May 17, 1960 J. J. KILIAN 2,936,482

SPINNERET ASSEMBLY

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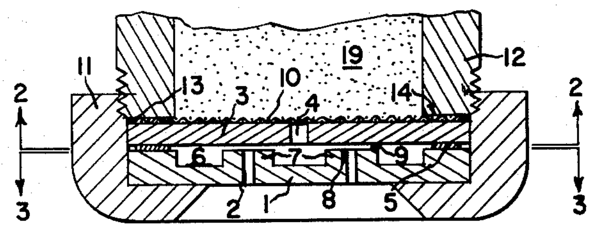

Fig.1

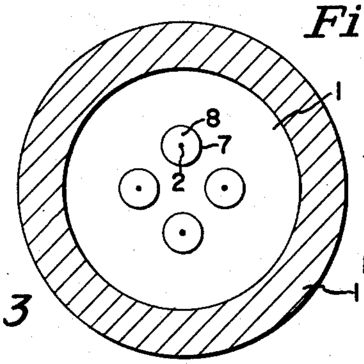

Fig.3

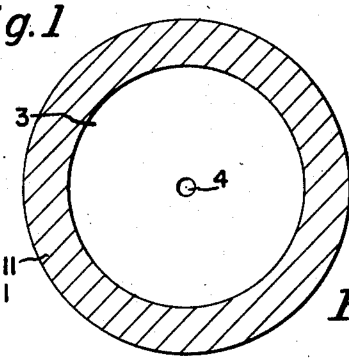

Fig.2

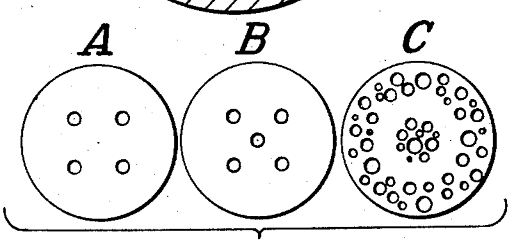

Fig.4

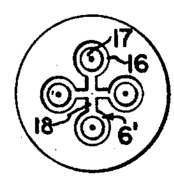

Fig.5

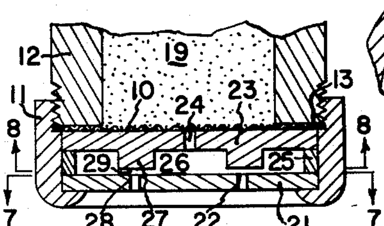

Fig.6

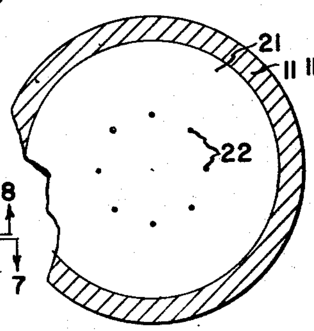

Fig.7

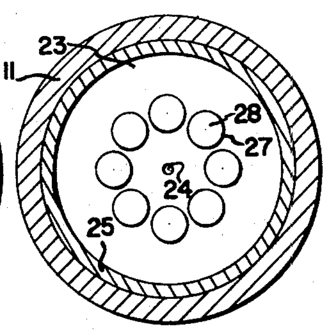

Fig.8

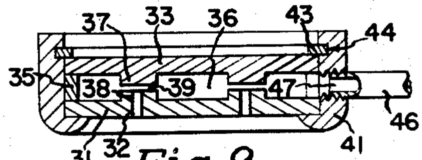

Fig.9

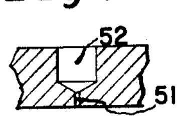

Fig.10

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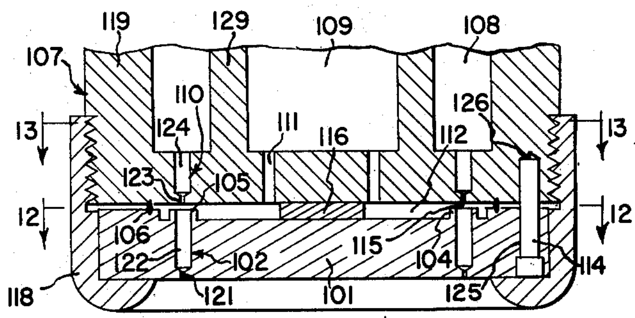
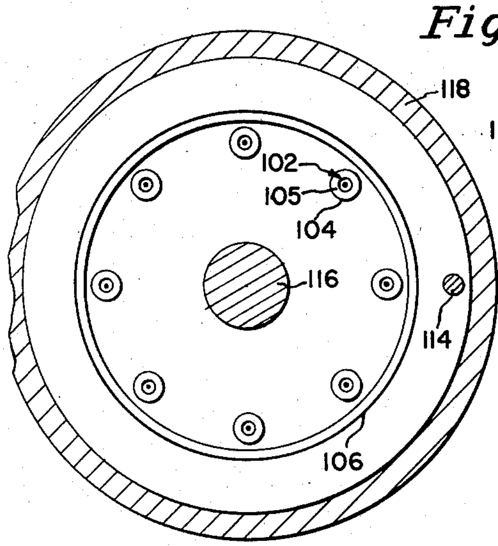


Fig.11



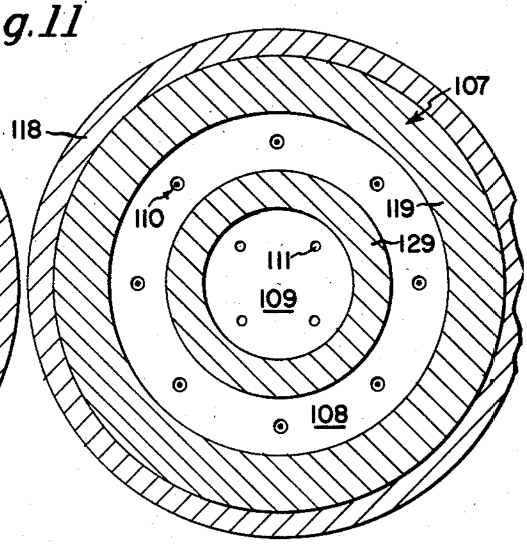
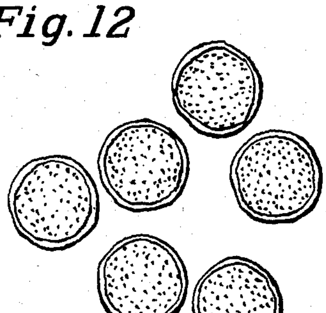


Fig.12

Fig.13



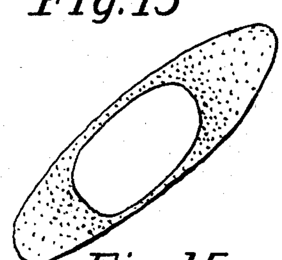


Fig.15

Fig.14

Fig 16

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SPINNERET ASSEMBLY

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Application June 30, 1955, Serial No. 519,031

7 Claims. (Cl. 18—8)

This invention relates to metering of fluids through orifices, relating particularly to spinneret means for extruding synthetic fiber-forming liquids into filamentary form.

Many devices have been proposed for ensuring uniform supply of homogeneous fiber-forming fluid to the orifices of a multiple-orifice spinneret with the object of producing multiple filaments identical in denier and other characteristics. Such apparatus usually involves variations in diameter or location of orifices in single or multiple spinneret plates. Despite the manifest efforts of persons highly skilled in the art, interfilament denier nonuniformity remains a problem in the manufacture of synthetic multifilaments. A related problem of unform fluid supply is encountered in attempts to extrude more than one fiber-forming liquid simultaneously through the same orifice of a spinneret to form multicomponent filaments, being especially severe with multicomponent multifilaments, as might be expected.

A primary object of the present invention is accurate metering of one or more liquids for even distribution to and through a plurality of orifices having common access to the liquid supply. Another object is production of multifilament yarns having improved interfilament denier uniformity. A particular object of this invention is provision of improved multicomponent filaments, especially with an individual sheath-core configuration, regardless of difference in viscosity or other characteristics of the components. Other objects, together with means and methods for attaining the various objects, will be apparent from the following description and the accompanying diagrams.

Figure 1 is an axial longitudinal section through a spinneret assembly of this invention. Figure 2 is a transverse cross section of the apparatus of Figure 1 taken at 2—2 to show the bottom of the back or top plate thereof. Figure 3 is a transverse cross section of the apparatus of Figure 1 taken at 3—3 to show the plan of the front or bottom spinneret plate thereof. Figure 4 shows the plan of other back plates useful in the apparatus of Figure 1. Figure 5 shows the plan of another front plate useful in the apparatus of Figure 1. Figure 6 is an axial longitudinal section of another spinneret assembly embodying the present invention but containing different front and back plates. Figure 7 is a transverse cross section of the apparatus of Figure 6 at 7—7 showing the plan of the front or bottom plate. Figure 8 is a transverse cross section of the apparatus of Figure 6 taken at 8—8 to show the bottom of the back plate. Figure 9 is an axial longitudinal cross section of another form of spinneret apparatus of this invention. Figure 10 is an enlarged axial longitudinal cross section of a single orifice useful in the plates of a spinneret assembly of this invention.

Figure 11 is an axial longitudinal section of a spinneret assembly designed according to this invention for extrusion of multicomponent filaments. Figure 12 is a

transverse cross section of the apparatus of Figure 11 taken at 12—12 thereof and showing the plan of the front or bottom spinneret plate. Figure 13 is a transverse cross section taken at 13—13 of Figure 11 to show the plan of the top or back plate thereof. Figure 14 is a transverse cross section of a filamentary product of the apparatus of Figure 11. Figures 15 and 16 are transverse cross sections of filamentary products of apparatus based upon that of Figure 11.

In general, the objects of the present invention are accomplished by imparting to fluid channeled from a fluid supply to each of a plurality of extrusion orifices a pattern of flow convergent substantially radially to each orifice entrance; the invention contemplates achievement of this by interposing in the vicinity of each orifice entrance a constriction adapted to impede the flow more than it is impeded in the relatively unconstricted supply channel. This invention comprehends a spinneret assembly comprising a front or bottom plate containing a plurality of extrusion orifices and an opposed back or top plate spaced therefrom, with the opposing face of at least one of the plates characterized by uniform protrusions in the form of plateaus, each of which provides considerably diminished separation of the opposing faces about the entrance to a single orifice. In particular, the present invention includes a spinneret assembly, having the components just mentioned, in which the back plate contains orifices opening opposite the orifices in the front plate and communicating with a first supply chamber and in which the region of undiminished separation between the two plates communicates with a second supply chamber. The invention contemplates formation of multicomponent filaments by jetting one or more core-forming components into radially converging flow of sheath-forming component and extruding the combination with the sheath-forming component surrounding the core-forming component. Details of practice of the invention are discussed below with frequent reference to the diagrams.

Figure 1, which represents a generally cylindrical spinneret assembly sectioned along its axis, shows bottom or front plate 1 with orifices 2, top or back plate 3 with central aperture 4, and gasket 5 located between opposing faces of the two plates at the periphery thereof. The two plates are retained inside the end of cylindrical housing 12 by open cap 11 threaded onto the housing; fitting between the back plate and end face 14 of the housing is screen 10, surrounded by seal 13 at its peripheral edge, which retains filtering medium 19. Except in the vicinity of the orifices, the plates are separated from one another by relatively unconstricted region 6; about each orifice, protrusion 7 rises from the top face of the front plate to terminate in plateau 8 close to but out of contact with the back plate, thus forming constricted region 9 therebetween. Figure 2, being a transverse section of the same apparatus along the upper face of the back plate, shows the single central aperture therein. The front plate appears in Figure 3 viewed from the level of the plateaus, which are circular in plan and conentric with their respective orifices, four of which appear in these figures.

Operation of this apparatus is readily understood. Fluid composition having fiber-forming properties is forced in obvious manner through the filtering medium, the retaining screen, and the aperture of the back plate into the relatively unconstricted region between the back and front plates. From there, the fluid passes out through the orifices of the front plate after having flowed over the top of each plateau to converge radially to the orifice entrance. Upon extrusion, the respective streams become self-supporting filaments in the usual manner.

The relatively large impedance presented to the fluid by the constricted regions exceeds the impedance presented by the relatively unconstricted region to such an extent that any variation in impedance to the supply of fluid throughout the relatively unconstricted region constitutes an insignificant portion of the total and, thus, does not appreciably affect the flow into the extrusion orifice. Accurate sizing of the constricted regions by precise formation of the plateaus in both height and diameter and exact spacing of the two plates facilitates equalization of the flow impedances in the separate constricted regions. Furthermore, according to this invention, the impedance presented by each extrusion orifice to flow of liquid through it also is a relatively small portion of the total impedance (from supply to extrusion), which consequently minimizes the disturbing influence of any orifice irregularity upon the characteristics of the extruded filaments; in fact, the orifice impedance may be exceeded by the impedance presented to the flow converging to the orifice entrance across the plateau when closely spaced from the opposing plate surface.

The back plate of the apparatus of Figure 1 may be replaced, without affecting the operation adversely, by any of a wide variety of plates, including those shown in plan view in Figure 4: plate A having four apertures located at the corners of a square, plate B having five apertures located at the corners and center of a square, and plate C having a multitude of apertures distributed throughout the plate except in a ring above the plateaus. The illustrated arrangements supply fluid only to the relatively unconstricted region between the plates to assure radially convergent flow across the tops of the plateaus to the orifice entrances.

The relatively unconstricted region between the plates need not be so extensive as that provided by the front plate of Figure 1; instead, it may be composed of recesses surrounding the protrusions and having a suitable supply channel for the fiber-forming fluid. An alternative front plate of this type appears in plan view in Figure 5, in which unconstricted region **6′** is made up of recesses **16** (about protrusions **17**) and connecting central cruciform channelling **18**. The front plate of Figure 5 may be employed with back plate B or C of Figure 4, instead of that of Figure 3, although this normally would not be done because most of their apertures fail to communicate with the recesses or connecting channels in that front plate; back plate A is completely unsuitable to use with this alternative front plate because of lack of such communication.

As shown in Figure 6, the essential protrusions may occur on the bottom face of the back plate, instead of on the top face of the front plate; this figure shows front or bottom plate **21** with orifices **22**, back or top plate **23** with aperture **24**, and spacing gasket **25** providing relatively unconstricted region **26** between the two plates. Protrusions **27** from the bottom face of the back plate terminate opposite the orifices in the front plate, from which plateau-like faces **28** of the protrusions are separated by constricted regions **29**. These elements replace the corresponding elements of Figure 1 in an otherwise similar spinneret assembly, such as that illustrated, including filtering medium **19** retained by screen **10** (surrounded by seal **13**) along with the plates in housing **12** by cap **11**. The front plate of Figure 6 appears in plan view in Figure 7, showing eight orifices uniformly spaced in a circle. A bottom view of the back plate of Figure 6 appears in Figure 8; this view shows not only the single central aperture but also eight plateaus constituting the bottoms of the protrusions. Of course, the two plates are assembled in the illustrated orientation so as to locate each plateau concentric with one of the orifices in the opposing plate.

If desired, both front and back plates may have plateau-like protrusions to be located opposite one another in a spinneret assembly. Furthermore, regardless

of whether the plateaus appear on the back or the front plate, or both, fluid may be introduced into the relatively unconstricted region between the two plates from the side, rather than through any aperture in the back plate. Figure 9 shows these modifications of the foregoing apparatus. Front plate **31**, which has orifices **32** extending through plateau-like protrusions **38** on the top face, and back plate **33**, which has protrusions **37** on its bottom face, are separated by gasket **35**, thus defining relatively unconstricted region **36** between opposing faces of the two plates and constricted regions **39** between the plateaus of the opposing protrusions. The plates and the separated gasket are held in cap-shaped housing **41** by retaining ring **43** fitting in recess **44** in the top or back of the cap and against the top face of the back plate near the outer edge thereof. Supply pipe **46** is threaded into opening **47** in one side of the cap, and the spacing gasket is cut away about the end of the pipe to permit flow of the fluid supply thereby to the relatively unconstricted region between the plates.

Although in all the preceding diagrams, the orifices are shown as capillaries of constant diameter, in axial cross section the orifices in any of the illustrated embodiments may be composed of a relatively short capillary **51** terminating at the bottom face of the plate (only the surrounding portion being illustrated, in section) and connected by counterbore **52** to the top face of the plate; this is a usual construction, which appears in enlarged axial section in Figure 10.

The following example illustrates formation of filamentary product by a spinneret assembly conforming essentially to that first described.

EXAMPLE I

Molten polyhexamethylene adipamide having an inherent viscosity of 1.01 as measured on a solution of it in m-cresol (0.5 gram per hundred milliliters at 25° C.) and containing 0.3% titanium dioxide is supplied at 275° C. to an assembly patterned after that of Figures 1, 4C, and 3. The front plate contains 13 orifices spaced on an inch radius, each orifice consisting of a capillary 0.009 inch in diameter and 0.012 inch long and a connecting counterbore 0.040 inch in diameter. The entrance to each orifice is centered in a plateau 0.125 inch in diameter, forming the top of a cylindrical protrusion extending 0.0625 inch from the recessed top of the front plate. The distribution plate having multiple apertures is spaced 0.003 inch above the plateaus by a gasket. The polymer is supplied directly to the unconstricted region behind the spinneret plate through the plate and a 50-mesh woven wire screen supported by it to constitute the bottom element of a conventional sand type of filter pack. The respective pressure drops through the relatively unconstricted region, over a plateau, and through an orifice are computed to be about 1.8×10^4, 6.5×10^7, and 7.5×10^7 relative to one another, assuming Newtonian flow. The extruded filaments are wound up at 1200 yards per minute and the yarn so formed is drawn over a pin at 45° C. to 3½ times its original length (i.e., a 3½× draw). At ten different locations in the yarn, lengths of 9 centimeters are cut out, and each removed filament segment is weighed to determine its denier. The standard deviation in interfilament denier (square root of the arithmetic mean of the squares of the deviations of each sample from the arithmetic mean of all the samples) is determined to permit computation of the coefficient of variation (100 times the standard deviation divided by the arithmetic mean). The coefficient of variation is found to be 5%, as compared to 9% for a control yarn spun from a spinneret assembly like that of this example except for a plate thickness of 0.3125 inch (actually the spinneret plate of the above example before recessing to form the protrusions).

The above example illustrates the kind of improvement in interfilament denier uniformity obtainable according to the practice of this invention; the improvement is even more striking when the orifices are non-round (e.g., slotted, cruciform, or shaped like a dumbbell or dogbone) because of the increased difficulty in reproducing such a shape exactly from orifice to orifice. If desired, the spacing between the constricted region provided by the plateaus may be made so shallow or narrow as to prevent passage of particles capable of clogging the extrusion orifices; as a filter this construction may supplement or supplant the indicated conventional filtering arrangement. Narrow spacing also provides a high rate of shear of the fluid at the entrance of the orifice, as is often desirable in the formation of filamentary structures. The capacity of the plateau as a filter is proportional to its circumference; this normally is sufficiently great that many particles can be collected and retained without altering the flow impedance of the plateau significantly. Although the above example is drawn to operation upon a particular nylon polymer, there is no apparent limitation upon the variety of polymeric fiber-forming materials that can be spun advantageously from like spinneret assemblies.

By jetting another fluid component into the radially converging flow toward an orifice entrance, modification of the above apparatus and method facilitates formation of desirably uniform multicomponent filaments. Figure 11 shows in axial section a spinneret assembly useful for this purpose. Front or bottom plate **101** with orifices **102** is recessed at the back about cylindrical protrusions **104**. Back or top plate **107** is sealed against and spaced from the front plate by gasket **106** and shim **116**, the former being ring-shaped and located near the periphery of the opposing faces of the two plates and the latter being disc-shaped and located concentric with the two plates. Relatively unconstricted region **112** between the two plates is interrupted at intervals by constricted regions **115** between the opposing face of the back plate and plateaus **105** of the protrusions from the front plate. The back plate is partitioned on top by outer wall **119** and inner wall **129** into annular chamber **108** and central chamber **109**. The annular chamber communicates with the constricted regions between the two plates through counterbored apertures **110**, and the central chamber communicates with the intervening relative unconstricted region through holes **111**. The two plates are retained in place by cap **118** threaded onto the end of the back plate. 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 **114** through cylindrical openings (opening **125** in the front plate and opening **126** in the back plate) near one edge of the plates ensures concentricity of the two plates.

Figure 12 shows the plan of the front plate. Appearing in this view are eight 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 11, each orifice consists of capillary **121** at the exit end and larger counterbore **122** extending to the capillary from the plateau. Also visible, supported in a shallow annular groove, is gasket **106**, the opposing face of the back plate being similarly grooved to ensure a good seal between the two plates. The apertures in the top plate opposite the orifices of the bottom plate are similarly constructed, each being composed of terminal capillary **123** and introductory counterbore **124**.

Figure 13 shows the appearance of the back plate sectioned as indicated on Figure 11. Visible are the concentric outer and inner walls, the capillaries and counterbores of eight apertures spaced uniformly on a circle between the two walls, and four openings located within the central chamber defined by the inner wall.

Supply of fluid from the central chamber to the relatively unconstricted space between the plates occurs in like manner and with like fundamental result in the apparatus just described as in the apparatus previously described and exemplified. Flow of the corresponding fluid (designated herein as the "sheath-forming" component) supplied from the inner or central chamber over the plateaus and through the extrusion orifices is remarkably uniform, despite any asymmetry of the supply, because of the identical high impedances to the flow presented by the constricted regions between the plateaus and the opposing plate face.

In addition, the present apparatus permits injection of additional fluid into the center of the radially converging flow of sheath-forming component to pass centrally through the extrusion orifice. This fluid, supplied from the outer or annular chamber through apertures in the back plate is designated herein as the "core-forming" component. Thus, the apparatus provides a two-component or "sheath-core" filamentary configuration in which the relative disposition of the sheath and the core is constant and reproducible, each filament so produced having a uniform cylindrical core surrounded by a concentric sheath. The relative amounts of sheath and core in the product depend upon the relative rates of flow of the two fluids. As in the single component assembly, the component flowing over the plateaus may be supplied through suitable channels and recesses having access to a common source, or substantially all of the top of the front plate may be recessed about the plateaus. Use of such spinneret assemblies for production of multicomponent filaments is exemplified below in illustrative detail.

EXAMPLE II

A spinneret assembly is constructed like that of Figures 11 to 13, inclusive, except for substitution of interconnected recesses about the protrusions on the top of the front plate (instead of substantially complete recessing of the surface about the protrusions) and presence of 34 extrusion orifices in the front plate (instead of the smaller number shown. The resemblance of this front plate to that of Figure 5 is apparent. A conventional filter pack containing sand as the filtering medium is located just above the top of the back plate. The plates are 3$\frac{3}{16}$ inches in diameter, with the respective orifices and aligned apertures spaced uniformly upon an inch radius. The depth of recessing on the top surface of the front plate (i.e., the plateau height) is 0.062 inch, and each plateau is 0.125 inch in diameter. The capillary of each extrusion orifice is 0.040 inch long with a diameter of 0.012 inch, and the counterbore is 0.04 inch in diameter and 0.50 inch long. The relatively unconstricted space between the opposing faces of the two plates is 0.062 inch in width about each plateau and extends radially inward as grooves or channels 0.062 inch wide to an interconnecting channel surrounding the shim, which is 0.80 inch in diameter, and opposite the supply openings of the central chamber; the relatively constricted region above the plateaus is 0.001 inch deep. Two molten batches of polyethylene terephthalate are made as described by Whinfield and Dickson in Patent 2,465,319; one batch with inherent viscosity of 0.25 is supplied to the central chamber, and a batch with inherent viscosity of 0.65 and containing 0.3% titanium dioxide is supplied to the outer chamber of the spinneret assembly just described (inherent viscosity measured in 0.5% solution in 60/40 tetrachloroethane/phenol at 30° C.). Ratio of the melt viscosities of these two polymers is 1/25 at 290° C., the spinning temperature. The flow ratio of core-fluid to sheath-fluid is 70/30. The relative pressure drops through the unconstricted region, over the plateau, and through the extrusion orifice are computed to be 6×10^3, 2.5×10^8, and 7.8×10^7, respectively, assuming Newtonian flow. Extrusion at 290° C. into air at 30° C. with windup at 1000 yards per minute gives sheath-core multifilament of unusually good denier uniformity and remarkable sheath-core symmetry, as shown by representative transverse cross sections of the product in Figure 14. The yarn is drawn 2× at 40° C. after wetting to give a rough surfaced fiber having wool-like resilience and other properties; the resulting tenacity is 3.0 grams per denier with elongation of 35%.

Attempts to produce a yarn having sheath-core filaments similar to those of the above example by means of a simple two-plate spinneret assembly like that of the example but lacking the plateaus were unsuccessful because of incomplete and imperfect covering of the core-forming component by the intended sheath-forming component and accompanying variation in the ratio of relative amounts of sheath and core in the individual filaments, some filaments being composed exclusively of one or the other component.

Repetition of the procedure of Example II upon a like spinneret assembly having a slotted extrusion orifice (rectangular transverse section) produced filaments of elongated transverse cross section with an elliptical core, as illustrated in Figure 15. Non-parallelism of a plateau and the opposing plate face gives rise to non-uniform impedance about the orifice entrance; for example, a 3-degree divergence in the intervening constricted region of a spinneret assembly otherwise like that of Example II (maintaining a relatively high average impedance across the plateau) produced round filaments with elliptical core located uniformly eccentrically, as shown in Figure 16. These two supplementary runs suggest the broad scope of benefits provided by the plateaus in apparatus of this invention, which is well adapted to manufacture of non-round multicomponent filaments, controlled modification in the plateaus producing corresponding departure of the sheath-core configuration from circular concentricity. Of course, complete absence of the plateaus results in destruction of the desired sheath-core configuration.

Of course, many other fiber-forming components may be employed in spinneret assemblies designed for extrusion of multicomponent filaments according to this invention. The core-forming component may contain a delustering or coloring pigment whose presence at the surface of the yarn filament is undesirable. In this manner, a nylon multifilament was formed (with the apparatus of Example II) having unpigmented sheath and a core containing 0.3% titanium dioxide in a volume ratio of 15/25 sheath-core. Similarly, an extractable ingredient may be present in either sheath- or core-forming component to permit formation of pores in the filament after extrusion. For example, with a spinneret assembly like that of Example II except that the entire relatively unconstricted space is extended by recessing to uniform depth to surround all the plateaus over substantially the complete top face of the front plate (as in Figures 11 to 13, inclusive) rather than limited to recesses and interconnecting grooves, a nylon multifilament was formed from polyhexamethylene adipamide of 1.04 inherent viscosity as the sheath and the same substance containing 10% by weight of finely ground calcium carbonate as the core in a ratio of 70/30 sheath/core; after a 3× draw at 40° C. the yarn was boiled for 5 minutes in 2% aqueous acetic acid to give in the dried state a highly delustered light-weight yarn having the surface characteristics of a conventional bright nylon filament.

EXAMPLE III

By the procedures described by Jacobson in Patent 2,436,926 and Arnold in Patent 2,486,241, two different acrylonitrile polymers having intrinsic viscosity of 1.70 (determined in dimethyl formamide at 25° C.) are formed: (1) the homopolymeric polyacrylonitrile and (2) a 96/4 copolymer of acrylonitrile and methyl acrylate. A solution of the copolymer containing 22% by weight in dimethyl formamide and containing also 1½% carbon black by weight, with an absolute viscosity of 50 poises,

is supplied to the central compartment of a spinneret assembly patterned after that of Figures 11 to 13, inclusive; a 24% solution of the homopolymer in N,N-dimethyl formamide, having a viscosity of 80 poises at 125° C. is supplied to the outer chamber. The depth of the region above the plateaus is 0.001 inch thick, and each plateau has an outside diameter of 0.220 inch and a height of 0.062 inch with respect to the recessed portion of the top face of the bottom plate, recesses about the plateaus being connected to a central recess by grooves 0.062 inch wide. Each extrusion orifice has a capillary 0.004 inch in diameter and 0.008 inch long and a connecting counterbore 0.04 inch in diameter. The aligned apertures for the core-forming component are uniformly cylindrical with diameter of 0.010 inch and length of 0.125. The flow ratio is 33/67 sheath/core, and the respective pressure drops through the relatively unconstricted region, over a plateau and through an orifice are 3.4×10^4, 5.4×10^7, and 1.3×10^9, as computed upon assumption of Newtonian flow. The filaments are extruded at 95° C. into air at about 200° C. and wound up at 200 yards per minute to give yarn subsequently drawn 4× in water at 95° C. The drawn filaments exhibit a dogbone cross section having a thin sheath portion of substantially uniform depth.

The apparatus and procedure of Example III were employed subsequently to spin sheath-core filaments with the same solutions as in the example but with the homopolymer as the sheath-forming component and the copolymer as the core-forming component. The extrusion operation and the resulting yarn characteristics were similarly satisfactory. Reversal in location of the two components did not affect the uniform coverage of core by sheath; however, repeated attempts to duplicate either procedure using a spinneret assembly lacking the plateaus (i.e., only a conventional flat-faced spinneret plate) were unsatisfactory, giving filaments in which the two components were located more nearly side by side than in the desired sheath-core arrangement.

The apparatus and procedure of Example III were converted from dry-spinning to wet-spinning by extruding the filaments directly into an aqueous solution of sodium thiosulfate (32% $Na_2S_2O_3$) maintained at a temperature of between 98° and 100° C. This general method of yarn formation, as applied to acrylonitrile fiber-forming polymers, is described by Hare in Patent 2,530,962. The yarn was washed and drawn 4× in water at 95° C. The resulting filamentary configuration showed a uniformly located core of polyacrylonitrile and constant covering of the copolymer of acrylonitrile and methylacrylate.

By the procedure of Example III, using a similar spinneret assembly having only 4 extrusion orifices and surrounding like protrusions, the same copolymer was spun as the sheath for a core spun from a solution of 13 parts of the copolymer with 17 parts calcium acrylate in 70 parts dimethylformamide in a 50/50 sheath/core ratio. The calcium acrylate was extracted from the core of the resulting filaments by washing in water, and the porous yarn so formed was drawn 3× in atmospheric steam giving a tenacity of 1.2 grams per denier and an elongation of 107%. In a subsequent run, reversal of the components to place the solution containing the leachable additive in the sheath and the copolymer in the core produced satisfactory filaments; the calcium acrylate was washed quantitatively from the sheath, and the porous-surfaced yarn had a notably dry hand. After 3× drawing the yarn, which had a specific gravity of unity, exhibited tenacity of 1.0 gram per denier, elongation of 80% and denier per filament of 2.

The acrylonitrile copolymer of Example III as the sheath, and phytic acid as the core, are dry-spun by the same procedure using a like spinneret assembly. No difficulty was encountered in the extrusion process, and water-extraction of the resulting filaments gave a hollow configuration. The hollow filaments were drawn 3× in atmospheric steam, giving a yarn of low density exhibiting a tenacity of 1.8 grams per denier and elongation of 43%. In a similar manner, other cores were spun of non-fiber-forming materials (e.g., silicone oil), which were not removed by subsequent processing.

Many possible variations in core or surface characteristics and suitable combinations of sheath and core components will be apparent; the following example illustrates the preparation of yet another sheath-core yarn according to this invention.

EXAMPLE IV

In a four-liter stainless steel beaker equipped with an overhead air stirrer are placed 27.5 grams (0.175 mole plus 5% excess) bis(p-aminocyclohexyl)methane, 5.0 grams sodium lauryl sulfate ("Duponol ME"), 10.0 grams sodium hydroxide, 5.0 grams anhydrous sodium carbonate, 200 ml. washed and dried chloroform, and 1250 ml. water. To this stirred emulsion are added 43.7 grams (0.125 mole) biphenyl disulfonyl chloride dissolved in 130 ml. of washed and dried chloroform. The reaction mixture is stirred for 25 minutes, then 2,000 ml. n-hexane are added to break the emulsion. The granular precipitate is collected on a Büchner funnel, washed (three times with hot water, denatured alcohol, hot water, and ethanol in turn), and dried in a vacuum oven overnight at 70° C. The yield is 52 grams of a polysulfonamide; a 0.5% solution in dimethylformamide reveals an inherent viscosity of 1.13 at 25° C.

A 13% solution of this polymer in dimethylformamide is spun as the core of a two-component fiber in apparatus patterned on Figures 11 to 13, inclusive, under conditions similar to those of Example II with a 22% solution of the copolymer of Example II in dimethylformamide as the sheath fluid. The resultant yarn is drawn 320% in hot water. The physical properties of the drawn yarn in 90° water (indicative of the susceptibility of resultant fabrics to damage in laundering, dyeing, and other hot wet processing steps) are given in the table below and there compared to a one-component yarn made of the acrylonitrile copolymer itself.

Table

	Tenacity, g.p.d.	Elongation, Percent	Initial Modulus
Sheath-core yarn	1.35	6.2	4.7
Acrylonitrile methyl acrylate copolymer yarn	0.59	157.0	0.7

The sheath-core yarn displayed surface properties (i.e., dyeability and hand) of the acrylonitrile copolymer fiber yet had the strength and stiffness, particularly in a hot wet state, corresponding to the stronger and stiffer core material.

A simple extension of the above teachings permits manufacture of filamentary configurations having a single sheath surrounding a multiple core (by injection of more than one core-forming component through apertures above an extrusion orifice to whose entrance the sheath-forming component flows radially) and, further, configurations having an innermost core and an outermost sheath with one or more annular regions in between (by providing one or more additional stages in a sheath-core spinneret assembly, with a corresponding number of plates with aligned apertures or orifices). Requirements and permissible variations in holding and spacing means for the various plates, materials suitable for the parts of the illustrated and the suggested assemblies, and extrusion conditions will come readily to mind for persons skilled in the art of synthetic fiber manufacture and, thus, need no further explanation here. The benefits of the present invention in its many aspects will be apparent most fully to those undertaking to practice it.

The claimed invention:

1. In a spinneret assembly comprising a front plate containing a plurality of extrusion orifices and an opposing back plate spaced from the front plate thereby forming a fluid-carrying channel means positioned between said plates, the improvement comprising means defining constricted passageways communicating with said fluid-carrying channel means and the entrance of each orifice, each of said passageways communicating with an associated orifice at all points along the perimeter of the entrance to said orifice and impeding the flow of fluid substantially more than does the fluid-carrying channel means.

2. In a spinneret assembly comprising a front plate containing a plurality of extrusion orifices and an opposing back plate spaced from the front plate thereby forming a fluid-carrying channel means positioned between said plates, the improvement comprising means defining a constricted zone surrounding the entrance of each extrusion orifice formed by a protrusion in the form of a plateau on the opposing face of at least one of said plates, each of said constricted zones communicating with an associated orifice at all points along the perimeter of the entrance to said orifice and impeding the flow of fluid substantially more than does the fluid-carrying channel means.

3. The apparatus of claim 2 in which each extrusion orifice passes through one of said protrusions and the orifice entrance is positioned in the center of the plateau formed by the protrusion.

4. The apparatus of claim 2 in which the separation between the opposing faces of the plates provided by protrusions in the form of plateaus is less than the least transverse dimension of the extrusion orifices.

5. The apparatus of claim 2 in which the back plate contains at least one aperture communicating with the channel means.

6. The apparatus of claim 1 having an aperture in the back plate opposite each orifice in the front plate, a first-fluid supply chamber located behind the back plate and communicating with the apertures therein, and a second-fluid supply chamber communicating with the channel means.

7. The apparatus of claim 6 in which the second-fluid supply chamber is located behind the back plate.

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