

June 15, 1965

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3,188,689

SPINNERET ASSEMBLY

Original Filed May 27, 1958

2 Sheets-Sheet 1

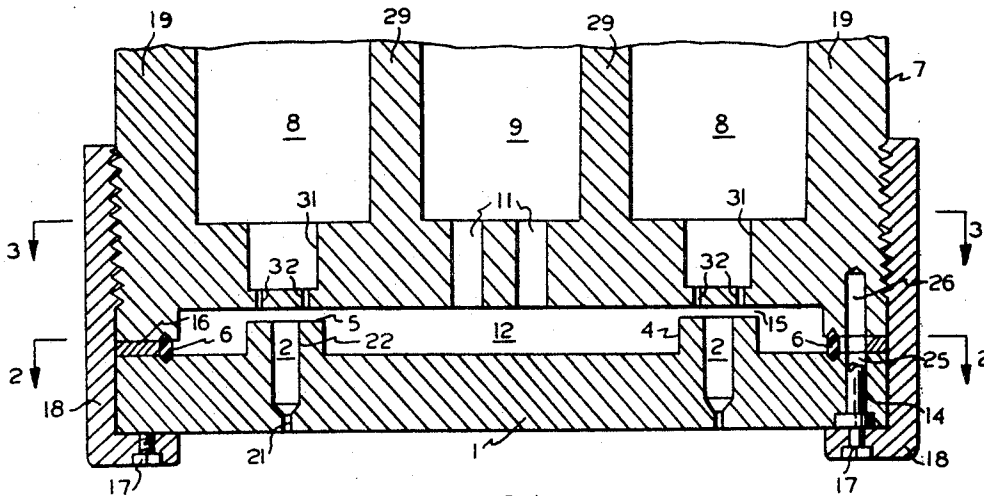


FIG. 1

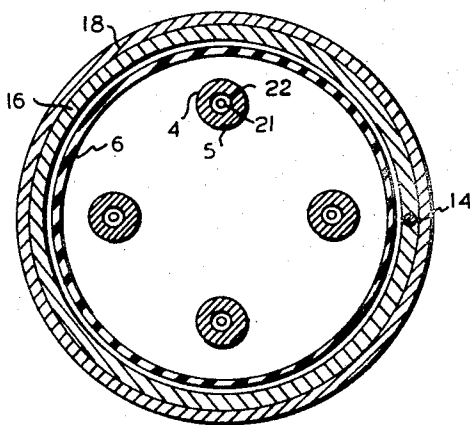


FIG. 2

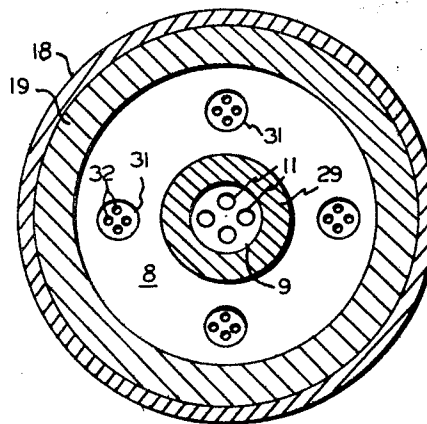


FIG. 3

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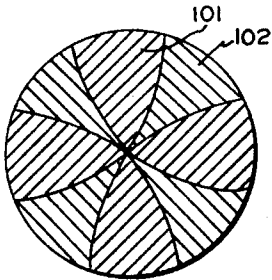


FIG. 4

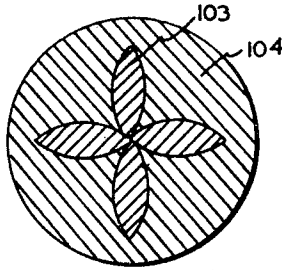


FIG. 5

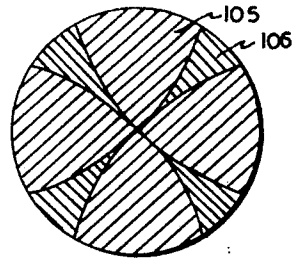


FIG. 6

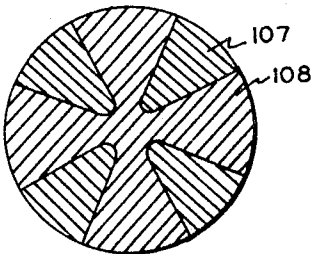


FIG. 7

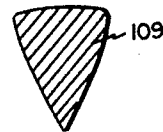


FIG. 8

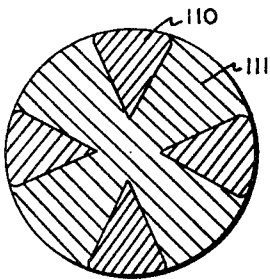


FIG. 9

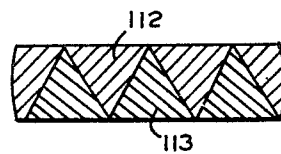


FIG. 10

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1

3,188,689

SPINNERET ASSEMBLY

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Original application May 27, 1958, Ser. No. 738,166.

Divided and this application June 7, 1962, Ser.

No. 200,758

1 Claim. (Cl. 18—8)

This invention relates to the manufacture of filaments of a novel cross-section.

Much effort has been expended towards the preparation of fabrics that are silk-like from filaments of modern synthetic polymers. Although various proposed methods have duplicated one or more of the important characteristics of a silk fabric, a completely satisfactory substitute has not yet been found.

The desirability of producing textile filaments having one or more sharp longitudinal edges for obtaining silk-like fabrics has long been recognized. Despite numerous proposals mainly drawn to extrusion orifice designs, it has not been feasible to produce textile filaments having sharp edges in cross-section by the extrusion of melts or solutions of fiber-forming polymers. This is due to the fact that the surface of a filament formed by extrusion through an orifice tends to assume the cross-sectional contour of a circle, the smallest boundary for the given cross-sectional area.

One object of this invention is to produce filaments of synthetic linear polymers having one or more sharp longitudinal edges.

A further object is the preparation of a fabric that has the properties of silk. Other objects will become apparent in the course of the following discussion.

In accordance with one embodiment of the invention a composite filament of substantially uniform cross-section composed of segments of at least two dissimilar synthetic polymeric compositions, said cross-section having at least two segments of at least one of said polymers, any contact between such segments of the same polymer being substantially point contact is extruded. This may be accomplished through the use of the spinneret assembly more completely described below. After drawing, as desired, the filament may be separated into its component sections by mechanical action. Alternatively, all sections composed of one polymer composition are removed as for example by dissolution or chemical decomposition.

By the term "segment" is meant a portion of a filamentary cross-section having at least one sharp point formed by the intersection of two straight or curved lines. The segment may have: one sharp point such as in a teardrop-shape as shown in 110 of FIGURE 9; 2 sharp points such as in a lens-shape as shown in 103 of FIGURE 5 or such as in the shape shown in 107 of FIGURE 7; 3 sharp points as in a plane or curvilinear triangle; or a multiplicity of sharp points such as in a figure formed by the joining of 2 or more simple segments as in a formée cross.

FIGURE 1 shows in axial section a spinneret assembly useful for this purpose. Front or bottom plate 1 with orifices 2 is recessed at the back about plateau-like protrusions 4. The outer wall at the bottom of back or top plate 7 is sealed against and spaced from the front plate by gasket 6 and shim 16. Relatively unconstricted region 12 between the two plates is interrupted at intervals by constricted regions 15 between the opposing face of the back plate and plateaus 5 of the protrusions from the front plate. The back plate is partitioned on top by outer wall 19 and inner wall 29 into annular chamber 8 and central chamber 9. The annular chamber

2

communicates with the constricted regions between the two plates through lead holes 31 and orifices 32, and the central chamber communicates with the intervening relatively unconstricted region through holes 11. The two plates are retained in place by cap 18 which is threaded onto the end of the back plate and is fixed to the front plate with set screws 17. The upper part of the housing (not shown) receives suitable piping or other supply means for separate connection to the two chambers, which may constitute distribution or filtering spaces as desired. Pin 14 through cylindrical openings (opening 25 in the front plate and opening 26 in the back plate) near one edge of the plates ensures rotational positioning of the two plates.

FIGURE 2 shows a reduced view of the plan of the front plate. Appearing in this view are four plateaus, each concentric with an extrusion orifice and uniformly spaced about a circle inside the outer gasket. As shown in this view and in FIGURE 1, each orifice consists of capillary 21 at the exit end and larger counterbore 22 extending to the capillary from the plateau. Also visible, supported in a shallow annular groove, is gasket 6, the opposing face of the back plate being similarly grooved to ensure a good seal between the two plates. FIGURE 3 shows a reduced view of the back plate sectioned as indicated on FIGURE 1. Visible are the concentric outer and inner walls, the capillaries and counterbores of four apertures spaced uniformly on a circle between the two walls, and four openings located within the central chamber defined by the inner wall. As shown in this view, the apertures in the top or back plate opposite the orifices of the bottom plate are each composed of four terminal capillaries 32 and introductory counterbore or lead hole 31.

FIGURES 4, 5, 6, 7, 9, and 10 represent transverse cross-sectional views of representative composite filaments of the present invention before separation into their sharp-edged component filaments.

FIGURE 8 is a transverse cross-sectional view of one of the sharp-edged component filaments after separation from the composite filament.

Operation of the described apparatus in the practice of this invention is readily understood. Different polymer compositions are supplied to the inner and the outer chambers, respectively, of the back plate; the former flows through the openings into the relatively unconstricted space between back and front plates, through the relatively constricted regions between the plateaus and the opposing plate face, and through the extrusion orifices while the latter passes first through the apertures in the back plate and directly onto the top of the plateau and then through the aligned orifices in the front plate.

Suitable pairs of components for use in this invention can be found in all groups of synthetic fiber-forming materials. Where it is desired to separate the filament into its component sections by mechanical action, the components should have low adhesion to each other. Obviously this is not necessary where one component of the pair is to be removed by dissolution or chemical decomposition. 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 preferred for application in this method. Suitable polymers can be found for instance among the fiber-forming polyamides and the polyesters which are described in such patents as U.S. Patents 2,071,250; 2,071,253; 2,130,523; 2,130,948; 2,190,770 and 2,465,319. The preferred group of polyamides comprises poly(hexamethylene-adipamide) poly(hexamethylene sebacamide), poly(epsilon-caproamide) and the copolymers

thereof. Suitable polyesters, besides poly(ethylene terephthalate), are the corresponding copolymers containing sebacic acid, adipic acid, isophthalic acid as well as the polyesters containing recurring units derived from glycols with more than two carbons in the chain, e.g., diethylene glycol, butylene glycol, decamethylene glycol and trans-bis-1,4-(hydroxy methyl)-cyclohexane.

Other groups of polymers useful as components in filaments of the present invention can be found among the polyurethanes, the polyureas, cellulose esters and cellulose ethers as well as among the polyvinyl compounds including such polymers as polyethylene, polyacrylonitrile, polyvinyl chloride, polyvinylidene chloride, polyvinyl alcohol, and copolymers containing the monomers of these polymers and similar polymers as disclosed in U.S. Patents 2,601,256; 2,527,300; 2,456,360 and 2,436,926.

When it is desired to remove all sections composed of one polymer composition by dissolution, a solvent for such polymer is selected that will not dissolve or have an adverse effect on sections composed of other polymer compositions. Thus in Example I which appears below, formic acid was used to remove the polyamide sections from the filament having both polyester and polyamide sections in its cross-section. The extent of dissolution of the soluble portion can be controlled as desired.

Similarly, all sections composed of one polymer composition can be removed by chemical decomposition. Thus polyester sections of a polysegmented filament having alternate polyester and polyamide sections, would be degraded by treatment with hot caustic as would the copolyamide or polyurea portions of polysegmented filaments having copolyamide-polyacrylonitrile or polyurea-polyacrylonitrile alternating sections by treatment with mineral acids.

In the examples, the relative viscosity (η_r) i.e., viscosity of a solution of polymer relative to that of the solvent is used as a measure of the molecular weight. The polyamide solutions contained 5.5 g. of polymer in 50 ml. of 90% formic acid and the viscosity was measured at 25° C. The polyester solutions contained 2.15 g. of the polymer in 20 ml. of a 7/10 mixture of tetrachlorophenol/phenol and the viscosity was measured at 30° C.

Example I

A spinneret similar to that shown in FIGURES 1 to 3 with 17 orifices was constructed. The plateau 4 was $\frac{1}{8}$ in. in diameter and $\frac{1}{16}$ in. high. The counterbore 22 was 40 mils in diameter and extended to within 48 mils of the face of the spinneret. The capillary 21 had a diameter of 12 mils. The lead hole 31 in the upper plate 7 was $\frac{3}{32}$ in. diameter was drilled to within 94 mils of the bottom of plate 7. The upper orifices 32 were 9 mils in diameter and were drilled on a circle having a 39.5 mil radius the center of which was concentric with the upper lead hole and with the plateau in the orifice in the lower plate. The spinneret was assembled with a 3 mil thick shim 16.

Poly(hexamethylene adipamide) of η_r 36 was fed to chamber 9 of the spinneret and extruded to form the triangular segments of the filament and poly(ethylene terephthalate) of η_r 33 containing 0.3% of TiO_2 was fed to annulus 8 and then through orifices 32 to form the formée cross segment of the filament's cross-section. The two molten polymers were extruded in the ratio of 9.5/10.0 by volume respectively at 290° C. and the yarn wound up at 1000 y.p.m. The yarn was drawn 4× over an 88° C. pin and then passed over a 140° plate to reduce shrinkage. A cross-section of a typical filament is shown in FIGURE 7. The yarn had a tenacity of 3.9 g.p.d., an Mi of 53, an ultimate elongation of 32% and a total denier of 50.

The yarn was knitted into a tubing which was quite lean in appearance and had poor visual covering power. The tubing was extracted for 3 hours with 98% formic acid in a Soxhlet extractor, removed, rinsed with water and dried. Despite the loss of about 50% of the fiber weight

by dissolution of the polyamide sectors the visual covering power of the tubing was greatly increased. The extracted tubing had a soft silk-like handle and was scroopy. The cross-section of filaments remaining in the extracted fabric resembled a formée cross as shown in 108 of FIGURE 7.

Example II

Using the same spinneret as in Example I, poly(ethylene terephthalate) of η_r 26.9 containing 0.3% of TiO_2 was fed to chamber 8 of the spinneret and extruded as the segments of a composite filament designated 101 in FIGURE 4 while poly(hexamethylene adipamide) of η_r 36 was fed to chamber 9 and extruded as the segments of a composite filament designated 102 in FIGURE 4. The polymers were extruded at 290° C. and the yarn wound up at 400 y.p.m. The yarn was drawn 4.3× over a 98° C. pin. The resulting yarn had a tenacity of 4.1 grams per denier, and initial modulus of 56 and had a denier per filament of 8.3. A portion of the drawn yarn was wound on a perforated metal bobbin and immersed in cold 98% formic acid for 3 hours. After rinsing and drying the residual polyester yarn had a tenacity of 3.8 g.p.d., a Mi of 73, an ultimate elongation of 28% and a total denier of 80 for the 68 filaments then present. A typical cross-section of a filament is shown in 109 of FIGURE 8.

A portion of the original yarn was woven into a 2×2 twill fabric having 120 yarns per inch in the warp and 84 yarns per inch in the filling. The resulting fabric was immersed in 98% formic acid for 60 minutes until the poly(hexamethylene adipamide) sectors were dissolved from the composite filaments. The fabric possessed all of the properties of a silk fabric as liveliness and drape, the subtle scroop of silk, the handle, the low denier per filament, the high modulus and good recovery properties.

A repetition of the above spin with positions of the 2 polymers changed gives filaments which after treatment with formic acid leaves fillet-shaped sectors of the polyester similar to segment 102 of FIGURE 4.

Example III

The following example illustrates the different cross-sections obtained by varying the volume of polymers delivered to various sectors of the composite filaments.

Using the spinneret of Example I with a three mil shim, poly(ethylene terephthalate) of η_r 28.1 containing 2.0% of TiO_2 was fed to chamber 8 of the spinneret and poly(ethylene terephthalate) of η_r 31 fed to chamber 9. The polymers were extruded at 290° C. and the yarn wound up at 1000 y.p.m. The volume of the two polymers entering the composite filaments were varied by adjustment of their respective constant displacement pumps. In the first spin the volumes of the pigmented polymer to the non-pigment polymer was 1:1 and filaments were obtained having cross-sections similar to that shown in FIGURE 4. When the ratio of pigmented to bright polymer was set at 4/16, filaments with cross-sections similar to FIGURE 5 were obtained. When the pumps were adjusted to give a ratio of 16/4 as above cross-sections similar to FIGURE 6 were obtained.

The above spins are repeated replacing the unpigmented polyester with the copolyester poly[ethylene/poly(ethylene oxide) glycol terephthalate] with a composition of 80/20 by weight, the poly(ethylene oxide) glycol units having a molecular weight of 6000. Upon immersing the yarns in a hot 5% solution of NaOH the segments corresponding to 102, 104, 106 in FIGURES 4, 5, and 6 are dissolved and residual cross-sections of poly(ethylene terephthalate) corresponding to 101, 103, 105 in FIGURES 4, 5, and 6 remain in the respective yarns.

Example IV

Using the apparatus and polymers of Example I the positions of the two polymers were reversed. The polyester and polyamide were extruded at 290° C. at a ratio

5

of 12/16 by volume respectively and the composite filaments wound up at 500 y.p.m. The yarn was drawn 4.2X over a 100° pin. A typical cross-section of the drawn filament is shown in FIGURE 9. A portion of a yarn was wrapped on a perforated metal tube and immersed in acetone for 5 minutes. The dried yarn was pulled over the edge of a glass microscope slide under a tension of about 0.5 g.p.d. so that the yarn suffered a 90° change of direction in the process. The above process caused the filament to partially fragment longitudinally along the interfaces of the sectors. A total of three passages of the yarn over the sharp edge caused complete separation of the polyester and polyamide segments so that the yarn was composed of filaments which in cross-section resembled 110 and 111 of FIGURE 9.

The filaments in the above drawn yarn were completely separated into the polymeric components by one passage through an air jet as described in United States Patent No. 2,783,609 at a feed rate of 50 y.p.m. and a windup rate of 48 y.p.m. using 2 cu. ft. of air per minute at 90 p.s.i. to operate the jet.

A portion of the above drawn yarn not exposed to acetone or fragmented was wound on a perforated metal tube and placed in 98% formic acid at the boiling point for 30 minutes. The tube and yarn was then placed in cold formic acid for an additional 15 minutes, rinsed with water and dried. The residual polyester filaments, which in cross-section resembled segment 110 of FIGURE 9, had a tenacity of 3.6 g.p.d., an ultimate elongation of 31%, a Mi of 68, and a denier per filament of 1.0. The yarn was used as a filling face in the weaving of a satin with yarn of round cross-section, poly(ethylene terephthalate), as a warp. The fabric had a dry, crisp, silk-like handle across the filling band but was less silk-like than the fabric of Example II.

Example V

Using the apparatus and polymers as in Example IV, composite filaments are extruded and the continuous filaments wound up at 5000 y.p.m. The yarn is dipped in acetone and then drawn 2X over a pin at 88° C. The segments of polyester break and split during the drawing so that a yarn somewhat resembling spun staple is obtained in which the cruciform-like filaments of polyamide in cross-section have short lengths of polyester microfibrils attached to a surface which project beyond the original periphery of the filaments.

Example VI

Solutions of polyacrylonitrile and cellulose acetate, both in dimethylformamide are dry spun from the spinneret of Example I. The resulting filaments in cross-section have alternate segments of the two polymers with a crenulated periphery. An acetone bath dissolves the cellulose acetate portions of the filaments and leaves small denier filaments of polyacrylonitrile of shape similar to FIGURE 8.

The composite filaments have been produced in the examples by the melt spinning technique. Obviously, other spinning methods like "plasticized melt" spinning, dry spinning, wet spinning, can be employed successfully. In some instances, particularly when the melting behavior or the solubility of the components in a combination would not permit spinning the components by similar methods, a combination of dissimilar methods can be used. Thus, for instance, one component, can be spun as a solution in a high boiling solvent or as a plasticized melt, while the other component is extruded as a molten polymer. In these instances, the solvents or plasticizers may be wholly or partially removed subsequently, preferably by washing them out by the help of low boiling solvents.

The composite filaments illustrated in this invention

6

have substantially round cross-sections before separating of the components. However, it will be apparent to those in the art that by altering the shape of the orifice 21, the final cross-section can be controlled to a certain extent. Although square filaments cannot be extruded, filaments in cross-section which resemble a square with rounded corners can be obtained by the use of square or slotted orifices and these in turn would offer segments that are plane triangles or a combination of plane and curvilinear triangles for example. Similarly, cross-sections in the shape of ellipses, cruciforms, etc. can be extruded and segments placed in such filaments as desired.

It will also be obvious to those skilled in the art that other modifications of the composite filaments and hence of the shape of the residual filaments after dissolution can be altered by changing the number and placement of the upper orifices 32. Other means of altering the configuration of the composite filaments will be by varying the diameters of the upper orifices used in relation to the size of the plateaus, and/or the rate at which polymers are extruded through the upper orifices 32 and over the plateau. Alteration of the viscosities of the component polymers affects the configuration obtained. A low viscosity polymer tends to be pushed inward more readily by the flow of a more viscous polymer and hence alters the shape of the segment that it will make. The configuration in the component filaments is also affected by the interfacial tension and the individual tendencies of the polymers to wet the spinneret surfaces.

Although the spinneret used in the examples is a convenient apparatus for the preparation of the filaments of this invention it will be obvious to those skilled in the art that other spinnerets can be used. Other spinnerets permit the production of filaments or ribbons having alternating segments 112 and 113 as shown in FIGURE 10 which can be split or dissolved apart to give sharp-edged filaments.

The process of this invention affords a convenient means of obtaining filaments having one or more sharp points in cross-section and of a lower denier than can be otherwise attained. Thus, the invention permits the production of sharp-edged filaments having a denier of 0.1 to 10 or larger. Its greatest utility, however, is in the range of 0.1 to 5 denier per filament. The novel filaments can be used to obtain all manner of new and novel effects in fabric handle, scroop, appearance and covering power by proper selection of the polymer composition and filamentary cross-section.

This is a divisional application of copending application of copending application Serial No. 738,166, filed May 27, 1958 and now abandoned.

The invention is to be limited only by the scope of the following claim.

I claim:

In a spinneret assembly, a first and second fluid supply means, an upper plate common to said fluid supply means, at least one distribution orifice from each of said fluid supply means defined by said upper plate, a lower plate having an extrusion orifice defined thereby, the lower plate spaced from said upper plate, a fluid carrying chamber defined by the upper and lower plates, at least one boss integral with said lower plate about the extrusion orifice and extending into said fluid carrying chamber, said boss containing a channel leading from the top surface of the boss to the extrusion orifice, the boss being positioned beneath said first fluid supply means and with the channel therein eccentrically located with respect to said distribution orifice of the first fluid supply means thereby permitting fluid issuing therefrom to impinge on isolated points of its shoulder, the distribution orifice from said second fluid supply means emptying into the fluid carrying chamber surrounding the boss.

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5

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