Sept. 16, 1969 R. S. HECKROTTE 3,466,703

SPINNERET ASSEMBLY

Filed Aug. 11, 1967 2 Sheets-Sheet 1

FIG. 1

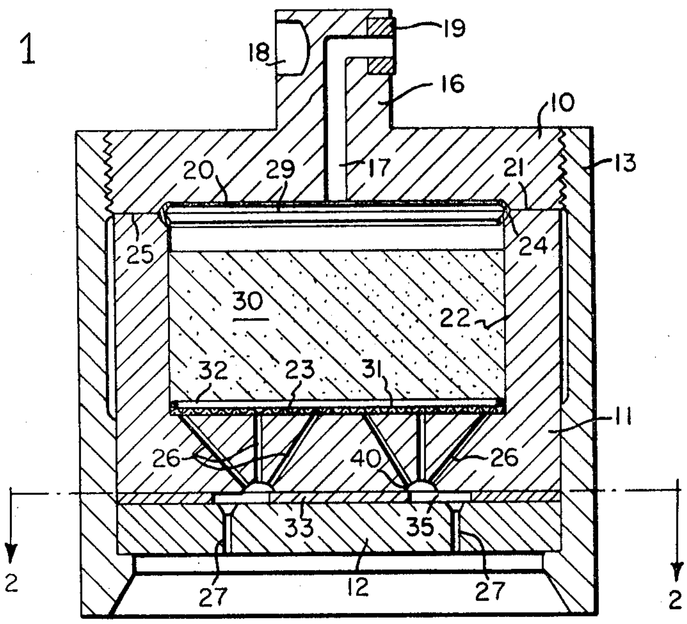


FIG. 2

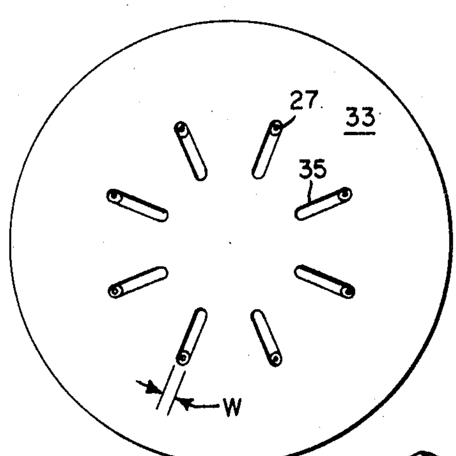
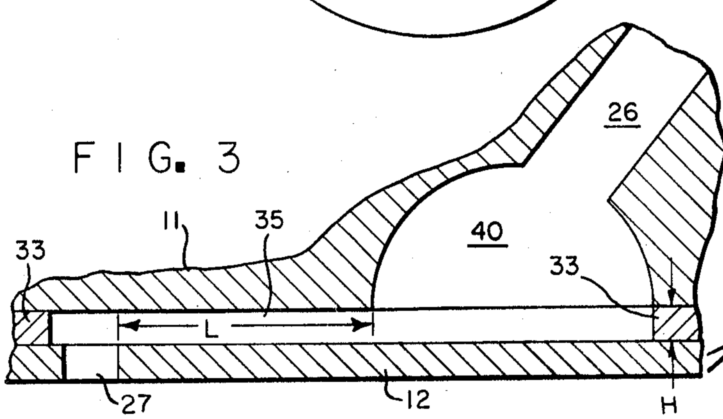


FIG. 3



INVENTOR
ROBERT S. HECKROTTE

Norris E. Rushman
ATTORNEY

Sept. 16, 1969 R. S. HECKROTTE 3,466,703

SPINNERET ASSEMBLY

Filed Aug. 11, 1967 2 Sheets-Sheet 2

FIG. 4

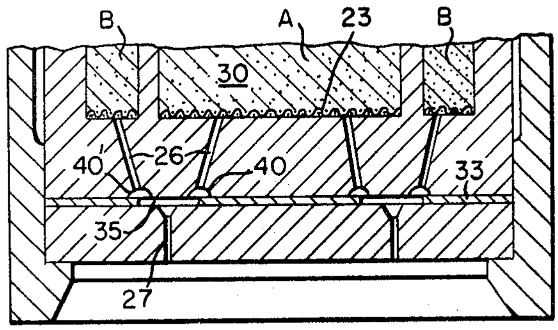


FIG. 5

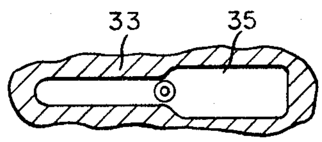


FIG. 6

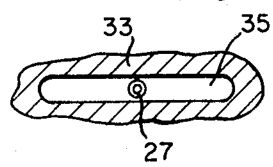
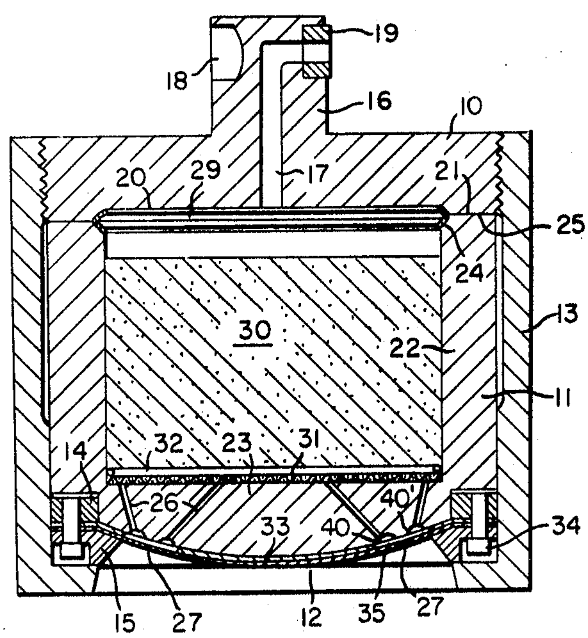


FIG. 7



INVENTOR
ROBERT S. HECKROTTE

BY Norris E. Ruckman
ATTORNEY

United States Patent Office 3,466,703
Patented Sept. 16, 1969

1

3,466,703

SPINNERET ASSEMBLY

Robert S. Heckrotte, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed Aug. 11, 1967, Ser. No. 660,019
Int. Cl. D01d *1/08;* B29f *3/12*
U.S. Cl. 18—8 4 Claims

ABSTRACT OF THE DISCLOSURE

Spinneret assemblies are disclosed which include a thin metal metering plate sealed between the spinneret plate and a support member having polymer-supply channels. An equal flow of polymer is metered to each spinning orifice, in the spinneret plate, through passages having rectangular cross sections formed by non-circular apertures in the metering plate which have a width of 1 to 12 times the diameter of the spinneret orifice. The length of an aperture is determined by the distance from the polymer-supply channel to the spinneret orifice, which is offset sufficiently to provide a metering passage length, measured between the nearest edges of the channel and orifice, of 0.4 to 12 times the spinneret orifice diameter. The metering plate has a thickness, in the range of 0.004 to 0.050 inch, which provides metering passages having an impedance to polymer flow at least as great as the spinneret orifice. The improved assembly provides more uniform spun filaments and is easy to clean. The metering plates may be readily produced by relatively inexpensive operations.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to spinnerets useful in the production of synthetic filaments by dry-, wet-, or melt-spinning procedures and more particularly to a spinneret assembly incorporating a thin metering plate.

Description of the prior art

In conventional methods for producing synthetic fibers, fluid polymer is extruded through tiny orifices located in a suitable spinneret plate. The freshly extruded polymer in its shaped filamentary form is then solidified by well-known methods. A single spinneret plate customarily contains many capillaries fed by a single supply conduit so that many fibers can be produced simultaneously from the same supply conduit. A problem associated with such a system is denier variability. In the case of bicomponent filaments, that is, those filaments containing two separate and distinct polymeric species in intimate adherence along their length, both species being spun from a single spinning capillary, the proportion of each species in the filaments invariably is nonuniform. Filaments with variable denier and those with unequal distribution of polymeric components are undesirable for many uses. Many schemes have been proposed to avoid these problems. Knowing that filament denier nonuniformity is oftentimes the result of certain orifices of a spinneret discharging a greater amount of polymer than other orifices, artisans have taken great care to match capillaries in single spinnerets. In addition, the metering function of the tiny, delicate spinneret capillaries has been purposefully lessened by use of upstream metering plates as is shown by Cobb in U.S. Patent No. 3,095,607, dated July 2, 1963, which meter fairly accurate quantities of polymer to individual spinning capillaries. However, none of the attempts to achieve a high degree of precision in matching orifices or to fabricate metering devices which meter polymer accurately have been completely satisfactory, either because of the expense of manufacture of the devices or because of the difficulty experienced in disassembly and cleaning the devices which is frequently necessary.

2

The present invention provides a spinning assembly for producing synthetic filaments having improved uniformity of denier. A second provision is a spinning assembly for producing bicomponent filaments in which the proportion of each polymeric species in the filaments is uniform. Another provision is a spinning assembly which is easy to disassemble and clean, the components of the assembly having no stagnation points or like passages. Other provisions will appear hereinafter.

SUMMARY OF THE INVENTION

These provisions are realized by an improvement in a spinneret assembly having a channeled support member and a spinneret for extrusion of fiber-forming material into a plurality of shaped filaments. The improvement comprises a thin apertured metering plate contactingly sandwiched between the support-member face and the spinneret, the apertures having a width in the area just upstream of the capillaries at least equal to the diameter of the spinneret capillaries, the members being arranged so that said apertures form metering passages having substantially rectangular cross sections of length to diameter ratios greater than 0.5, where the diameter is the hydraulic diameter of the passage, for metering the passage of fiber-forming material between the exits of said channels and the entrances of said capillaries in communication therewith, and said metering passages having a resistance to polymer flow therethrough which is at least as great as the resistance to flow offered by the spinneret orifice.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become clearer as the following specification progresses, reference being had to the accompanying drawings wherein:

FIGURE 1 is a side sectional view of an embodiment of the spinning assembly of the present invention, the section being taken along a plane including the central axis of the assembly.

FIGURE 2 is a sectional view taken along the lines 2—2 of FIGURE 1, showing the top face of the metering plate.

FIGURE 3 is a side sectional view of a metering aperture in conjunction with a spinneret capillary, the section being taken as in FIGURE 1.

FIGURE 4 is a side sectional view of a spinning assembly for spinning two-component fibers.

FIGURES 5 and 6 are outline views of alternate configurations for apertures in the metering plate.

FIGURE 7 is a sectional view of a spinning assembly using a thin metering disc in conjunction with a thin spinneret stretched transversely in its mounting.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGURE 1 of the drawings the major elements include a lid **10**, spinneret-supporting member consisting of a filter container or filter holder **11** and having channels **26**, a spinneret **12** and a metering plate **33**.

The lid **10** is provided with an upstanding web **16** which has an L-shaped flow passage **17** extending through the lid. Opposite flow passage **17**, web **16** has a depression **18** which accommodates a bolt or clamping lug on the spinning machine by means of which the assembly is supported so that the passage **17**, with its associated metallic gasket **19**, is held against a mating port of the manifold (not shown) through which liquid polymer flows to the assembly. On the lower side thereof, lid 10 has a circular recess 20 and an annular surface 21.

Filter holder 11 has a cylindrical side wall 22 and an internal annular recess which forms a ledge 24 and terminates in a surface 25 complementary to surface 21 on lid 10. The inner rim of surface 25 is chamfered so as to form a V-shaped groove with the similar formation on lid 10 when the surfaces 21, 25 are engaged. Bottom wall 23 has a plurality of distribution channels 26 extending therethrough which terminate in annular groove 40.

Spinneret plate 12 is provided with capillaries 27 through which liquid polymer is extruded to form filaments. The collar 13 is tubular and provided at one end with an inturned flange which engages the lower surface of spinneret plate 12. At its opposite end collar 13 is internally threaded for engagement with threads provided externally on lid 10.

The joint between surfaces 21, 25 is sealed by a band-shaped metallic gasket 29 which is seated between ledge 24 and lid 10. Within the filter holder 11 is a body of an inert filtering medium such as sand. The filtering medium 30 is supported and contained by a fine screen 31 which is held in place by a metal ring 32. Between filter holder 11 and spinneret 12 is sandwiched metering plate 33 having metering passages 35. Thus, polymer passes through channels 26, through passage 35 and extrudes in the form of filaments through spinneret capillary 27.

In FIGURE 2, metering plate 33 contains metering passages 35, through which the polymer flows radially, and which terminate at the spinneret capillaries 27. An oblong shape of passage is illustrated in FIGURE 2, but it can also be elliptical, circular or irregular when viewed as in FIGURE 2, provided that all of the passages are alike. It will be apparent that the passages will have substantially rectangular cross sections in any event.

In FIGURE 3 the critical passage 35 in which polymer is metered from distribution channel 26 to spinneret capillary 27 is shown. The length of this passage 35 is defined by L and its height is equal to the thickness H of the metering plate 33; the width W of the passage 35 is shown in FIGURE 2.

In FIGURE 4 a spinneret assembly, substantially similar to the assembly of FIGURE 1, is shown but into which two polymers are fed; one polymer is fed to chamber A, the other polymer is fed to chamber B. The two polymers pass through their respective channels 26 into annular grooves 40 and 40′, into metering passages 35 and merge just before they pass through and extrude from spinning capillaries 27 as single filaments.

In FIGURE 5 a metering passage 35 is shown having one portion of greater width W than another portion and thus, in the case of spinning two-component fibers as with the apparatus of FIGURE 4, making it possible to allow for differences in the flow rates of the two polymers or differences in polymer characteristics such as viscosity; the polymers merge (at the upstream portion of the spinning capillaries 27) at substantially the same pressure, materially different pressures at this merge point not being tolerable.

In FIGURE 7 another embodiment of the present invention is shown. The numbers apply to the same parts as the numbers of the apparatus of FIGURE 1. In this embodiment a very thin spinneret plate 12 is shown just underneath metering plate 33. The spinneret plate and the metering plate are stretched transversely in their assembly in the spinning pack. The bottom of the spinneret rests against ring 15 and is supported by rings 14 and 15 which are held together by bolts 34. In an embodiment such as this (FIGURE 7), in which a very thin spinneret is used, it is preferred to use a metering passage 35 of such proportions that the polymer pressure drop occurring in the passage or passages 35 is substantially in excess of the pressure drop occurring in the spinning capillaries 27, preferably by a factor of at least 2 to 1. The length of the capillaries is usually very short (owing to the use of a very thin spinneret 12), thus the pressure drop is usually small; however, it may be desired to minimize the pressure drop in the capillary 27 in which case the diameter (or equivalent hydraulic diameter of the capillary 27 if not round) should be made large in proportion to the height H and width W of the passage 35. Such a configuration provides energy release or pressure letdown in the metering passage 35, the resulting effect being to reduce the degree of bulging of the "carrot" that would normally appear in the polymer stream below the spinneret 12. Such a reduction is believed to be beneficial in reducing the birefringence of the spun fibers.

The apertured metering plates of the present invention may be constructed of any rigid material customarily used for devices which come into contact with polymer, stainless steel being preferred. The plates may be of from 0.004 to 0.050 inch (0.010 to 0.127 cm.) thick and are preferably about 0.010 inch (0.0254 cm.) thick.

The nonround passages in the metering plate provide a definite metering length for metering the passage of polymer therethrough. This metering length is taken to be the distance between the boundary wall of the support-member groove and the nearest edge of a spinning capillary, as designated in FIGURE 3 by L, and should be 0.4 to 12 times the spinneret orifice diameter and preferably 0.7 to 6.6. The thickness of the metering passages (designated as H in the same figure) is the thickness of the metering plate itself. The width W of the passages, noted in FIGURE 2, should be from 1 to 12 times their height H and is preferably at least twice their height H. The width W should also be from 1 to 12 times the diameter D of the capillary 27 and is preferably of the order of 1.1 to 4.0 times D. The pressure drop (ΔP) from the entrance to the exit of the metering apertures caused by flow impedance through the apertures is substantial in relation to other resistances to flow along the plurality of paths to the spinneret capillaries. The metering apertures should present, to fluid passing therethrough, an impedance at least as great as that presented by the spinning capillaries of the spinneret. Thus the new passages provide a true metering function in the process in which they are used.

It is seen that great accuracy of metering may be provided by the new passages because, as contrasted to conventional round cross-section metering passage of the prior art where the ΔP is proportional to the fourth power of the passage diameter and where it can be seen that slight variations in diameter affect metering accuracy substantially, the present plate has rectangular cross-section metering passages, ΔP being proportional only to about the third power of the plate thickness, which is easily made uniform by employing thin-rolled metal plate, small pieces of which, say less than 12 inches (30.5 cm.) in diameter, are very uniform in thickness. ΔP is also proportional to only about the first power of the passage width. Also, the new plate contains no blind elbows or the like which make cleaning onerous.

The L/D ratio, defined as the effective metering length (L of FIGURE 3) divided by the hydraulic diameter of the aperture in the area of L, should preferably be greater than 0.8 and, more preferably, greater than 1.0. L/D ratios up to 6.6 have been used with the new assembly. L/D ratios of up to 12 are possible. High L/D is beneficial because entrance effects of the polymer to the spinneret capillaries are less of a problem than with low L/D ratios.

Another advantage in using the new metering plates is that, because a substantial proportion of the metering is accomplished by these plates and the spinneret capillaries are relieved to a great extent from performing this function, larger capillary diameters may be used in spinning the same-count yarn at the same spinning speed. Large diameter capillaries are easier to make than conventional small diameter ones.

The spinneret used may be any of those conventional spinnerets useful in spinning synthetic high polymers to filaments. The spinneret plates may be of conventional thickness or they may be extremely thin, of the order of about 0.010 inch (0.025 cm.) thick, and stressed transversely to about 99.5% of the yield tension of their constituent metal, as shown in FIGURE 7.

An important advantage of the new apparatus is the denier uniformity obtained thereby. Another advantage is the ease of manufacture of the apparatus. The new thin metering plates may be made by milling, drilling, punching or even by photoetching procedures well known in the art. The plates are easy to disassemble and clean. Furthermore, bicomponent filaments produced for the apparatus of the present invention show extreme uniformity in their proportions of different polymeric species.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

I claim:

1. In a spinneret assembly which includes a spinneret plate having orifices for spinning polymer into filaments and a support member having channels for supplying polymer to the spinneret orifices; the improvement for metering the polymer to produce more uniform filaments wherein the improvement comprises, a thin metering plate sealed between the spinneret plate and support member, apertures in the metering plate forming metering passages for flow of polymer from said channels to the spinneret orifices, each orifice being interconnected to a channel by a separate metering passage, the nearest edges of channel and orifice being spaced from each other by a distance of 0.4 to 12 times the orifice diameter, each passage having a width from 1 to 12 times the diameter of the spinneret orifice and from 1 to 12 times the thickness of the metering plate, and the metering plate being of a thickness within the range of 0.004 to 0.050 inch which provides metering passages having a resistance to polymer flow at least as great as the spinneret orifice.

2. The spinneret assembly defined in claim **1** wherein said distance at which the nearest edges of channel and orifice are spaced is from 0.7 to 6.6 times the diameter of the spinneret orifice, the width of said metering passages is from 1.1 to 4.0 times the diameter of the spinneret orifice, and said metering plate has a thickness of about 0.010 inch.

3. The spinneret assembly defined in claim **1** wherein each spinneret orifice is interconnected to two polymer supply channels by said metering passages and the channels are arranged to supply different polymers for spinning bicomponent filaments.

4. The spinneret assembly defined in claim **1** wherein the spinneret plate has a thickness of about 0.010 inch and is stressed transversely in the assembly to about 99.5% of the yield tension of the constituent metal.

References Cited

UNITED STATES PATENTS

3,016,568 1/1962 Gagne.

WILLIAM J. STEPHENSON, Primary Examiner