

July 2, 1963

J. S. COBB, JR
SPINNERET ASSEMBLY

3,095,607

Filed July 10, 1962

2 Sheets-Sheet 1

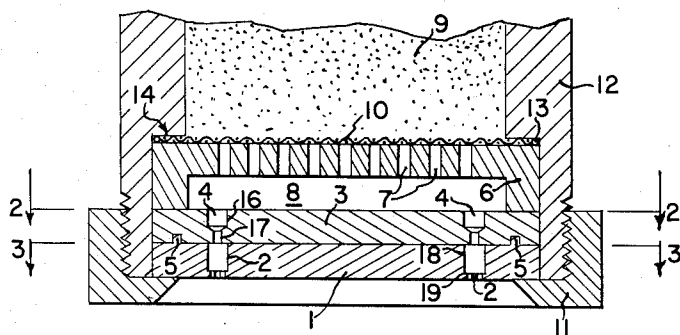


Fig. 1

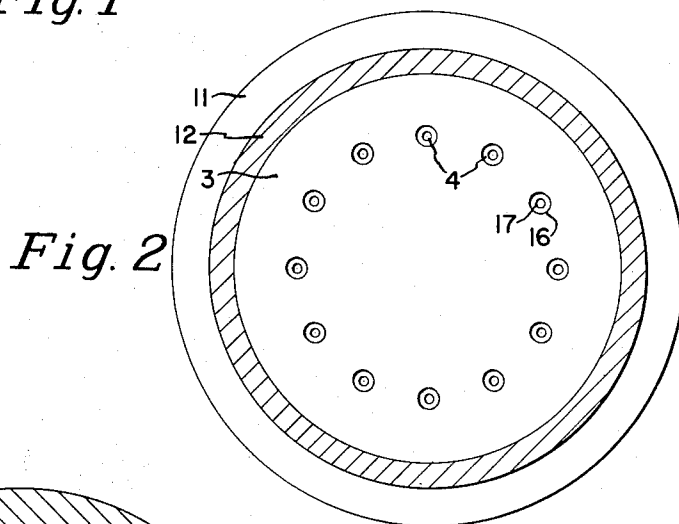


Fig. 2

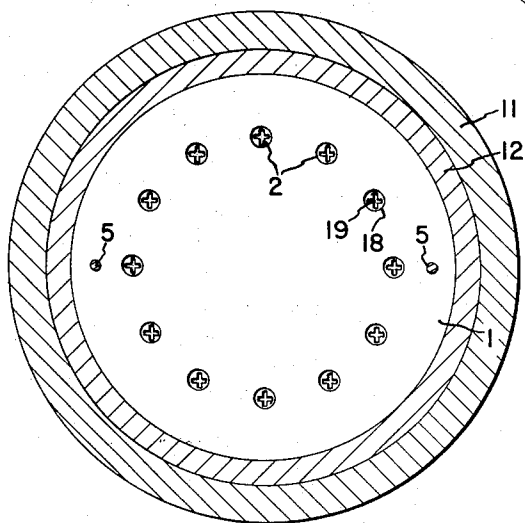


Fig. 3

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Fig. 4

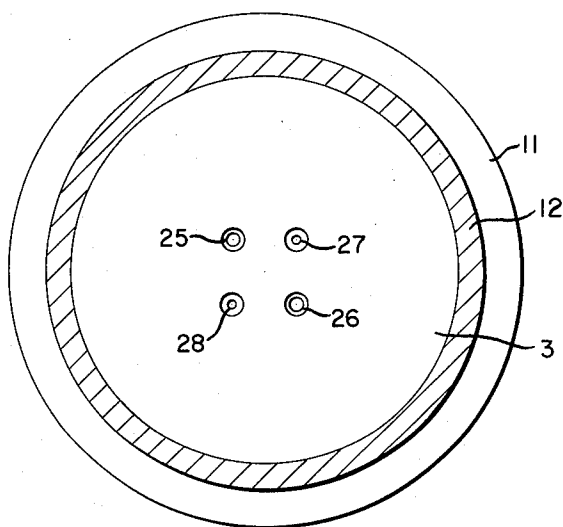
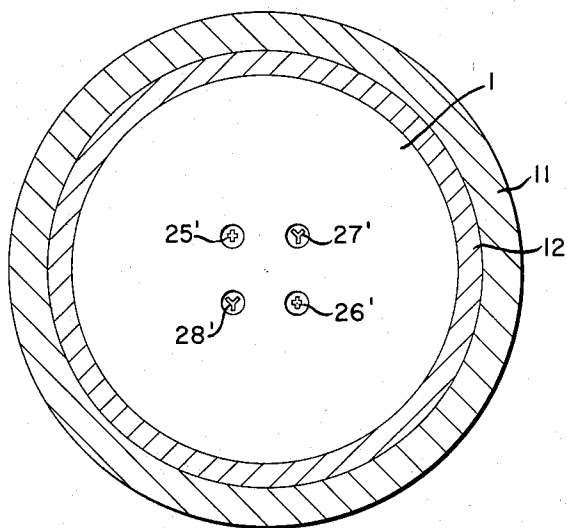


Fig. 5



INVENTOR
JAMES S. COBB, JR.

BY

Sol Schwartz

ATTORNEY

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James S. Cobb, Jr., Martinsville, Va., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed July 10, 1962, Ser. No. 208,748

4 Claims. (Cl. 18—8)

This invention relates to extrusion of fiber-forming compositions into filamentary form, concerning especially multifilament spinneret assemblies. This application is a continuation-in-part of application Serial No. 519,053, filed June 30, 1955.

Uniformity of filaments extruded or "spun" from a multiple-orifice spinneret is desirable because non-uniformity of denier, for example, is conducive to unevenness in drawing or other processing of the filaments and in dyeing and finishing of textiles composed of them. Interfilament variation in the product from any one spinneret often is attributable to differences in dimensions of its individual extrusion orifices. As might be expected, the problem is especially severe in spinnerets designed to produce filaments having cross sections other than circular, inasmuch as precision in formation of non-round orifices is difficult and expensive to achieve.

For some purposes such as described in U.S. Patent No. 2,980,492, one may wish to spin groups of filaments of different cross sections or different deniers from the same spinneret. However, even in those instances, interfilament variations within any one group is undesirable.

A primary object of the present invention is improvement in interfilament denier uniformity of synthetic multifilaments. An object is production of more nearly identical filaments from a multiple-orificed spinneret plate without altering the plate. A further object is the production of groups of substantially identical filaments (within each group) from a multiple-orificed spinneret plate. Other objects of this invention, 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 of a spinneret assembly embodying the present invention. FIGURE 2 is a transverse section of the apparatus of FIGURE 1, taken at 2—2 thereof and showing the plan of a metering element of this invention located directly behind the spinneret plate. FIGURE 3 is a transverse section taken at 3—3 to show the plan of the spinneret plate. FIGURE 4 is a schematic representation showing a further embodiment of a metering plate of the invention. FIGURE 5 is a schematic representation of a spinneret plate which may be used in conjunction with the plate of FIGURE 4.

In general, the objects of the present invention are accomplished by supplying fiber-forming composition to the entrance of the orifices of a multiple-orificed spinneret directly from the exit of corresponding apertures of a multiple apertured metering plate designed to impede passage of the composition uniformly and to a much greater extent than the spinneret plate does. Thus, the invention comprehends a spinneret assembly comprising a spinneret plate having a plurality of orifices and a metering plate juxtaposed to the back or up-stream face of the spinneret plate and having apertures communicating with the orifices thereof, the metering plate being adapted to transmit liquid equally through each of its apertures and to impart to the liquid a pressure differential at least twice the pressure differential imparted to the same liquid flowing to the same extent through the orifices of the spinneret plate. The application of this concept to the production of groups of filaments differing in shape and/or denier between groups but substantially identical within each

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group can readily be accomplished in an analogous manner. For example, molten polymer may be supplied to a group of similar orifices (with regard to both size and shape) of a spinneret having at least one other group of orifices of a different size and/or shape. The polymer is fed directly from the exits of a group of corresponding apertures of a metering plate having at least one other group of apertures of a different size communicating with the other groups of orifices. The metering plate is thus adapted to transmit liquid equally through each of its apertures in the group while providing the high pressure differential referred to above.

As illustrated, this invention is embodied conveniently in an otherwise conventional spinneret assembly designed for extruding cruciform multifilaments. FIGURE 1, which represents a spinneret assembly sectioned along its flow axis, shows spinneret plate 1 with orifices 2, adjacent metering plate 3 with apertures 4, and contacting cupped distribution plate 6 with holes 7—located up-stream from one another in that order inside the end of cylindrical housing 12 and retained therein by open cap 11 threaded onto the housing. Pins 5 on the top face of the spinneret plate are recessed into the opposing bottom face of the metering plate. Distribution space 8 is present between the opposing faces of the metering and distribution plates. The upstream face of the distribution plate is in contact with screen 10, which—along with gasket 13 at its peripheral edge—rests against shoulder 14 of the housing. The body of the housing (shown only in part) is filled with filtering medium 9, which is retained by the screen from entering the holes in the distribution plate.

Both the metering apertures and the spinning orifices illustrated have compound shapes, each aperture 4 consisting of capillary 17 and counterbore 16 and each orifice consisting of counterbore 18 and jet 19. As shown in FIGURE 2, the metering plate has twelve of these apertures arranged in a circle concentric with the circular plate; the capillaries and the counterbores are both circular, the counterbore area being quite a few times as large as the capillary area. The corresponding transverse view of the spinneret plate shows twelve similarly located extrusion orifices; the circular counterbore of each orifice gives way to a cruciform jet at the bottom or downstream end. In the assembled structure with the locating pins properly recessed into both locations in the face of the metering plate, the entrance to the counterbore of a spinning or extrusion orifice is coterminous with the exit from a metering capillary, of course. As shown in the various views, the metering capillaries are both smaller in transverse area and deeper or longer than the cruciform jet portion of the spinning orifices, dimensional differences in the respective counterbores being relatively insignificant.

The metering plate of FIGURE 4 has four apertures arranged in a square. Apertures 25 and 26 (group 1) are identical to each other and apertures 27 and 28 (group 2) are identical to each other but have smaller capillary areas than the apertures in group 1. The capillaries and counterbores are all circular. The corresponding view of the spinneret plate of FIGURE 5 shows four similarly located extrusion orifices. Orifices 25' and 26' are similar in size and of cruciform shape. Y-shaped orifices 27' and 28' are similar in size to each other and are substantially larger than orifices 25' and 26'. When the structure is assembled, the entrances to the counterbores of extrusion orifices 25', 26', 27' and 28', are coterminous with the respective exits from metering capillaries 25, 26, 27, and 28.

In an example of the use of apparatus like that illustrated in FIGURES 1–3 (except for the number of extrusion orifices and metering apertures), metering and spinneret plates measuring about 3 inches in diameter and ¼ inch thick are employed in extrusion of ten filaments

from polyhexamethylene adipamide of 39 relative viscosity, melted from flake and extruded as described by Waltz in Patent 2,571,975. The 10 extrusion orifices and the aligned metering apertures are spaced evenly on an inch radius. Each metering capillary is 0.025 inch in diameter and 0.187 inch in length or depth; the cruciform portion of each spinning orifice is composed of perpendicular slots each 0.050 inch long, 0.003 inch wide, and 0.012 inch deep. Spun and quenched conventionally at about 460 yards per minute, the individual filaments average 64 denier, with maximum interfilament spread of ± 3.2 denier. Curtain fabric made of the filaments after subsequent customary drawing exhibits no defect in dyeing and use. Repetition of this procedure with the same assembly lacking only the metering plate (replaced by a spacer ring) produced filaments of the same average denier but with a spread of ± 12 denier; the non-uniformity of these filaments gave rise to a much higher frequency of breaks in the drawing operation than was experienced with those made with the assembly using the metering plate. Comparison of the pressure drops in the two devices at identical throughputs of polymer indicated that the pressure differential attributable to the metering plate was several times the pressure differential attributable to the spinneret plate alone.

In general, for a uniform perforation straight through a plate the associated pressure differential will be directly proportional to the thickness of the plate and inversely proportional to the square of the area of the perforation; various deviations from such a relationship will be apparent with irregular openings and at viscosity extremes. For the purposes of the present invention the metering apertures not only should be as nearly identical to one another as practicable but also should present to fluid passing therethrough an impedance at least about twice as great as presented by the spinning orifices. Of course, where there are multiple groups of apertures corresponding to multiple groups of orifices wherein the groups of orifices differ from each other with respect to size and/or shape, the apertures of any single group should be as nearly identical to one another as practicable. Where a metering aperture is counterbored, as shown, the capillary is the substantial flow-impeding or "metering" element; these apertures may be formed in known manner by drilling or punching, or a combination of the two. Broach-burnishing with an appropriately sized steel ball or ball-shaped broach is conducive to surface smoothness and diametral regularity of the metering capillaries; of course, a metering aperture may be all capillary where plate strength or support is adequate to prevent distortion under spinning pressure, and where counterboring is not utilized as a fine control on impedance (through variation in capillary length).

Although the invention is illustrated in a spinneret assembly designed to produce cruciform filaments, such filamentary shape is not critical, of course. As illustrated, the spinneret may have a plurality of cruciform-shaped orifices intermingled with a plurality of Y-shaped orifices. In this instance, the metering apertures aligned with the Y-shaped orifices may have one size while those apertures aligned with the cruciform-shaped orifices may have another size. In similar manner, filaments of several different cross sections, including round, may be spun from a single spinneret with good control of filament denier. As suggested above, however, the utility is greatest where high uniformity of extrusion orifices is most difficult to achieve. Accordingly, the benefits of its use are somewhat less spectacular with spinneret plates having circular orifices. Of course, in some fabrics made from single filaments segregated in drawing or windup small discrepancies become quite noticeable as barré or dyeing streaks; this kind of non-uniformity is especially objectionable in knitted goods, such as stockings.

The simplicity and compactness of the metering means is especially advantageous; no matter how closely spaced the orifices of a spinneret are, a metering aperture can be aligned with each orifice. Of course, no disturbing side flow should occur along the opposing faces of the metering and spinneret plates, which most suitably are maintained in lapped contact, especially in the extrusion of liquids of low viscosity. It may be advantageous, as in the formation of highly irregular filamentary configurations, to provide more than one metering aperture per extrusion orifice; this has the additional effect of reducing the likely effect of minor discrepancies in sizing of the metering apertures.

This invention is applicable to spinneret assemblies for dry-spinning and wet-spinning, as well as for the extrusion of molten fiber-forming compositions, as exemplified above by the most widely known nylon composition. It is especially helpful in melt-spinning, however, where conditions of temperature and pressure are conducive to deterioration of the spinneret orifices. Many well-known polyamides, copolyamides, polyesters and copolyesters customarily are extruded by that method.

What is claimed is:

1. In a spinneret assembly for the extrusion of fiber-forming material into a plurality of shaped filaments by passage through a bank of non-circular orifices in a spinneret plate, the improvement comprising a metering plate directly adjacent the upstream face of the spinneret plate and having a plurality of substantially identical circular apertures therein in alignment with said orifices, each aperture communicating directly with a single orifice, the apertures providing substantially equal flow of fluid to the respective orifices with which they are aligned and providing a resistance to flow of fluid at least twice the resistance offered by the orifices of the spinneret plate to the same fluid flowing to the same extent through the orifices.

2. The apparatus of claim 1 in which the orifices of the spinneret plate are cruciform in cross section.

3. The apparatus of claim 1 in which the orifices of the spinneret plate are Y-shaped in cross section.

4. In a spinneret assembly for the extrusion of fiber-forming material into a plurality of shaped filaments by passage through a bank comprising multiple groups of orifices in a spinneret plate, at least one of said groups being non-circular orifices, the improvement comprising a metering plate directly adjacent the upstream face of the spinneret plate and comprising multiple corresponding groups of circular apertures therein with the apertures in each group being substantially identical to each other, and in alignment with the corresponding group of orifices, each aperture communicating directly with a single orifice, the apertures in any one group providing substantially equal flow of fluid to the respective orifices with which they are aligned and providing a resistance to flow of fluid at least twice the resistance offered by the orifices of the spinneret plate to the same fluid flowing to the same extent through the orifices.

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