

Aug. 20, 1968

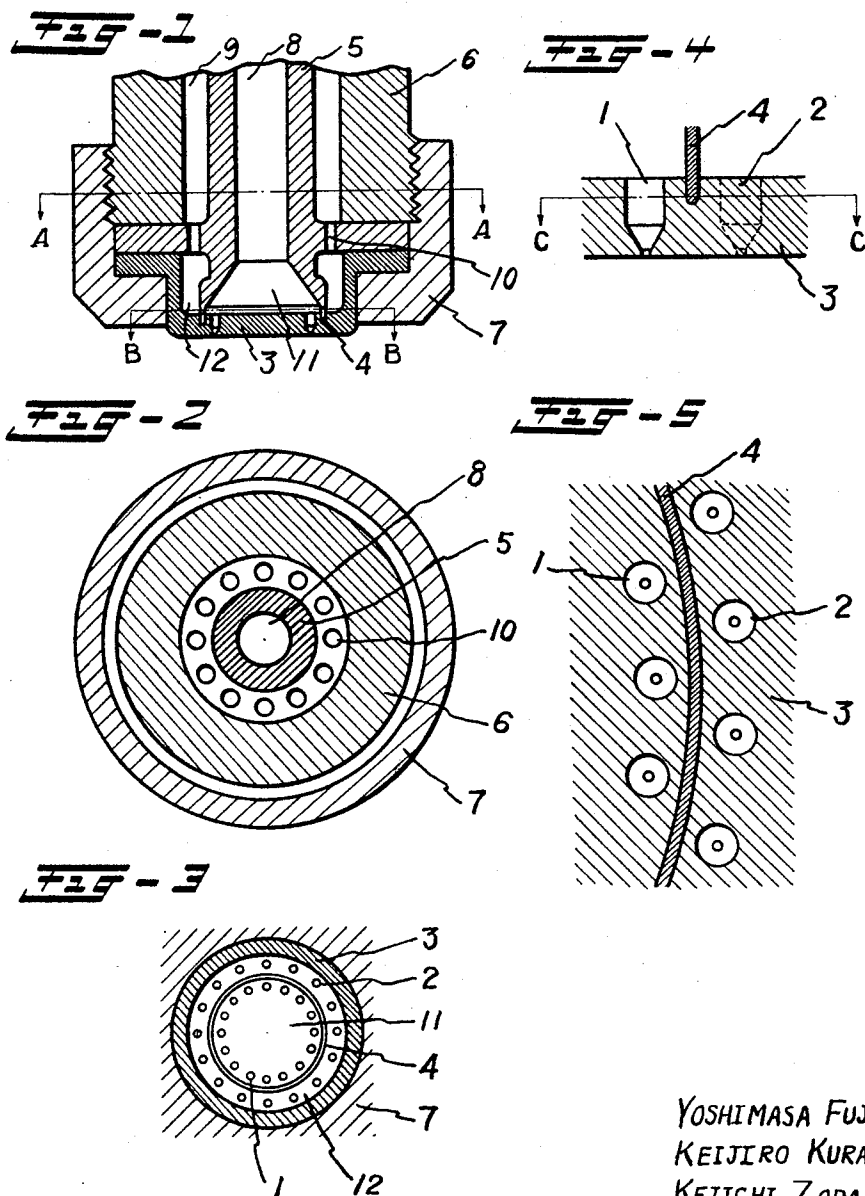
YOSHIMASA FUJITA ET AL

3,397,426

APPARATUS FOR PRODUCING BULKY YARN AND ITS FABRICS

Filed Oct. 2, 1963

2 Sheets-Sheet 1



YOSHIMASA FUJITA,
KEIJIRO KURATANI, AND
KEIICHI ZODA

Inventors

By *Wendert, Lind
and Porack*
Attorneys

Aug. 20, 1968

YOSHIMASA FUJITA ET AL

3,397,426

APPARATUS FOR PRODUCING BULKY YARN AND ITS FABRICS

Filed Oct. 2, 1963

2 Sheets-Sheet 2

FIG-6

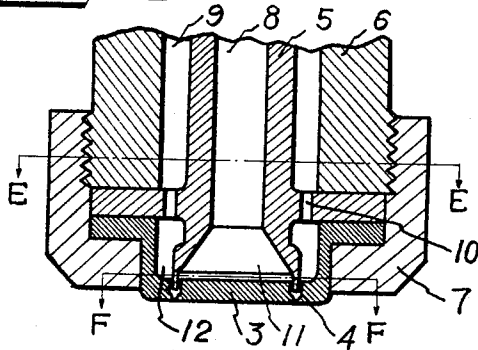


FIG-9

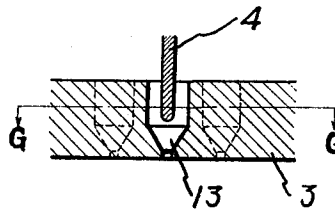


FIG-7

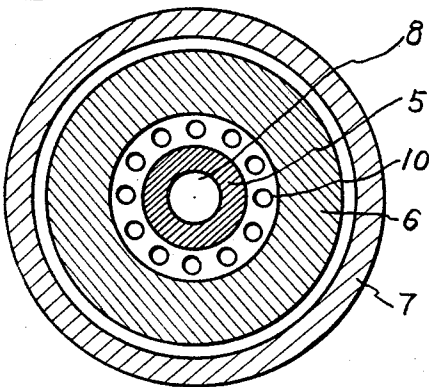


FIG-10

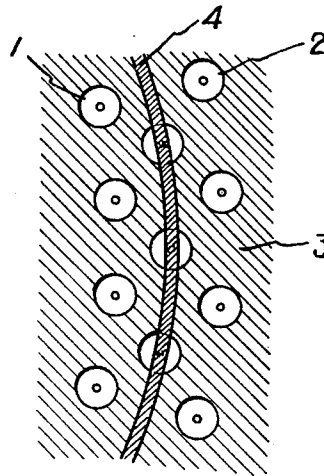
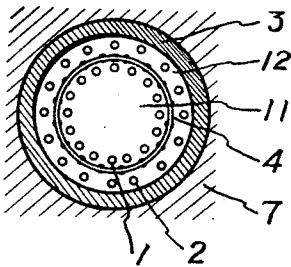


FIG-8



YOSHIMASA FUJITA,
KEIJIRO KURATANI, AND
KEIICHI ZODA

Inventors

By *Wendert, Lind
& Pnack*
Attorneys

1

3,397,426

APPARATUS FOR PRODUCING BULKY YARN AND ITS FABRICS

Yoshimasa Fujita, Keijiro Kuratani, and Keiichi Zoda,
Saidaiji, Japan, assignors to Japan Exlan Company
Limited, Osaka, Japan

Filed Oct. 2, 1963, Ser. No. 313,269

Claims priority, application Japan, Oct. 6, 1962,
37/43,877

1 Claim. (Cl. 18—8)

ABSTRACT OF THE DISCLOSURE

Apparatus is provided for producing filament yarn. In forming the yarn of synthetic fibers a plurality of different fiber-forming polymers are extruded through a plurality of groups of orifices in a common spinneret to form a tow containing a plurality of fibers of different fiber-forming polymers. In one aspect apparatus is provided for producing a tow containing fibers of a first polymer, fibers of a second polymer and bi-component conjugate polymers composed of the first and second fiber-forming polymers.

This invention relates to apparatus for producing bulky filament yarns of polymers.

At present, the conventional method for making a bulky yarn of synthetic fibers such as synthetic acrylic fibers, involves the blending together two types of fibers having different properties from each other; (a) a first type of fiber which exhibits high shrinkage upon the application of heat and (b) a second type of fiber which exhibits low shrinkage upon the application of heat. The yarns or fabrics made from such a blend of fibers spun together are heat-treated so as to permit the high-shrinkage fibers to shrink. Another known method comprises imparting bulkiness to filament yarns by passing the yarns through a high-velocity air jet stream so that irregular slackness and loops are formed in the filament yarns.

It is an object of the present invention to provide novel bulky yarn which is composed of continuous filaments of polymers (e.g. acrylic polymers) and which has both a good "bulk" and those advantages associated with filament yarn and also with textile spun yarn.

It is another object of this invention to provide a novel and simple apparatus for producing such a filament yarn.

Briefly, according to the invention, a plurality of different fiber-forming polymers which, when shaped into filaments, have a difference in thermal shrinkage are concurrently extruded through a plurality of orifices in a single spinnerette to form continuous filaments of a plurality of groups different in the components, and the filaments are subsequently heat treated to develop bulkiness in the composite filament yarn.

According to the present invention the above method is conveniently carried out by using a spinning device with a spinnerette having a plurality of orifices which is isolated into a plurality of groups so that the different polymers are extruded through the respective groups of orifices.

The invention will best be understood from the following detailed description made by referring to the accompanying drawings in which:

FIG. 1 is a longitudinal cross-section of a device suitable for carrying out the method of this invention;

FIGS. 2 and 3 are cross-sections of the same device taken along lines A—A and B—B respectively of FIG. 1;

FIG. 4 is a partial cross-section, on an enlarged scale, of a spinnerette of the same device;

FIG. 5 is a cross-section taken on the line C—C of FIG. 4;

2

FIG. 6 is a view similar to FIG. 1 but showing another device of this invention;

FIG. 7 and FIG. 8 are cross-sections taken along lines E—E and F—F, respectively, of FIG. 6;

FIG. 9 is a partial cross-section, on an enlarged scale, of a spinnerette of the device of FIG. 6; and

FIG. 10 is a cross-section taken on the line G—G of FIG. 9.

Referring to the drawings and, more particularly, to FIGS. 1–5, there is illustrated a spinning device for producing bulky filament yarn according to this invention generally comprising a spinnerette 3 having a number of orifices 1, 2. In the device shown the orifices are divided into two rows, inner row 1 and outer row 2, disposed in concentric relation. Within a supply tube 6 is arranged a cylindrical sleeve 5 whose lower edge 4 is fitted into a groove formed in the back face of the spinnerette 3 and disposed between the inner orifice row 1 and the outer orifice row 2 as well shown. The spinnerette 3 and the cylindrical sleeve 5 are suitably assembled and supported on the end of the supply tube 6 by means of a nut 7. When assembled, there is formed an annular space 9 between the supply tube 4 and the cylinder sleeve 5. A different spinning solution or molten polymer is introduced into each of the spaces 8 and 9 from separate supply sources. The first spinning fluid flows from the space 8 down into a chamber 11 and toward orifices 1. The second spinning fluid flows from the space 9 down into an annular chamber 12 through a plurality of openings 10 and toward the orifices 2. It will be understood that different filaments are concurrently extruded through the inner orifices 1 and the outer orifices respectively so that continuous tow or filament yarn composed of the two different kinds of filaments is obtained.

Referring next to FIGS. 6 through 10, there is illustrated another embodiment of the device of this invention which is different from that shown in FIGS. 1–5 only in that the orifices are divided into three rows 1, 13 and 2 arranged concentrically and that the lower edge 4 of the cylindrical sleeve 5 is fitted into a circular groove formed in the back face of the spinnerette 3 and along and across the orifices 13 of the intermediate row. The arrangement of the separating edge 4 is such that it extends into each orifice 13 while isolating the inner orifices 1 and outer orifices 2. A different spinning solution or molten polymer is introduced into each of the spaces 8 and 9 isolated by the cylinder 5 from separate supply sources. The first spinning fluid is extruded from the chamber 11 through the inner orifices 1 while the second spinning fluid is extruded from the annular chamber 12 through the outer orifices 2. It will be understood in this case that portions of these two fluids are also extruded concurrently through the orifices 13 of the intermediate row as bi-component streams of viscous fluid to form bi-component or so-called conjugated filaments. Thus, by the device of FIGS. 6–10, there is obtained a continuous tow or filament yarn composed of three different kinds of filaments.

It will be understood that the number of orifices and also the number of rows thereof in the spinnerette may be increased or decreased depending upon the desired fineness of the final filament yarn and the desired proportion of dissimilar filaments composing the yarn. While the arrangement of orifices may be varied and thus the orifices may be disposed in a plurality of straight rows, the concentric arrangement as shown in the drawings is preferred in view of the structural consideration to facilitate the supply of different spinning solutions and the isolation of the spinning solutions and orifices. Furthermore, it will be understood that, if desired, the orifices may be divided or isolated into three or more groups and the spinning

device may correspondingly be modified so that three or more different spinning solutions may be concurrently extruded through the respective groups of orifices.

Thus, by selecting a suitable construction or arrangement of the spinning device, a wide variety of filaments composed of different components in different combinations can be extruded concurrently.

The components which constitute the filaments of the invention may be selected from various synthetic fiber-forming high polymers provided that the selected ones can be extruded into filaments under similar spinning conditions and that they, when shaped into filaments, exhibit different thermal shrinking properties.

Thus, the components which make up the filaments may be selected, for example, from polycondensates such as polyesters, polyamides, etc., polymers of ethylenically unsaturated monomers such as acrylonitrile, vinyl chloride, vinylidene chloride, vinyl acetate; copolymers and graft-copolymers thereof. Among them acrylonitrile polymers and copolymers containing at least about 80% by weight of acrylonitrile are preferred because the difference in thermal shrinkage of the components may be readily controlled by copolymerizing acrylonitrile with one or more of suitable monomers copolymerizable therewith or by incorporating into acrylonitrile polymer or copolymer one or more additional ingredients in the form of graft-copolymers or polymer mixtures.

Representative compounds which may be copolymerized with acrylonitrile or whose polymers may be blended with acrylic polymers to control the thermal shrinkage of the resulting polymeric material useful for the practice of this invention are, for instance, the vinyl esters of saturated aliphatic monocarboxylic acids, e.g. vinyl acetate, vinyl propionate, vinyl butyrate, etc., the esters of unsaturated carboxylic acids, e.g. methyl, ethyl, propyl, butyl, etc. acrylates and methacrylates, etc., and other ethylenically unsaturated monomers.

It is further possible to incorporate into the polymer other compounds which are useful in improving the dyeability of the filaments. Examples of such compounds are basic nitrogen-containing heterocyclic compounds such as vinylpyridines, methyl vinylpyridines, vinylpyrrolidones, etc., ethylenically unsaturated sulfonic acids such as vinyl-sulfonic acid, allylsulfonic acid, methallylsulfonic acid, styrenesulfonic acid, etc., and ethylenically unsaturated carboxylic acids such as acrylic acid, itaconic acid, methacrylic acid, etc.

These additional ingredients for controlling the thermal shrinkage and improving the dyeability of filaments may be incorporated as copolymers or graft-copolymers with acrylonitrile, or as polymers mixed with acrylonitrile polymers.

It is important in carrying out the invention to suitably select a difference in thermal shrinkage between the different filaments. The difference in the thermal shrinkage can be controlled as desired by suitably selecting the filament components and by varying the temperature at which the subsequent heat treatment of the filaments is carried out. The difference in thermal shrinkage and hence the extent of bulkiness of a filament yarn may be varied depending upon the particular use of the yarn. Generally, a practically satisfactory bulkiness is obtained when there is a difference in thermal shrinkage of more than 10%. Generally speaking, the rates of shrinkage increase with increase in the proportion of other vinyl compounds copolymerized with acrylonitrile. Additionally, the amount of shrinkage increases with increase in temperature at which the filament yarn is heat treated.

In carrying out the method of this invention, any type of spinning process, i.e. wet spinning process, dry spinning process, melt spinning process, may be employed. In order to minimize the variation in the denier of the different filaments making up a filament yarn, it is preferable that the dissimilar spinning fluids are not substantially different from each other in viscosity.

After extruded from the orifice the filaments may be treated in the usual manner including stretching for molecular orientation, and then twisted to form a filament yarn. When the filament yarn or its product (fabrics, articles of clothing, etc.) is subsequently heat treated under a relaxed condition there is developed a bulk therein due to the difference in thermal shrinkage between the different filaments composing the yarn. If desired, the filaments may be cut into staple, which may be spun into yarn prior to the final heat-treatment.

Thus, for example, in case of wet spinning wherein different acrylic polymers are dissolved separately in a concentrated (e.g. 40-55% by weight) inorganic salt (e.g. zinc chloride, sodium thiocyanate, calcium thiocyanate, etc.) aqueous solution and the respective spinning solutions are concurrently extruded through the respective isolated groups of orifices into a common coagulating bath of an aqueous type which may be water or may be consisted of a dilute (e.g. less than 35%, preferably 6-15% by weight) aqueous solution of such inorganic salt as mentioned before. Usually the coagulating bath is maintained at a temperature between -5°C . to 10°C .

The coagulated filaments are then washed with water at room or lower temperature, and stretched to effect the molecular orientation. This stretching operation may be carried out in a well known conventional manner. Thus for example, the filaments are stretched about 6 to 16 times the original length in a hot water higher than 80°C . If desired it is also possible to carry out the so-called two step stretching operation wherein the filaments are preliminarily stretched 1.5 to 4 times the original length at a temperature from -2°C . to 40°C . and are further stretched 3-15 times the length in hot water or steam at a temperature from 70°C . to 100°C .

The filaments are then dried. It is preferable to carry out this drying operation in a drying atmosphere under specific conditions of temperature and humidity falling within a particular area fully described in T. H. Robertson et al. U.S. Patent No. 2,984,912 dated May 23, 1961. When dried under such condition, the structure of the filaments is collapsed or the filaments are non-structured and densified.

The preparation of acrylic polymer spinning solution, spinning thereof in an aqueous coagulating bath, stretching the filaments for molecular orientation and the subsequent drying are known per se and do not constitute a distinctive feature of the present invention so that any further detailed explanation thereabout will be unnecessary.

Then the filaments are twisted into a filament yarn. If desired this twisting may be carried out after the stretching out before the drying mentioned above. When the final yarn or its fabric is heat treated in a relaxed state at an elevated temperature (e.g. 105°C . to 160°C .) there is developed a bulk due to the difference in thermal shrinkage between the different filaments making up the yarn. If desired the final filaments after drying may be processed in a conventional manner well known in the art to prepare materials for bulky yarns. Thus, for example, the filaments may be cut into desired staple length and the staple fibers blended with or without other fibers are spun into yarns. The yarns or their products may be subjected to a heat-treatment in a relaxed state to develop bulkiness.

The following example illustrate some embodiments of the invention, but the invention is not limited by these examples. All parts and percentages (except those for thermal shrinkage) are by weight. The viscosity $[\eta]$ was measured with dimethyl formamide solution.

Example 1

Ten parts of a copolymer ($[\eta]=0.21$) of 89.3% acrylonitrile and 10.7% vinyl acetate were dissolved in 90 parts of a 48% aqueous solution of sodium thiocyanate to prepare a spinning solution (referred to as A). Another spinning solution (referred to as B) was prepared by dissolv-

ing 10 parts of a copolymer ($[\eta]=0.21$) of 93.1% acrylonitrile and 6.9% vinyl acetate in 90 parts of a 48% aqueous solution of sodium thiocyanate.

These two different spinning solutions were concurrently extruded into a common coagulating bath of an 8% aqueous solution of sodium thiocyanate at 0° C. by means of a spinning apparatus similar to the one shown in FIG. 1 which is furnished with two metering pumps. The spinnerette had 20 orifices (each 0.09 mm. in diameter) arranged in two concentric circular rows. The spinning solution (A) was extruded through the orifices in the outer row while the spinning solution (B) was extruded through the orifices in the inner row.

The coagulated gel filaments thus obtained were washed with water and stretched 8 times the length in boiling water. The filaments were then given Z twists of 50_T per meter and wound into a skein. The skein was dried in a hot humid atmosphere at a dry bulb temperature of 105° C. and a wet bulb temperature of 70° C. until the moisture content of the skein is reduced to 3%. The skein was then heat-treated in a relaxed state for 4 minutes in saturated water vapour of a temperature from 105° C. to 130° C. The relation of the difference in thermal shrinkage between the two filaments and the heat-treatment temperature was as follows:

Temperature of heat treatment, ° C.:	Difference in shrinkage between two filaments (A) and (B), percent
105	6.0
115	8.0
125	18.2
130	29.0

As is apparent from the above table, the filament yarn showed excellent bulkiness when heat-treatment was made at a temperature of about 125° C. and higher.

Example 2

The spinning solution (A) of Example 1 and another spinning solution (referred to as (C)) prepared by dissolving 10 parts of a copolymer ($[\eta]=0.22$) of 89.8% acrylonitrile and 10.2% vinyl acetate in 90 parts of a 48% aqueous solution of sodium thiocyanate, were concurrently extruded into a coagulating bath and the filaments were treated in the same manner as described in Example 1. The relation between the heat-treatment temperature and the difference in thermal shrinkage between the filaments (A) and (C) composing the filament yarn was as follows:

Temperature of heat treatment, ° C.:	Difference in shrinkage between two filaments (A) and (C), percent
105	4.0
115	6.0
125	13.0
130	20.0

Example 3

Ten parts of a copolymer ($[\eta]=0.22$) of 93% acrylonitrile and 7% methacrylic acid were dissolved in 90 parts of a 50% aqueous solution of sodium thiocyanate to prepare a spinning solution (referred to as (D)). Another spinning solution (referred to as (E)) was prepared by dissolving 10 parts of a copolymer ($[\eta]=0.23$) of 91% acrylonitrile and 9% of methyl methacrylate in 90 parts of a 50% aqueous solution of sodium thiocyanate.

These two different spinning solutions were concurrently extruded into a common coagulating bath of an 8%

aqueous solution of sodium thiocyanate maintained at 0° C. by means of a spinning apparatus similar to that shown in FIG. 6 which is furnished with two metering pumps. The spinnerette had 20 orifices (each 0.1 mm. in diameter) disposed in three concentric circular rows. The spinning solution (D) was extruded through the orifices of the innermost row and the spinning solution (E) was extruded through the orifices of the outermost row, while through the orifices of the intermediate row were concurrently extruded the solution (D) and solution (E) so as to form bi-component conjugated filaments.

The extruded gel filaments were washed with water and stretched 8 times the length in boiling water. Then the filaments were dried in a hot humid atmosphere at a dry bulb temperature of 105° C. and a wet bulb temperature of 65° C. until the moisture content of the filaments is reduced to 2%. The filament yarn thus obtained was then heat-treated in a relaxed state for 10 minutes in saturated water vapour at a temperature of 125° C., and then dried at 80° C. The resulting filament yarn was a composite yarn composing of filaments of the component (D), filaments of the component (E) and bi-component filaments which are composed of both (D) and (E). The yarn had an excellent bulk which was resistant to various wet and heat-treatments including drying, finishing, etc.

What we claim is:

1. An apparatus for simultaneously producing a bundle of filaments consisting of

- (A) filaments composed of a first fiber-forming polymer;
- (B) filaments composed of a second fiber-forming polymer; and
- (C) bicomponent filaments composed of the first and second polymers,

which apparatus comprises a composite spinnerette having

- (1) at least three concentric circular rows of orifices consisting of at least one outer row, at least one middle row and at least one inner row;
- (2) a circular groove formed on said spinnerette and extending along and across the orifices of the middle row;
- (3) a circular separating plate the edge of which is tightly fitted into said groove and extends into and divides the orifices of the middle row and separates the inner orifices and outer orifices; and
- (4) means for feeding the first and second fiber-forming polymer solutions to the inner orifice row section and the outer orifice row section respectively;

said apparatus permitting the spinning of filaments of the first and second fiber-forming polymers respectively through the inner row orifices and outer row orifices while permitting the spinning of bicomponent conjugate filaments of the first and second polymers through the orifices of the middle row.

References Cited

UNITED STATES PATENTS

2,386,173	10/1945	Kulp et al.	18—8
2,398,729	9/1946	Taylor et al.	18—8
3,038,236	6/1962	Breen	264—117 X
3,092,892	6/1963	Rynn et al.	
3,176,344	4/1965	Opferkuch	18—8
3,182,106	5/1965	Fujita et al.	64—168 X

JAMES A. SEIDLECK, *Primary Examiner.*

J. H. WOO, *Assistant Examiner.*