April 5, 1966 C. J. HOLLANDSWORTH, JR 3,244,785

PROCESS FOR PRODUCING A COMPOSITE SHEATH-CORE FILAMENT

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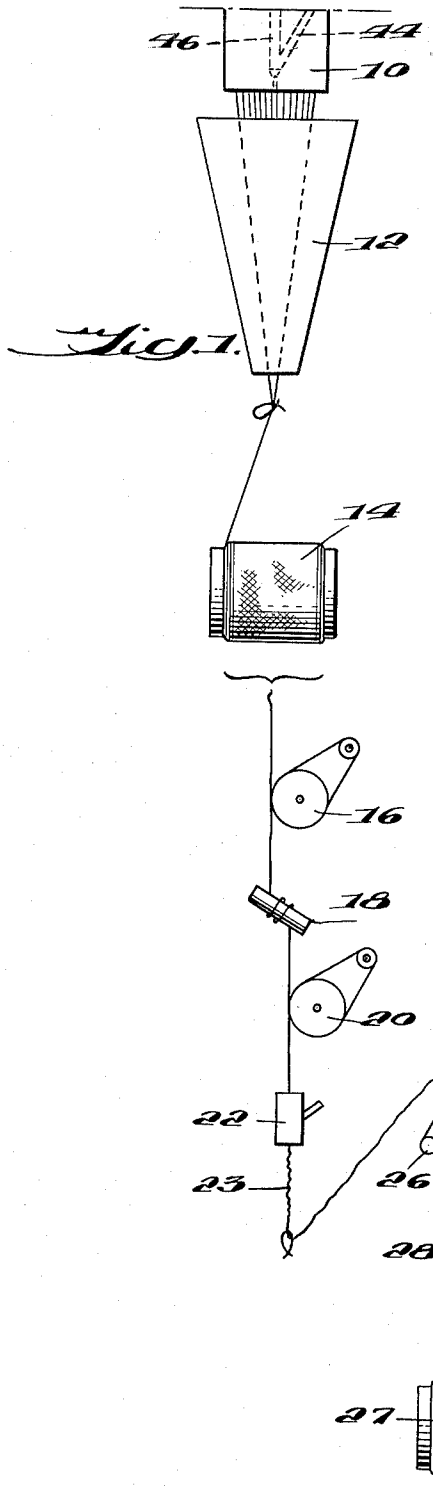

Fig. 1.

Fig. 3.

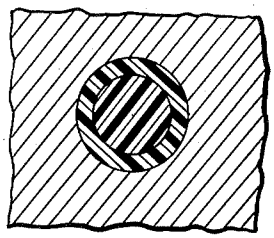

Fig. 4.

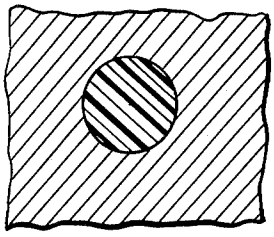

Fig. 5.

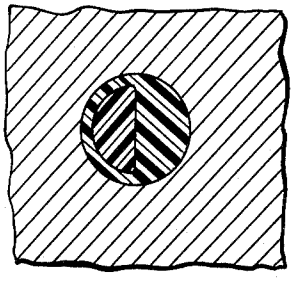

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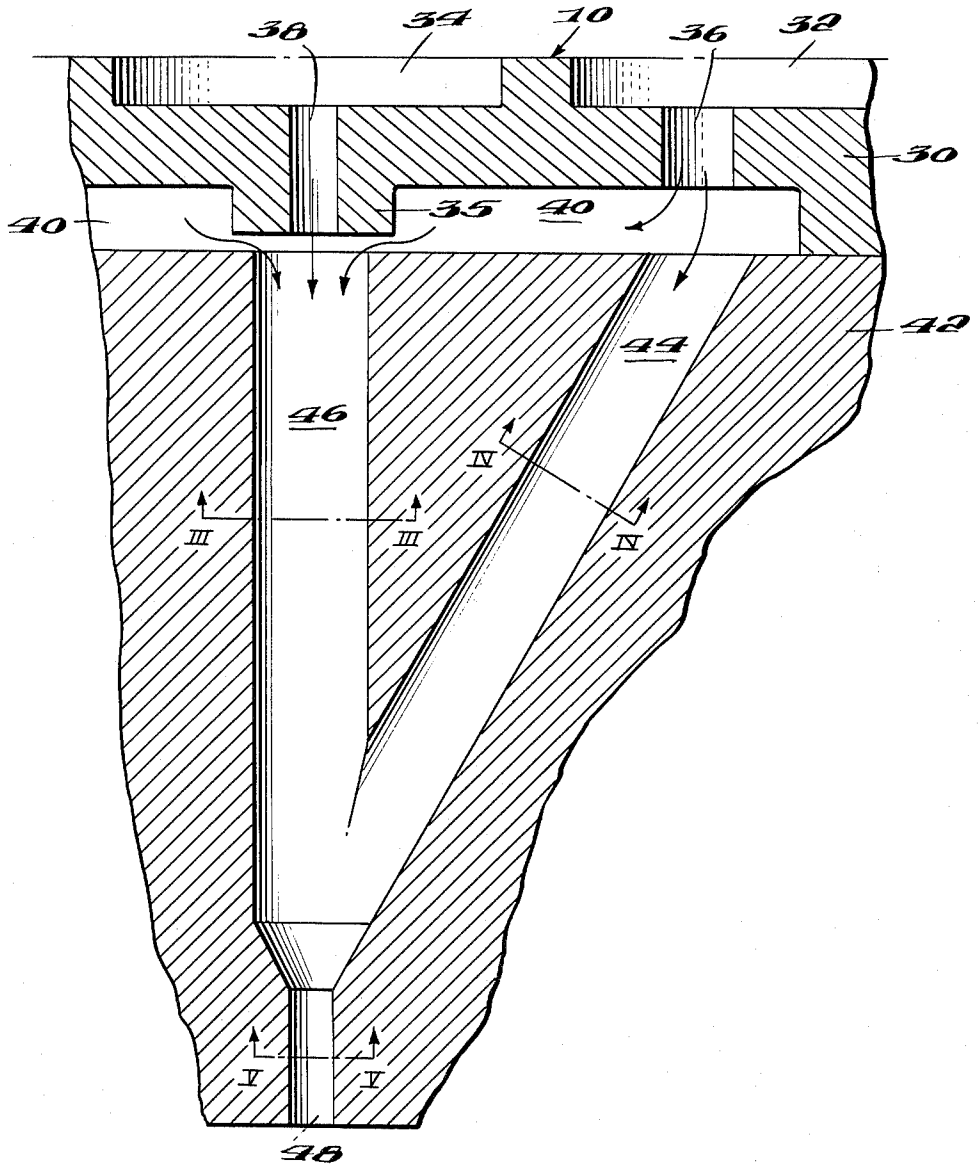
Fig. 2.



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PROCESS FOR PRODUCING A COMPOSITE SHEATH-CORE FILAMENT

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This invention relates to a process for the production of sheath-core composite filaments from synthetic polymers.

In the production of sheath-core filaments of the type disclosed by Breen in U.S. Patent No. 2,987,797, certain difficulties are encountered with known spinning processes. These difficulties are primarily associated with inaccurate and inconsistent control of the relative positions of the sheath and core. Manifestly, good control in these respects is necessary to the production of uniform filaments.

The most important object of this invention is to provide an improved process for the production of sheath-core filaments. More particularly, the objective is a process in which the position of the core within a filament can be accurately and consistently controlled.

The above objects are accomplished in a process involving the steps of preparing first and second viscous fiber-forming polymeric materials for spinning, discharging the first material under pressure into two separate flow passages in a spinneret, simultaneously discharging the second viscous material axially into one of said passages and spinning the materials from the two passages in side-by-side relationship, thus forming an eccentric sheath-core filament.

Other objectives and advantages will be apparent from the following descriptions and examples wherein reference is made to the accompanying drawing in which:

FIGURE 1 is a schematic illustration of equipment useful in carrying out the exemplified process;

FIG. 2 is a partial transverse sectional view through an operable embodiment of the spinneret pack shown schematically in FIG. 1;

FIGS. 3 and 4 are sectional views taken on lines III—III and IV—IV of FIG. 2, showing also the viscous flow in the respective passages; and

FIG. 5 is a similar but enlarged sectional view taken on line V—V of FIG. 2.

The various procedures described in the examples have been shown schematically in FIG. 1, including the formation of filaments in a spinneret **10** and their passage through a quenching chamber **12** to a package **14**. Subsequently, the filament bundle is withdrawn from the package and advanced over a feed roll **16**, in several wraps around a draw pin **18**, to a draw roll **20**, whence it passes under low tension through a crimping chamber **22** in which the filaments are crimped into helical form by exposure to a heated gaseous fluid. From chamber **22**, the crimped bundle is guided to snubbing pins **24**, **26** and delivered to a package **27** by rolls **28**, **29**.

Referring to FIG. 2, the spinneret pack chosen for purposes of illustration includes a filter block **30** having separate filtration cavities **32**, **34** from which different viscous polymeric materials are discharged through distribution passages **36**, **38**. The material from cavity **32** passes through a distribution space **40** between block **30** and a spinneret plate **42** and enters flow passages **44**, **46**, as indicated by arrows. The core material is discharged axially from distribution passage **38** into flow passage **46**, i.e., passages **38**, **46** are coaxial and the different polymeric materials flow through passage **46** in substantially concentric paths (FIG. 3). The width of a projection **35** relative to the diameter of passage **46** and its spacing from

plate **42** are important design considerations, the proper choice of which insures the concentric sheath-core distribution in passage **46**. At the juncture of passages **44**, **46**, the materials are combined in an essentially side-by-side relationship and extruded through a reduced spinning passage having an orifice **48**. Additional orifices are aligned longitudinally of spinneret **10** and are supplied by distribution passages corresponding to those shown at **36**, **38** from the two cavities **32**, **34**.

The different polymeric starting materials are, of course, selected in such a manner that the sheath and core components of the final filament exhibit different shrinkage characteristics when exposed to heat and/or swelling media whereby the desired crimped configuration is attained. Suitable polymeric starting materials may be selected from the various classes of polymers as will be discussed more fully hereinafter and as are well known in the art of producing two-component crimped or crimpable filaments.

Example I

An evaporator is charged with 370 gallons of an aqueous solution of hexamethylenediammonium sebacate (6–10 salt solution) containing 1,132 pounds of dry salt and 260 gal. of an aqueous solution of hexamethylenediammonium adipate (6–6 salt solution) containing 1,163 lbs. of dry salt and the resulting solution is heated at 13 p.s.i.g. until the temperature reaches 132° C., giving a salt concentration of approximately 75%. The solution is then transferred to an autoclave, heated to a temperature of about 205° C. and brought to a pressure of 250 p.s.i.g. At this point, sufficient 20% aqueous titanium dioxide slurry is added to give a concentration of 0.3% TiO_2 in the final polymer. The solution is then heated at 250 p.s.i.g. until the temperature reaches 225° C. The pressure is then reduced over a period of 80 minutes to atmospheric and the temperature is increased to 250° C. The polymer is then held, at atmospheric pressure, for 30 minutes at a temperature of 250–260° C., extruded under 90 p.s.i.g. nitrogen in the form of a ribbon, quenched on a water-cooled casting wheel and cut into 5/8-inch flake in the conventional manner. The copolymer, consisting of 50% polyhexamethylene adipamide and 50% polyhexamethylene sebacamide, has a relative viscosity of 45.

Polyhexamethylene adipamide (6–6 nylon) flake having relative viscosity of 46.5 is also prepared in the conventional manner. The two flakes (6–6 and 6–6/6–10) are fed separately to a dual screw melter where the flake is first conditioned by exposure to humidified nitrogen at 125° C. and then melted and pumped to a spinneret assembly of the type shown in FIGS. 1 and 2. The relative viscosity of the 6–6 flake after conditioning is 50 and that of the 6–6/6–10 copolymer flake is 55. The melt temperature of the 6–6 is 290° C. and that of the 6–6/6–10 is 282° C. The two polymers are then extruded, with the 6–6/6–10 copolymer as the core, from a spinneret which contains seven orifices arranged in a straight line. The clearance between the projection **35** on block **30** and spinneret plate **42** is 0.003 inch. The filaments are set by quenching, using a 60-inch chimney and an air temperature of 45° C., and wound into a package **14** at 461 y.p.m. The yarn is subsequently withdrawn from the package and drawn to a ratio of 4.29 over an unheated draw pin **18** situated between rolls **16**, **20** to give a final yarn denier of 45. The yarn is passed from the second draw roll through a tubular crimping chamber **22**, three inches in length, at 563 y.p.m. In the chamber, the yarn is heated by passing 0.5 cubic feet/minute of hot air at 30–38 p.s.i.g. through the chamber to give an air temperature of 201–208° C. at the exit. The yarn which is under low tension in the crimping chamber is crimped into helical form as indicated at **23** and then led over snubbing pins **24**, **26**

to remove the crimp by stretching the yarn slightly. The crimpable yarn is then wound into a package 27.

When transverse cross-sections of the yarn are prepared and examined microscopically, the cross-section is observed to be substantially as shown in FIG. 5. When this procedure is repeated on numerous samples, it is found that placement of the core within the sheath remains substantially constant. By comparison, sheath-core yarns made by prior art processes are found to vary considerably in this respect from sample to sample, the placement of the core within the sheath varying considerably, thus contributing to non-uniform crimping action when the yarn is crimped and therefore to uneven texture in knit fabrics.

When the yarn of this invention is exposed to hot water or steam it crimps in a very uniform fashion and the crimp diameter and crimp elongation are quite uniform. The crimp elongation at a load of 0.0012 g.p.d., determined as described in U.S. 2,987,797 (except that the yarn is crimped by exposure to steam at atmospheric pressure), is 13%. Then the yarn is knit into a welt fabric for use in women's semi-stretch hose with leg yarn from two component side-by-side 15 denier monofils wherein one component is 6–6 nylon and the other 6–6/6–10 copolymer. The fabric has a very uniform texture and performs well.

Example II

Yarn is prepared as in Example I except that the clearance between projection 35 and plate 42 is 0.005 inch and the air temperature in the crimping chamber is increased to give a temperature of 219° C. at the exit. Microscopic examination of cross-sections of this yarn shows it to be similar to that of Example I except that the sheath surrounding that half of the filament containing most of the core is slightly thicker. The crimp elongation, measured as in Example I, is 10.5%. When this yarn is knit into welt fabric for women's miniature stretch hose, the fabric has a very uniform texture and performs well when used with bicomponent leg yarn of the same 6–6 and 6–6/6–10 components.

The process of this invention permits accurate control of the thickness of the sheath in an eccentric sheath-core filament, thus insuring a uniformly crimped fiber and consequently the necessary uniformity in fabrics. While some success has been achieved by prior art processes employing asymmetric flow of the sheath and core materials into a capillary, the results have not been satisfactory for commercial production. The present process overcomes these difficulties in a simple and effective manner.

In carrying out the process disclosed herein, it is necessary that close tolerances be maintained on the various parts of the apparatus in order that filament-to-filament uniformity be achieved. In particular, passages 38, 46 must be concentrically aligned and the space between projection 35 and plate 42 as well as the dimensions of passages 36, 38, 44, 46 must be interrelated. Furthermore, these interrelationships must be correlated with the viscosities of the two polymers employed in order to insure a proper and uniform sheath-core distribution.

While the process of this invention is preferably used in the production of sheath-core filaments having kidney-shaped cores of the type disclosed by Breen and shown herein in FIG. 5, it may also be used to advantage for producing other types of sheath-core filaments since accurate and uniform placement of the core is an important factor, regardless of the shape or position of the core.

The process of this invention may be used in the production of sheath-core filaments containing components selected from various groups of synthetic fiber-forming polymeric materials. Because of their commercial availability, ease of processing, and excellent properties, the condensation polymers and copolymers, e.g., polyamides, polysulfonamides and polyesters, and particularly those that can be readily melt spun, are especially suitable for use in the production of sheath-core structures. Suitable polymer can be found, for instance, among the fiber-forming polyamides and polyesters described in U.S. Patents Nos. 2,071,250, 2,071,253, 2,130,523, 2,130,948, 2,190,770, 2,465,319 and elsewhere. The preferred group of polyamides comprises polyhexamethylene adipamide, polyhexamethylene sebacamide and copolymers thereof. The vinyl addition polymers may also be used to advantage in the process of this invention. For instance, suitable components may be selected from known polyacrylonitriles and interpolymers of the type described in U.S. Patent No. 3,039,524. Other suitable vinyl addition polymers include polyethylene, polypropylene, and polyvinyl chloride. Polyurethanes and polyureas may also be used. The process may also be used to advantage in the spinning of filaments from viscose or cellulose acetate solutions.

Depending on the polymeric materials employed, composite filaments may be melt spun and set by quenching, as exemplified, or the materials may be dissolved in a suitable solvent and wet spun or dry spun. Where the term "set" or "setting" is used herein, it is meant to indicate the hardening or solidification which is induced immediately after extrusion, e.g., by quenching, cooling or solvent evaporation. The choice of polymeric materials and similar variations and modifications of the exemplified procedures may be accomplished without departing from the spirit of the present invention which is accordingly intended to be limited only by the scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In the production of composite filaments having a core disposed eccentrically within a sheath, the steps of:
   - discharging a first viscous fiber-forming polymeric material under pressure into two separate flow passages in a spinneret;
   - discharging a second viscous fiber-forming polymeric material into one of said passages, axially thereof, as a core; and
   - spinning the materials flowing through said passages in side-by-side relationship, thus forming one of said composite filaments.

2. In the production of crimpable composite filaments having differentially shrinkable components, the steps of:
   - discharging a first viscous fiber-forming polymeric material under pressure into two separate capillary passages in a spinneret;
   - discharging a second viscous fiber-forming polymeric material into one of said passages, axially thereof, as a concentric core; and
   - spinning the materials flowing through said passages in side-by-side relationship, thus forming an eccentric sheath-core filament.

3. In the production of crimpable composite filaments having differentially shrinkable components, the steps of:
   - discharging a first molten polymer under pressure into two separate flow passages in a spinneret;
   - discharging a second molten polymer into one of said passages, axially thereof, as a concentric core; and
   - melt-spinning the polymers flowing through said passages in side-by-side relationship, thus forming an eccentric sheath-core filament.

4. In the production of crimpable composite filaments, the steps of:
   - discharging a molten polyamide under pressure into two separate capillary passages in a spinneret;
   - discharging a molten copolyamide into one of said passages, centrally thereof, as a core within the polyamide flowing therethrough;
   - combining the flow from said passages; and
   - melt-spinning a filament therefrom, said filament having said copolyamide core disposed eccentrically within a polyamide sheath.

5. The process of claim 4 wherein said polyamide is polyhexamethylene adipamide and said copolyamide is polyhexamethylene adipamide/sebacamide.

References Cited by the Examiner

UNITED STATES PATENTS

2,443,711	6/1948	Sisson	264—171
2,987,797	6/1961	Breen	264—171
3,007,205	11/1961	House	264—171
3,014,237	12/1961	Breen	18—8
3,017,686	1/1962	Breen et al.	18—54 XR
3,038,237	6/1962	Taylor	18—54 XR
3,081,490	3/1963	Heynen et al.	18—8
3,117,362	1/1964	Breen	264—171
3,117,906	1/1964	Tanner	264—171

FOREIGN PATENTS

1,102,339	3/1961	Germany.

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