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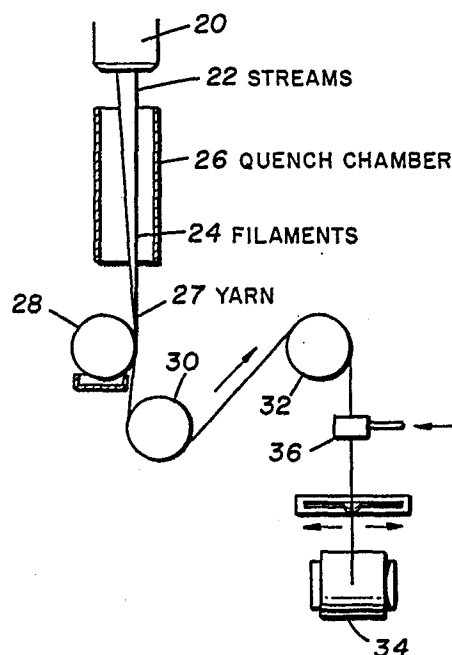
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Easily splittable self-texturing conjugate yarn.

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An easily splittable deep-dyeing conjugate filament is melt-spun by merging molten sub-streams of incompatible polymers outside the spinneret to form a combined stream, then quenching the combined stream to form the conjugate filament. The filament is preferably drawn prior to winding, increasing the crimp level and increasing the dye stability of the filament.



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EASILY SPLITTABLE SELF-TEXTURING CONJUGATE YARNSPECIFICATION

The invention relates to the art of melt-spinning splittable conjugate filaments. More particularly it relates to spinning filaments which are more readily splittable and which have improved dyeing properties.

It is known to spin splittable conjugate filaments by merging side-by-side a plurality of sub-streams of incompatible polymers into a combined or conjugated stream within the spinneret, the combined stream flowing along the spinneret capillary for several thousandths of an inch, e.g., 0.012 inch (0.305 mm.). The combined stream is then quenched to form a spun conjugate filament. The spun conjugate filament is then typically hot drawn or draw-textured. The resulting drawn conjugate filament can be vigorously treated with chemicals or mechanically worked, or both, so as to split the conjugate filament into sub-filaments, each of which is composed of one of the incompatible polymers. Typical references in this area are Tanner U. S. 3,181,224, Tanner U. S. 3,418,200, and Nishida U. S. 4,073,988. The required vigorousness of treatment of the filament (or of a fabric containing the filament) is disadvantageous because the hot drawing step reduces the dyeability of the filament, because of the added cost of the step of working the fabric, and because of possible damage to the fabric. If chemical treatment is involved, there is loss of fiber polymer in some cases and the added problem of disposal and handling of the chemicals involved so as to avoid environmental pollution.

According to the invention, these and other disadvantages in the prior art are avoided by a novel modification of the spinning process providing an

improved yarn with increased productivity and reduced manufacturing cost.

According to a first principal aspect of the invention, there is provided a process for melt-spinning
5 an easily splittable deep-dyeing conjugate filament from first and second incompatible polymers, the yarn being self-texturing in fabric form, comprising generating a first molten sub-stream of the first polymer and a second molten sub-stream of the second polymer
10 converging at substantially the same speed to merge side-by-side as a combined stream below the face of a spinneret, quenching the combined stream to form a conjugate filament comprising a first sub-filament of the first polymer lightly conjugated side-by-side with a
15 second sub-filament of the second polymer, withdrawing the filament from the combined stream at a predetermined spinning speed, and winding the filament at a given winding speed on a bobbin, the polymers and the spinning speed being selected such that the filament on the
20 bobbin splits substantially completely into the sub-filaments upon exposure to boiling water while under no tension. The first sub-stream is preferably a polyamide (preferably nylon 66) and the second sub-stream is preferably a polyester (preferably
25 poly(ethylene terephthalate)). The spinning speed is advantageously at least 2200 MPM and the filament shrinkage is preferably at least 10% (advantageously at least 20%). Preferably the filament is drawn prior to being wound on the bobbin. The winding speed and the
30 amount by which the filament is drawn are advantageously selected such that the filament wound on the bobbin has an elongation less than 70%, with best results being obtained when the winding speed and the amount by which the filament is drawn are selected such that the
35 filament wound on the bobbin has an elongation less than 50%.

According to a second principal aspect of the invention, there is provided a yarn package having wound thereon a substantially constant denier deep-dyeing conjugate filament comprising thermoplastic
5 sub-filaments temporarily adhering side-by-side along the length of the conjugate filament, the adhesion between the sub-filaments being sufficiently light that the conjugate filament splits substantially completely into the sub-filaments upon exposure to boiling water
10 while under no tension. One of the sub-filaments is preferably nylon 66 and the other of the sub-filaments is preferably poly(ethylene terephthalate). The filament preferably has a shrinkage greater than 10%, and advantageously the shrinkage is greater than 20%.
15 The filament preferably has an elongation less than 70%, and especially preferred is an elongation less than 50%.

According to a third principal aspect of the invention, there is provided a process for melt-spinning an easily splittable deep-dyeing conjugate filament from
20 first and second incompatible polymers, the yarn being self-texturing in fabric form, comprising generating a first molten sub-stream of the first polymer and a second molten sub-stream of the second polymer converging at substantially different speeds to merge
25 side-by-side as a combined stream below the face of a spinneret whereby an oscillation of the sub-streams occurs just below the face of the spinneret, quenching the combined stream to form a conjugate filament comprising a first sub-filament of the first polymer
30 lightly conjugated side-by-side with a second sub-filament of the second polymer, withdrawing the filament from the combined stream at a predetermined spinning speed, and winding the filament at a given winding speed on a bobbin, the polymers and the spinning
35 speed being selected such that the filament on the

bobbin splits substantially completely into the sub-filaments upon exposure to boiling water while under no tension. The first sub-stream is preferably a polyamide (preferably nylon 66) and the second
5 sub-stream is preferably a polyester (preferably poly(ethylene terephthalate)). The spinning speed is advantageously at least 2200 MPM and preferably the filament shrinkage is greater than 10% (advantageously greater than 20%). The filament is preferably drawn
10 prior to being wound on the bobbin. The winding speed and the amount by which the filament is drawn are advantageously selected such that the filament wound on the bobbin has an elongation less than 70%, with best results being obtained when the winding speed and the
15 amount by which the filament is drawn are selected such that the filament wound on the bobbin has an elongation less than 50%.

According to a fourth principal aspect of the invention, there is provided a yarn package having wound
20 thereon a substantially variable denier deep-dyeing conjugate filament comprising thermoplastic sub-filaments temporarily adhering side-by-side along the length of the conjugate filament, the adhesion between the sub-filaments being sufficiently light that the
25 conjugate filament splits substantially completely into the sub-filaments upon exposure to boiling water while under no tension. One of the sub-filaments is preferably nylon 66 and the other of the sub-filaments is preferably poly(ethylene terephthalate). The
30 filament preferably has a shrinkage greater than 10%, and advantageously the shrinkage is greater than 20%. The filament preferably has an elongation less than 70%, and especially preferred is an elongation less than 50%.

Other aspects will in part appear hereinafter
35 and will in part be obvious from the following detailed description taken together with the accompanying drawing, wherein:

FIGURE 1 is a vertical elevational schematic of a spinning apparatus usable according to the invention;

FIGURE 2 is a graph qualitatively showing how the shrinkage of PET and nylon 66 vary with spinning speed;

FIGURE 3 is a vertical sectional view of a spinneret showing a combined orifice according to certain aspects of the invention;

FIGURE 4 is a bottom plan view of the FIGURE 3 spinneret;

FIGURE 5 is a sectional view of a filament according to the invention;

FIGURE 6 is a schematic elevation view showing the oscillation of the molten streams just below the face of the spinneret; and

FIGURE 7 is a graph showing qualitatively the oscillation frequencies of a plurality of combined orifices in the same spinneret.

As shown in FIGURES 1, 3, 4, and 6, first and second polymers are conjugately melt spun as molten streams from spinneret 20. Molten streams 22 are quenched into filaments 24 by transverse quench air in quench chamber 26. The filaments are converged into yarn 27, with conventional spin finish applied at 28, the filaments being withdrawn from the molten streams at a spinning speed determined by unheated godet 30. The yarn next passes over unheated godet 32 prior to being wound onto a package by winder 34. Godet 32 preferably is driven at least slightly faster than godet 30, and it is particularly preferred that godet 32 be driven at a significantly higher speed so as to apply a draw to the filaments. The filaments may be entangled by conventional tangle chamber 36. While godets are preferred, godetless spinning is in accord with certain aspects of the invention, in which case the spinning speed will be determined by the winder. It is preferred that the godets be unheated if godets are used.

As shown in FIGURES 3 and 4, the preferred spinneret construction has counterbores 38 and 40 formed in the upper surface of spinneret 20. Capillary 42 extends from the bottom of counterbore 38 to bottom face 44 of spinneret 20, while capillary 46 extends from the bottom of counterbore 40 to face 44. Capillaries 42 and 46 are separated by land 48 on face 44, and their axes form an included angle so that the molten polymer streams metered therethrough converge to merge side-by-side below spinneret face 44 as a combined stream. The combined stream is conventionally quenched (as by transversely moving air) into a conjugate filament which is withdrawn from the combined stream at the predetermined spinning speed set by godet 30. The spinning speed is much higher than the speed of any of the molten sub-streams, so that the combined stream is attenuated substantially as it is being quenched. Since the pair of capillaries 42 and 46 cooperate to form a single combined stream, and ultimately a single filament, they are collectively referred to herein as a combined orifice.

EXAMPLE I

This is an example wherein the yarn has constant denier. A spinneret is provided containing 18 combined orifices, each combined orifice being as disclosed in this example. Thus the spinneret produces 18 conjugate filaments. Within each combined orifice, capillaries 42 and 46 have diameters of 0.009 inch (0.23 mm.) and are 0.1 inch long (2.54 mm.). The axis of each capillary is inclined 12° from the vertical, and thus the axes within a combined orifice form an included angle of 24° . Land 48 separating capillaries 42 and 46 on face 44 has a width of 0.017 inch (0.43 mm.).

While this paragraph for simplicity refers only to spinning of a single filament from a single

combined orifice, it will be understood that the same description applies to each of the other combined orifices in the spinneret. Molten nylon 66 polymer of normal molecular weight for apparel end use is metered and extruded as a first sub-stream through capillary 42, while molten poly(ethylene terephthalate) polymer of normal molecular weight for apparel end use is metered through capillary 46 to form a second sub-stream. The polymer melt temperatures are 285°C. The resulting combined stream is conventionally quenched into a conjugate filament by transversely directed air having an average speed of about 15-20 meters per minute, and the filament is withdrawn from the combined stream at a spinning speed of 3795 meters per minute (MPM). The polymer metering rates are selected such that equal volumes of polymer are extruded through capillaries 42 and 46 per unit of time, and such that the conjugate filament has a denier of 3.87. A conventional spin-finish is applied prior to winding at normal winding tension of about 0.1 gram per denier. The multi-filament conjugate yarn thus produced according to the invention comprises thermoplastic (nylon and polyester) sub-filaments temporarily adhering side-by-side along the length of the conjugate filaments. The adhesion between sub-filaments is sufficient that the filament (or a yarn comprising a plurality of such filaments) can be handled normally in such operations as texturing, knitting or weaving without difficulty, yet is sufficiently light or weak as to readily be overcome when the conjugate filament is exposed to boiling water, as in the normal scouring and dyeing operations employed in processing of fabrics. Under such conditions, the conjugate filament spontaneously and substantially completely splits into its constituent sub-filaments, thus avoiding the necessity for vigorously working the

fabric to achieve splitting as is necessary with prior art splittable conjugate filaments. Ordinarily no added step of working of the fabric is necessary with filaments and yarns according to the present invention.

5 The yarn is woven as filling across a conventional warp, then conventionally scoured and dyed at the boil. The filling filaments split substantially completely into their constituent sub-filaments spontaneously upon contact with the boiling water with
10 the PET sub-filaments shrinking most and forcing the nylon sub-filaments to protrude from the surface of the fabric in loops or arches. The fabric dyes more deeply than fabrics made from yarns which have been hot drawn.

15 A possible partial explanation for the unusual behavior of the yarns of the invention may be had with reference to FIGURE 2 of the drawing. As generally shown therein, the shrinkage of a 100% PET yarn falls rapidly from very high values of about 50-70% at intermediate spinning speeds to values below 10% over a
20 fairly narrow range of somewhat higher spinning speeds, while the shrinkage of nylon 66 does not exhibit such behavior. The exact spinning speed range in which polyester yarn exhibits the large change in shrinkage with spinning speed will vary with capillary diameter
25 (jet stretch). Yarns according to the invention may be made to be self-texturing in fabric form by selection of the spinning speed such that the PET sub-filament has substantially higher shrinkage than the nylon 66 sub-filament, as in the Example I yarn above. When such
30 yarns are put in fabric form, then subjected to the customary scouring and dyeing operations, the filaments split into their constituent sub-filaments, with the PET subfilaments then shrinking substantially more than the nylon subfilaments. This forces the nylon subfilaments
35 to the surface of the fabric in protruding arches or

loops, giving texture to the fabric. When the filaments have substantially constant denier as in Examples I and II herein, best self-texturing effects are obtained when the yarn on the bobbin has a shrinkage of at least 10%, preferably at least 20%.

Additional runs are made at different spinning speeds with the polymer metering rates adjusted to provide about 40 yarn denier, with results as follows.

TABLE 1

	Godet 30	Godet 32	Elongation,	Shrinkage,
<u>Item</u>	<u>MPM</u>	<u>MPM</u>	<u>%</u>	<u>%</u>
1	3700	3700	94	48
2	4000	4000	86	35
3	4250	4250	75	24
4	4500	4500	73	9

The resulting yarns are woven as filling across conventional warps, with the resulting fabrics conventionally scoured and dyed at the boil. The filaments split substantially completely into the sub-filaments and provide pleasing texture to the fabrics. However, the fabric from Item 4 has noticeably less texture than the fabrics from the other items.

Example II

A series of runs are made using the same spinneret and polymers. The polymer metering rates are reduced to produce about 40 yarn denier (about 2.2 denier per filament) while maintaining equal volumes of nylon and polyester. In each run, the actual winding speed is slightly lower than the speed of godet 32 in order to adjust the winding tension to about 0.1 gram per denier. Godet speeds and yarn properties are as set forth in Table 2.

TABLE 2

Item	Godet 32,	Godet 30,	Elongation,	Shrinkage,
	MPM	MPM	%	%
1	4000	3600	76	53
2	4000	3000	74	61
3	4500	3600	66	53
4	4500	3400	63	57
5	4500	3200	58	60
6	4500	3000	58	62
7	5000	3600	48	51
8	5000	3400	49	54
9	5000	3200	49	55
10	5000	3000	45	56

The yarns of Table 2 are superior to that of Example I above, particularly in terms of dye-fastness of the nylon component with respect to disperse dyes. A small amount of draw in conjunction with high speed spinning is highly desirable in this regard. Within the Table 2 yarns, items 5 and 6 are more desirable than items 1-4, while items 7-10 are still further improved.

Superior results are obtained when a small amount of in-line draw is applied as in this example. It is believed that the more viscous PET sub-stream bears most of the stress of the high speed spinning, preventing the nylon sub-stream from receiving sufficient stress for proper orientation of the molecules if the solidified filament is not drawn prior to winding. After the filament has solidified, however, a small amount of draw applied before winding orients the nylon enough for dye-fastness. It is further believed that if the spinning speed were sufficiently high that the yarn would have a shrinkage below 10% or so, a small amount of draw would increase the PET shrinkage while not greatly affecting that of the nylon, thus providing the large shrinkage difference between the nylon and polyester

components necessary for the self-texturing effect in fabric form.

EXAMPLE III

In contrast to the constant denier filaments produced in Examples I and II, a variable denier filament is readily produced by merging sub-streams extruded at substantially different speeds, producing an oscillation of the sub-streams just below the spinneret. This is preferably done by use of the FIGURES 3 and 4 type of combined orifice. The axes of capillaries 42 and 46 are each inclined 4° from the vertical. The axes thus form an included angle of 8° , and capillaries 42 and 46 are separated by land 48 on face 44. Capillary 42 has a diameter of 0.009 inch (0.23 mm.) and a length of 0.032 inch (0.81 mm.) while capillary 46 has a diameter of 0.016 inch (0.41 mm.) and a length of 0.146 inch (3.71 mm.). Land 48 has a width of 0.004 inch (0.1 mm.).

The same polymers are used as in Example I above, and the spinneret contains 18 combined orifice as described in the preceding paragraph. The polymer temperatures are each 282°C. , with the polyester being extruded through capillaries 42 and the nylon through capillaries 46. The metering rates are selected such that the polyester/nylon ratio is 60/40 by volume, and the resulting 18 filament yarn has a total denier of 41.1. The spinning speed is 3658 MPM and the molten streams are quenched and finished prior to winding, as in Example I.

The yarn is woven as filling across a conventional warp, then conventionally scoured and dyed at the boil. The filling filaments split substantially completely into their constituent sub-filaments spontaneously upon contact with the boiling water and provide fabric texture, as do the filaments in Example I above. Again, the polyester sub-filament has the higher

shrinkage, forcing the nylon sub-filaments to the surface of the yarn. Yarns according to this example give in fabric form various novelty effects not available with the Example I yarn. As with the Example II yarn above,
5 an in-line draw (prior to winding) is expected to increase the crimp level and improve the dye stability of the nylon sub-filaments to disperse dyes.

Yarn shrinkage is determined by the following method. The bobbin is conditioned at 21°C and 65%
10 relative humidity for one day prior to testing. 100 meters of surface yarn are stripped off and discarded. Using a Suter denier reel or equivalent, the yarn is wound to form a skein having about 18,000 skein denier. That is, the denier reel revolutions are 9000 divided by
15 the yarn denier. The skein yarn ends are tied together. The skein is suspended from a rod having a diameter of one centimeter and a 1000 gram weight is attached to the bottom of the skein. After 30 seconds, the skein length is measured to provide length L1. The 1000 gram weight
20 is then replaced by a 50 gram weight, whereupon the rod with skein and 50 gram weight are placed in a vigorously boiling water bath sufficiently deep that the skein is under tension from the 50 gram weight. After 10 minutes in the boiling water bath, the rod with skein and the 50
25 gram weight are removed from the bath and hung up for three minutes to permit excess water to drain off. The rod with skein and suspended 50 gram weight are then placed in a 120°C oven for 15 minutes, after which the rod with skein and suspended 50 gram weight are removed
30 from the oven and hung for 15 minutes at room temperature. The suspended 50 gram weight is then removed and replaced by a 1000 gram weight. After 30 seconds, the skein length is is measured to provide L2. The % shrinkage is defined as 100(L1 - L2) divided by L1.

By "incompatible polymers" is meant that the polymers are chemically dissimilar, as in the exemplified polyester and nylon.

5. The precise reason for the unexpected increased ease of splitting of the filaments of the invention as compared to prior art splittable filaments is unknown.

What is claimed is:

1. A process for melt-spinning an easily splittable deep-dyeing conjugate filament from first and second incompatible polymers, said filament being self-texturing in fabric form, comprising:

a. generating a first molten sub-stream of said first polymer and a second molten sub-stream of said second polymer converging at substantially the same speed to merge side-by-side as a combined stream below the face of a spinneret;

b. quenching said combined stream to form a conjugate filament comprising a first sub-filament of said first polymer lightly conjugated side-by-side with a second sub-filament of said second polymer;

c. withdrawing said filament from said combined stream at a predetermined spinning speed; and

d. winding said filament at a given winding speed on a bobbin;

e. said polymers and said spinning speed being selected such that said filament on said bobbin splits substantially completely into said sub-filaments upon exposure to boiling water while under no tension.

2. The process defined in claim 1, wherein said spinning speed is selected such that said filament has a shrinkage of at least 10%.

3. The process defined in claim 1, wherein said spinning speed is selected such that said filament has a shrinkage of at least 20%.

4. The process defined in claim 1, wherein said first sub-stream is a polyamide and said second sub-stream is a polyester.

5. The process defined in claim 4, wherein said first sub-stream is nylon 66 and said second sub-stream is poly(ethylene terephthalate).

6. The process defined in claim 5, wherein said spinning speed is at least 2200 MPM.

5 7. The process defined in claim 6, wherein said filament is drawn prior to being wound on said bobbin.

8. The process defined in claim 7, wherein the amount by which said filament is drawn is selected such
10 that said filament has a shrinkage greater than 10%.

9. The process defined in claim 7, wherein the amount by which said filament is drawn is selected such that said filament has a shrinkage greater than 20%.

10. The process defined in claim 7, wherein
15 said winding speed and the amount by which said filament is drawn are selected such that said filament wound on said bobbin has an elongation less than 70%.

11. The process defined in claim 7, wherein
20 said winding speed and the amount by which said filament is drawn are selected such that said filament wound on said bobbin has an elongation less than 50%.

12. A yarn package having wound thereon a substantially constant denier deep-dyeing conjugate filament comprising thermoplastic sub-filaments
25 temporarily adhering side-by-side along the length of said conjugate filament, the adhesion between said sub-filaments being sufficiently light that said conjugate filament splits substantially completely into said sub-filaments upon exposure to boiling water while
30 under no tension.

13. The package defined in claim 12, wherein one of said sub-filaments is nylon 66 and the other of said sub-filaments is poly(ethylene terephthalate).

14. The package defined in claim 13, wherein said filament has an elongation less than 70%.

15. The package defined in claim 13, wherein said filament has an elongation less than 50%

5 16. The package defined in claim 13, wherein said filament has a shrinkage greater than 10%.

17. The package defined in claim 13, wherein said filament has a shrinkage greater than 20%.

10 18. A process for melt-spinning an easily splittable conjugate deep-dyeing filament from first and second incompatible polymers, said filament being self-texturing in fabric form, comprising:

15 a. generating a first molten sub-stream of said first polymer and a second molten sub-stream of said second polymer converging at substantially different speeds to merge side-by-side as a combined stream below the face of a spinneret whereby an oscillation of said sub-streams occurs just below the face of said spinneret;

20 b. quenching said combined stream to form a conjugate filament comprising a first sub-filament of said first polymer lightly conjugated side-by-side with a second sub-filament of said second polymer;

25 c. withdrawing said filament from said combined stream at a predetermined spinning speed; and

30 d. winding said filament at a given winding speed on a bobbin;

35 e. said polymers and said spinning speed being selected such that said filament on said bobbin splits substantially completely into said sub-filaments upon exposure to boiling water while under no tension.

19. The process defined in claim 18, wherein said spinning speed is selected such that said filament has a shrinkage of at least 10%.

5 20. The process defined in claim 18, wherein said spinning speed is selected such that said filament has a shrinkage of at least 20%.

21. The process defined in claim 18, wherein said first sub-stream is a polyamide and said second sub-stream is a polyester.

10 22. The process defined in claim 21, wherein said first sub-stream is nylon 66 and said second sub-stream is poly(ethylene terephthalate).

23. The process defined in claim 22, wherein said spinning speed is at least 2200 MPM.

15 24. The process defined in claim 23, wherein said filament is drawn prior to being wound on said bobbin.

25. The process defined in claim 24, wherein the amount by which said filament is drawn is selected such that said filament has a shrinkage greater than 10%.

26. The process defined in claim 24, wherein the amount by which said filament is drawn is selected such that said filament has a shrinkage greater than 20%.

27. The process defined in claim 24, wherein said winding speed and the amount by which said filament is drawn are selected such that said filament wound on said bobbin has an elongation less than 70%.

28. The process defined in claim 24, wherein said winding speed and the amount by which said filament is drawn are selected such that said filament wound on said bobbin has an elongation less than 50%.

29. A yarn package having wound thereon a substantially variable denier deep-dyeing conjugate filament comprising thermoplastic sub-filaments temporarily adhering side-by-side along the length of said conjugate filament, the adhesion between said sub-filaments being sufficiently light that said conjugate filament splits substantially completely into said sub-filaments upon exposure to boiling water while under no tension.

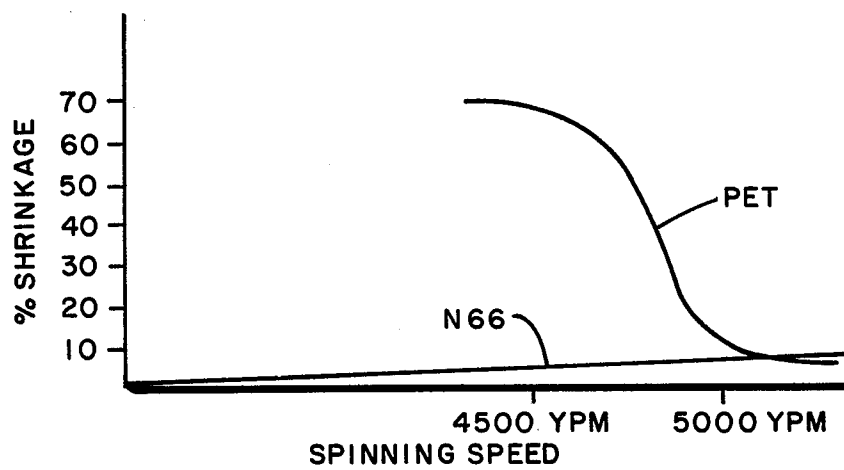
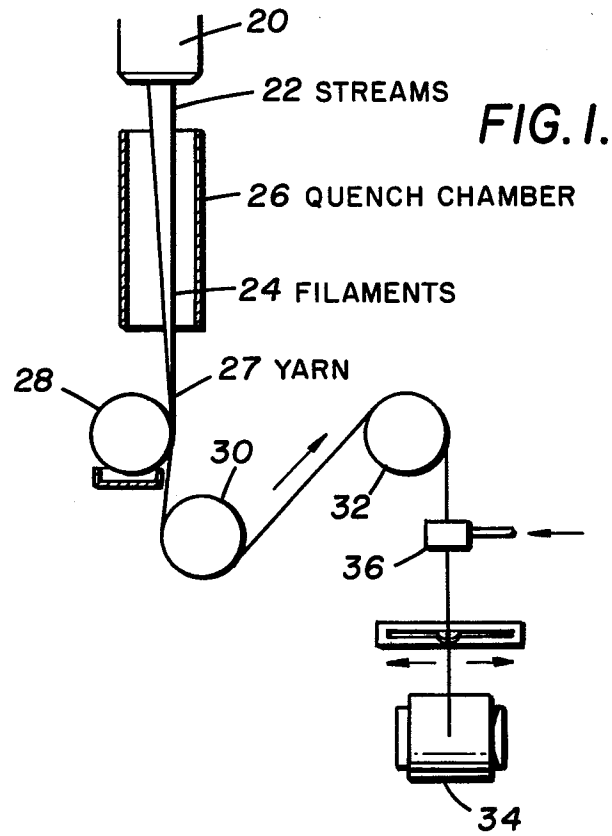
30. The package defined in claim 29, wherein one of said sub-filaments is nylon 66 and the other of said sub-filaments is poly(ethylene terephthalate).

31. The package defined in claim 30, wherein said filament has an elongation less than 70%.

32. The package defined in claim 30, wherein said filament has an elongation less than 50%

33. The package defined in claim 30, wherein said filament has a shrinkage greater than 10%.

34. The package defined in claim 30, wherein said filament has a shrinkage greater than 20%.



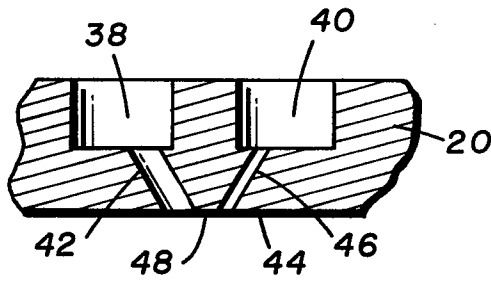


FIG. 3.

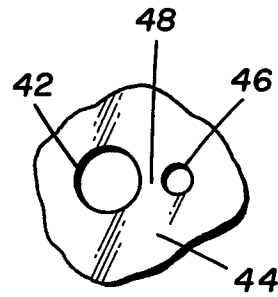


FIG. 4.

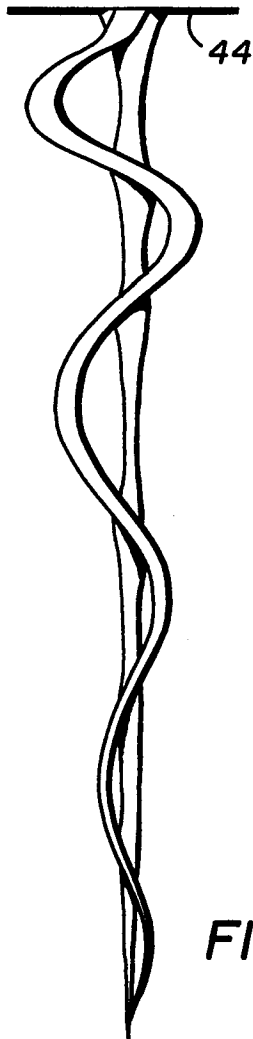


FIG. 6.

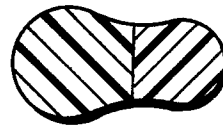


FIG. 5.

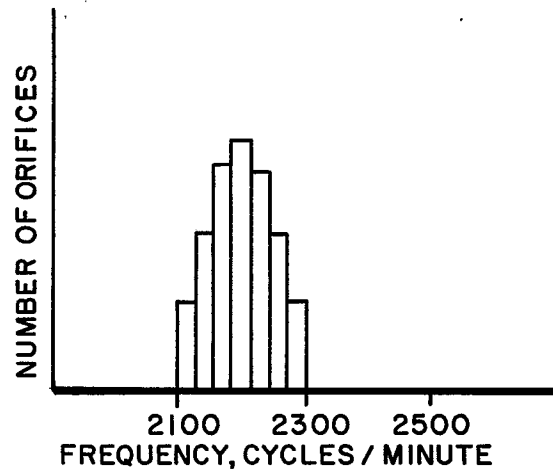


FIG. 7.