAN SEARCH REPORT

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Application number

EP 79 301 790.6

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                            |                                                                               |                                  | CLASSIFICATION OF THE APPLICATION (Int. Cl.)                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category                                                                                       | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim                |                                                                                                                                                                                                                                                                            |
|                                                                                                | <u>GB - A - 1 103 728</u> (SNIA)<br>* fig. 7 *<br>--                          | 1                                | D 02 G 3/00                                                                                                                                                                                                                                                                |
|                                                                                                | <u>DE - A - 1 934 845</u> (ALLIED CHEMICAL CORP.)<br>* fig. 3 *<br>--         | 1                                |                                                                                                                                                                                                                                                                            |
|                                                                                                | <u>US - A - 3 497 585</u> (R.M. CHAPMAN et al.)<br>* fig. 1 *<br>--           | 1                                | TECHNICAL FIELDS SEARCHED (Int. Cl.)                                                                                                                                                                                                                                       |
|                                                                                                | <u>DE - B - 1 238 610</u> (HOECHST AG)<br>* claim *<br>--                     | 1                                | D 01 D 5/00<br>D 02 G 1/00<br>D 02 G 3/00                                                                                                                                                                                                                                  |
| A                                                                                              | <u>DE - A - 2 409 053</u> (IMPERIAL CHEMICAL INDUSTRIES LTD.)<br>--           |                                  |                                                                                                                                                                                                                                                                            |
| A                                                                                              | <u>DE - A1 - 2 539 272</u> (VYZKUMNY USTAV PLETARSKY)<br>--                   |                                  |                                                                                                                                                                                                                                                                            |
| A,D                                                                                            | <u>US - A - 3 444 681</u> (C.E. REESE)<br>----                                |                                  |                                                                                                                                                                                                                                                                            |
|                                                                                                |                                                                               |                                  | CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                                                                                |
|                                                                                                |                                                                               |                                  | X: particularly relevant<br>A: technological background<br>O: non-written disclosure<br>P: intermediate document<br>T: theory or principle underlying the invention<br>E: conflicting application<br>D: document cited in the application<br>L: citation for other reasons |
|                                                                                                |                                                                               |                                  | &: member of the same patent family, corresponding document                                                                                                                                                                                                                |
| <input checked="" type="checkbox"/> The present search report has been drawn up for all claims |                                                                               |                                  |                                                                                                                                                                                                                                                                            |
| Place of search                                                                                |                                                                               | Date of completion of the search | Examiner                                                                                                                                                                                                                                                                   |
| Berlin                                                                                         |                                                                               | 30-11-1979                       | KLITSCH                                                                                                                                                                                                                                                                    |