Sept. 1, 1970 MASAO MATSUI ET AL 3,526,019

SPINNERET FOR CONJUGATE SPINNING

Filed June 21, 1967 4 Sheets-Sheet 1

Fig. 1

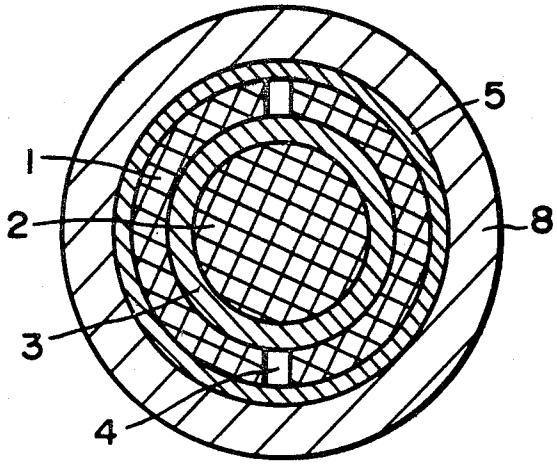
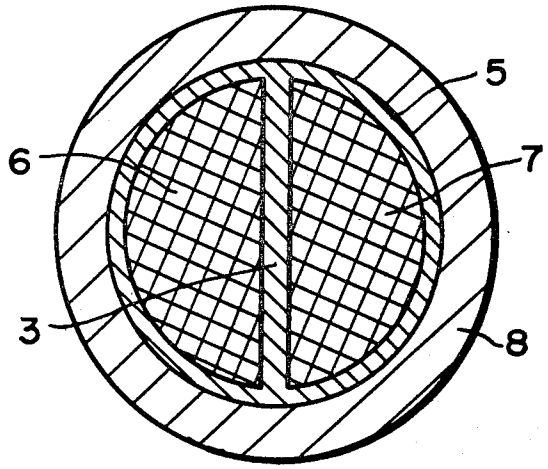


Fig. 2



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SPINNERET FOR CONJUGATE SPINNING

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Fig. 3

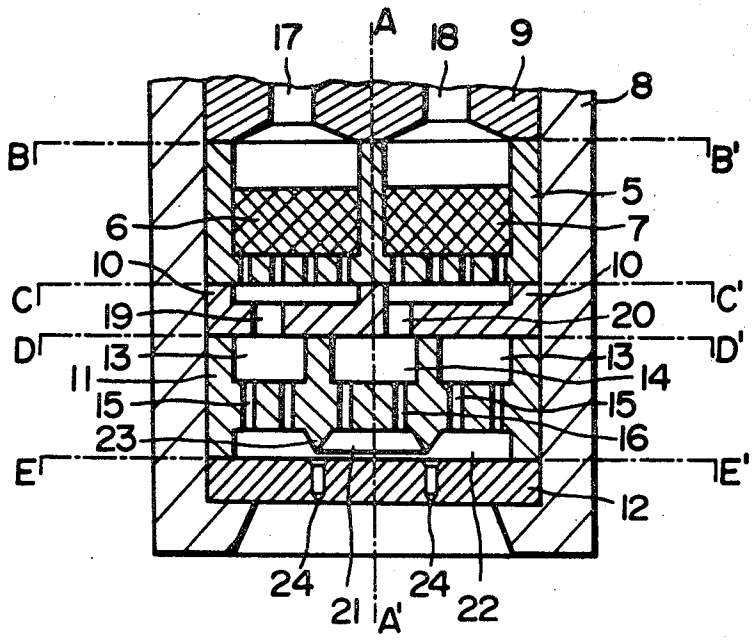
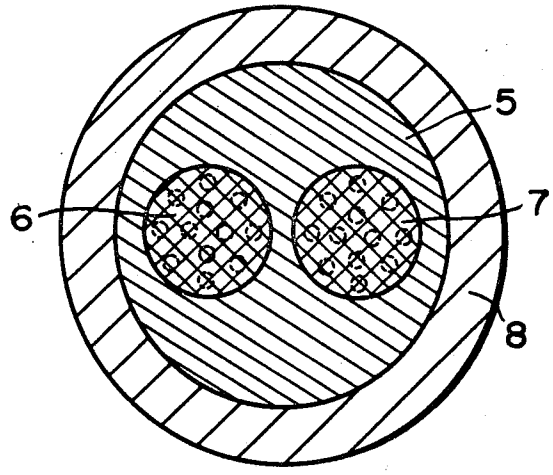


Fig. 4



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SPINNERET FOR CONJUGATE SPINNING

Filed June 21, 1967 4 Sheets-Sheet 3

Fig. 5

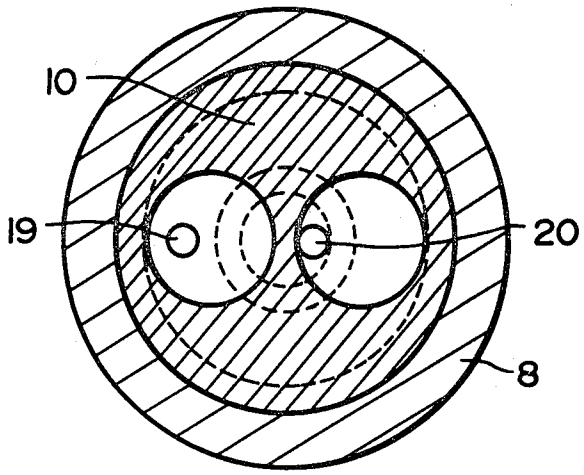
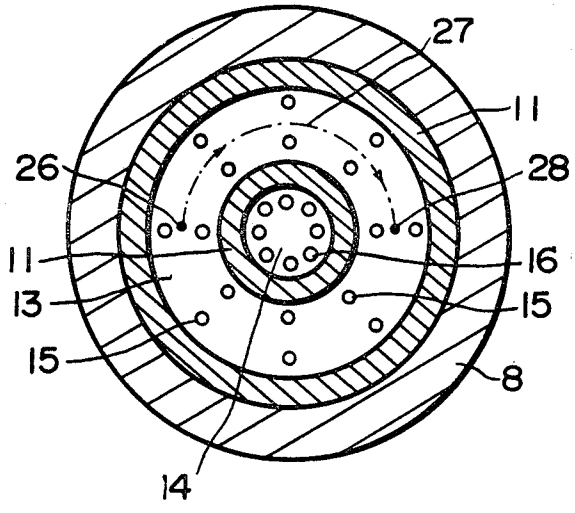


Fig. 6



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Fig. 7

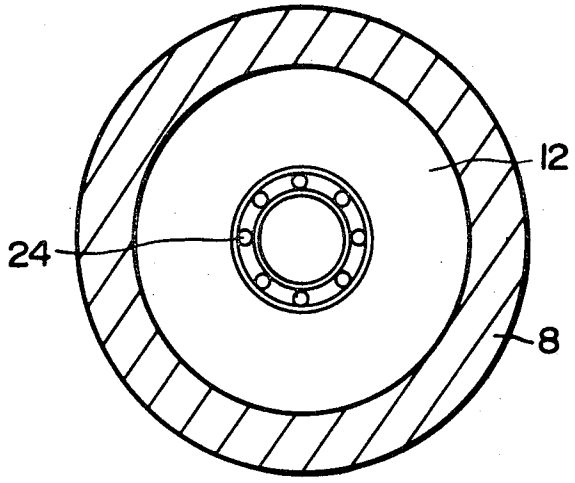
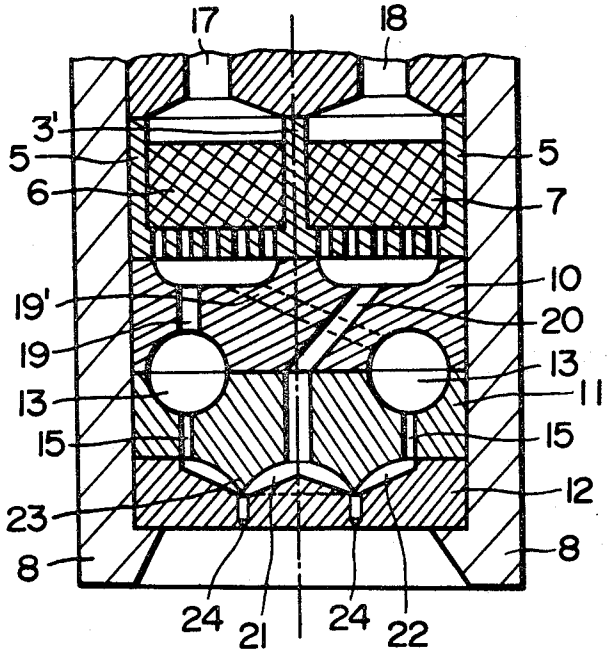


Fig. 8



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SPINNERET FOR CONJUGATE SPINNING

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Int. Cl. D01d 1/10
U.S. Cl. 18—8 8 Claims

ABSTRACT OF THE DISCLOSURE

A spinneret for conjugate spinning, in which a distributing mechanism for feeding two spinning solutions supplied from filter block to each orifice on a spinneret plate is provided between the filter block having two eccentrically arranged filters and a spinneret plate provided with a plurality of orifices arranged on its circumference, said distributing mechanism being constituted with main distributing channel and subdistributing channel and the sizes of said distributing channels being determined so as that a particular definition is satisfied.

The present invention relates to a spinneret for conjugate spinning, more particularly an apparatus for simultaneously extruding composite two-component filaments through a plurality of orifices arranged on a circumference of spinneret.

In production of two-component filaments, it is an important problem whether the filaments extruded through a plurality of orifices have uniform fineness, conjugate ratio and conjugate form or not. For this purpose, pressures to two spinning solutions subjected to each orifice must be equal between the orifices respectively.

Generally, a filter to filtrate a spinning solution is housed in a spinneret in order to facilitate assembling and replacement and therefore a spinneret for spinning two-component filaments houses two filters and in this case a concentric arrangement (concentric type) and an eccentric arrangement (eccentric type) are considered as the arrangement of the filter.

For a better understanding of the invention, reference is taken to the accompanying drawings, wherein;

FIG. 1 is a cross-sectional view of a conventional well-known concentric type of filter block;

FIG. 2 is a cross-sectional view of a typical eccentric type of filter block used in the spinneret of the present invention;

FIG. 3 is a longitudinal-sectional view of a concrete embodiment of the spinneret of the present invention;

FIGS. 4 to 7 are cross-sectional views of the spinneret shown in FIG. 3 taken on lines B–B′, C–C′, D–D′ and E–E′, respectively; and

FIG. 8 is a longitudinal-sectional view of another embodiment of the spinneret of the present invention.

When a spinning solution, after being filtrated with an eccentric type of filter, is supplied into a plurality of orifices arranged on a circumference of a spinneret, a stream of the solution is biased and it is difficult to obtain uniform two-component filaments, so that a concentric type of filter has been hitherto used mainly.

FIG. 1 is a cross-sectional view of a filter block of a conventional well-known spinneret and shows a concentric type of filter. In such a concentric type of filter, an outer filter **1** and an inner filter **2** of a filter portion are separated with a cylindrical partition **3**, but it is necessary to fix said partition to a peripheral wall **5** of a spinneret with supporting bars **4** in order to support said partition,

so that the concentric type of filter has such disadvantages that the construction is complicated and the filtering area is small.

FIGS. 2 and 4 show eccentric type filters, in which filters **6** and **7** are eccentrically arranged. Such an eccentric type of filter is easy to produce and if desired, the filtering area may be enlarged.

When the filter portion is concentrically divided into two portions with a circular partition as shown in FIG. 1 and the filter portion is eccentrically divided into two portions with a linear partition as shown in FIG. 2, wherein a radius of the filter portion is R and a width of the partition is T, the filtering area is approximately calculated as follows respectively. (Provided that areas of the divided filter portions are approximately equal respectively.)

$$\text{Concentric type: } \pi R^2 - \frac{2}{\sqrt{2}}\pi RT$$

$$\text{Eccentric type: } \pi R^2 - 2RT$$

For example, if R is 5.0 cm. and T is 0.8 cm., the filtering area in concentric type is about 60.7 cm.^{2} and in eccentric type about 70.5 cm.^{2}.

In a spinneret for two-component filaments the filtering area of one-component is approximately one-half that of a spinneret for single component filament, so that it is particularly required to increase the filtering area as far as possible. Notwithstanding an eccentric type of filter is preferable in order to increase the filtering area, it is difficult as mentioned above that the spinning solution, after being filtrated, is uniformly distributed and supplied to a plurality of orifices arranged on a circumference of the spinneret, so that the disadvantageous concentric type of filter has been necessarily adopted in most cases.

The object of the present invention is to extrude a plurality of two-component filaments having uniform conjugate ratio, conjugate form and fineness through a plurality of orifices arranged on the circumference by using a spinneret housing eccentric type filter.

Another object of the present invention is to provide a spinneret for conjugate spinning, in which the construction is relatively simple, the production and treatment is easy and the operational efficiency is excellent.

The present invention consists in a spinneret for conjugate spinning of the present invention comprising a filter block having two eccentric arranged filters, a spinneret plate provided with a plurality of orifices arranged on its circumference and a distributing mechanism between said filter block and said spinneret plate by which two spinning solutions supplied from the filter block are distributed to each orifice on the spinneret plate, characterized in that said distributing mechanism is a distributor consisting of a main distributing channel and subdistributing channel and having a distribution efficiency of more than 90%.

Referring to the accompanying drawings, the spinneret of the present invention consists essentially of five blocks arranged one upon the other in a case **8**, that is, a spinning solution supplying block **9**, a filter block **5**, an eccentric distributing block **10**, a concentric distributing block **11** and a spinneret plate **12** as shown in FIG. 3. The eccentric distributing block **10** and the concentric distributing block **11** constitute a distributor and said distributor further consists of an outer main distributing channel **13**, outer subdistributing channels **15** and center connecting aperture **14**. In the embodiment shown in FIG. 3, the center connecting aperture consists of an inner main distributing channel **14** and inner subdistributing channels **16**. The chain line A–A′ is a center line of the spineret and the concentric circular structure in which this straight line is a center axis is referred to as concen-

tric and the other structure is referred to as eccentric. In this case, the case **8**, the concentric distributing block **11** and the spinneret plate **12** are concentric and the other portions are eccentric.

Two spinning solutions are supplied from guide holes **17** and **18** in the spinning solution supplying block **9**, then filtrated with two eccentric filters **6** and **7** in the filter block **5** and thereafter introduced into the outer main distributing channel **13** and the inner main distributing channel **14** in the concentric distributing block **11** through connecting apertures **19** and **20** in the eccentric distributing block **10**. The two spinning solutions left from a distributor are introduced into upper spaces **21** (inner space) and **22** (outer space) on the spinneret plate **12** and bonded through a top of an annular separating plate **23**, and then extruded through a plurality of orifices **24** arranged along a circumference on the spinneret plate **12** to form filaments.

FIG. 4 is a cross-sectional view of the spinneret shown in FIG. 3 taken on line B–B′ in the arrow direction. The two circular filters **6** and **7** are eccentrically arranged in the filter block **5**. This type of filter has an advantage by which the production is very easy.

FIG. 5 is a cross-sectional view of the spinneret shown in FIG. 3 taken on line C–C′ in the arrow direction. A connecting aperture **19** joins the filter **6** to the outer main distributing channel **13** and a connecting aperture **20** joins the filter **7** to the inner main distributing channel **14**.

FIG. 6 is a cross-sectional view of the spinneret shown in FIG. 3 taken on line D–D′ in the arrow direction. The inner main distributing channel is a circular space **14** and the outer main distribtuing channel is an annular space **13**. Namely, the outer main distributing channel is constituted with an annular path of a square cross section. The inner subdistributing channel has eight small holes **16** and the outer subdistributing channel has sixteen small holes **15**.

FIG. 7 is a cross-sectional view of the spinneret shown in FIG. 3 taken on line E–E′ in the arrow direction and shows the upper plane of the spinneret plate **12**. Eight orifices **24** are arranged on a circumference of the spinneret plate.

The function of the distributor is shown by a distribution efficiency of the following equation.

$$\text{Distribution efficiency}=\left(1-\frac{X}{y}\right)\times 100(\%) \quad (1)$$

X: maximum pressure loss in the main distributing channel (dyne/cm.^{2})

y: pressure loss in the subdistributing channel (dyne/cm.^{2})

For example, the pressure loss until the spinning solution supplied from a connecting aperture **19** to a point **26** shown in FIG. **6** reaches a point **28** along line **27** is the maximum pressure loss in the main distributing channel. In order to increase the distribution efficiency it is desirable that a cross-sectional area of the main distributing channel is enlarged and a cross-sectional area of the subdistributing channel is reduced. As the result of the experiment, it has been found that two component filaments having an excellent uniformity are obtained when the distribution efficiency is more than 90%. A pressure loss in a distributing channel is shown in Hagen-Poiseuille's equation when a cross section form of said channel is a circle.

$$\text{Pressure loss } \Delta P=\frac{8QL}{\pi R^4}\eta \quad (2)$$

Q: stream amount of unit time (cm.^{3}/sec.)
R: radius (cm.)
L: length (cm.)
η: viscosity (poise)

For example, if the subdistributing channels are present at an equal interval of L in the main distributing channel

of circular cross section having a radius of R and the stream amounts of all the subdistributing channels are approximately same and q, the pressure loss ΔPN between No. N subdistributing channel of counted from the last to No. N+1 can be approximately represented by the following equation.

$$\Delta PN=\frac{8NqL}{\pi R^4}\eta \quad (3)$$

Therefore, if the number of the subdistributing channels is m, the maximum pressure loss of the main distributing channels X can be approximated by the following equation.

$$X=\sum_{n=1}^{m}\Delta PN=\frac{8qL}{\pi R^4}\eta\frac{m(m+1)}{2} \quad (4)$$

Thus, if radius and length of the subdistributing channel are r and l respectively, the distribution efficiency is shown by the following equation.

$$\text{Distribution efficiency }(\%)=\left\{1-\left(\frac{r}{R}\right)\frac{4L}{l}\,m\frac{(m+1)}{2}\right\}\times 100 \quad (5)$$

The distribution efficiency may be approximately calculated in this manner, but in order to manufacture the actual distributor, the dimensions of the main distributing channel having a circular cross section and the subdistributing channel are determined so as that the distribution efficiency is more than 90% and the cross-sectional form of the main distributing channel is one which circumscribes the above circle of the main distributing channel. Conversely speaking, it is sufficient when the distribution efficiency of the distributor consisting of a cylinder which inscribes the cross-sectional form of the main distributing channel and the subdistributing channels is more than 90%.

For the spinning solution of the inside the distributing channel is not always necessary.

FIG. 8 is one embodiment of the spinneret in which the spinning solution of the inside is concentrically fed by the center connecting aperture without the main distributing channel. In FIG. 8, two spinning solutions are passed through two filters **6** and **7** arranged eccentrically from supplying holes **17** and **18** and then introduced into an outer main distributing channel **13** through a connecting aperture **19** and into a connecting aperture **20**, which connects to the center connecting aperture opening to the inner space **21** on the spinneret plate respectively. The main distributing channel **13** and the subdistributing channel **15** have circular cross sections and the distributor having such a structure is simple, the manufacture is easy and further the dead space is small, so that such a distributor is most preferable. If the outer connecting aperture **19′** (indicated as the dotted line in FIG. 8) is provided in addition to the connecting aperture **19**, the distribution efficiency may be further increased.

For example, if radius R of cross section in the main distributing channel **13** is 10 times radius r of the subdistributing channel, the length l of the subdistributing channel is equal to the interval L and number m of the subdistributing channels is 10, the distribution efficiency is presumed approximately 99% by using the Equation 5. For example, in order to make the distribution efficiency more than 90% in m=10 and l=L, it is desirable that the ratio (R/r) of the radius R of the main distributing channel to a radius r of the subdistributing channel is approximately more than 5.

Many distributing mechanisms for concentrically distributing eccentrically supplied two spinning solutions have been previously proposed.

However, in all of them the distributor is constituted with a space formed by an upper surface on the spinneret plate and a separating plate and there has never

been the spinneret provided with a distributor for the distribution only according to the present invention. Furthermore, in order to increase a distribution ability of upper space on the spinneret plate it is necessary to extremely enlarge the space volume, but in most cases the enlarged space becomes a dead space (stagnation), so that the effect does not increase so high and also it is not preferable in view of the yarn property that the stay time of the spinning solution is longer.

On the contrary, the spinneret provided with a distributor on the upper portion of the spinneret plate according to the present invention has an extremely excellent distributing function as compared with a conventional spinneret.

Namely, a conventional distributing mechanism has a one-step distributor, while the distributing mechanism of the present invention has series two-step distributor.

Of course, in a one-step distributor and multi-step distributor it will appear that the multi-step distributor has an extremely higher function than the one-step distributor.

As the spinneret of the present invention is constituted as described above, even if, an eccentric type of filter having a high filter efficiency is used, two spinning solutions can be uniformly distributed to concentric orifices with a high filter efficiency and therefore the composite filament produced by using this spinneret has uniform conjugate ratio, conjugate form and fineness. Furthermore, the spinneret of the present invention is comparatively simple in the structure, so that there are advantages in which the treatments such as manufacture, assembling, disassembling, preservation, etc., are facilitated and the increase of filter efficiency enhances the operation ability.

In order to measure the distribution efficiency of the distributor experimentally, the spinning solution is flowed in the distributor and the stream amounts (cc./min.) of the solution flowed out from each subdistributing channel are measured and the maximum value is represented by $Q_{max.}$ and the minimum value is represented by $Q_{min.}$. Then said distribution efficiency is calculated by the following Equation 6

$$\text{Distribution efficiency} = \frac{Q_{min.}}{Q_{max.}} \times 100(\%) \qquad (6)$$

In the above described Equation 1, the distribution efficiency is shown as function of pressure loss, but the stream amount is in proportion to the pressure, so that the Equation 6 is the same as the Equation 1 as shown in the following:

$$\frac{Q_{min.}}{Q_{max.}} = \frac{X-y}{X} = 1-\frac{y}{X}$$

For example, when the distribution efficiencies of the distributors of the spinnerets in FIGS. 3 and 8 are determined practically, the spinneret plates are removed and the stream amounts flowed out from each subdistributing channel are measured.

Furthermore, when the distribution efficiency is calculated in approximation according to the Equation 5, if the value is negative, the spinning solution is not flowed out from some openings in the sub-distributing channels and such a spinneret has substantially no function as the distributor.

The invention will be further explained in detail by the following example.

EXAMPLE

By using Nylon-6 having a number average polymerization degree of 130, which contains no pigment and the Nylon-6 containing 1.5% by weight of powdery titanium oxide as a pigment, spinning test was made with respect to various spinnerets. Both the polymers were melted separately and fed to the conjugate spinning spinneret by gear pumps respectively. The amounts of the melted polymers fed by both the gear pumps were same, accordingly, the average conjugate ratio of the two polymers is 1:1. The used spinneret plate was provided with 18 orifices having a diameter of 0.3 mm., which were arranged in equal intervals on a circumstance having a diameter of 6 cm. The size of filaments, which were spun, cooled and wound, was 280 deniers/18 filaments.

The test was made by the following four spinnerets.

Spinneret I: Housing concentric filters and having no distributor.

Spinneret II: Structure as shown in FIG. 8, which houses eccentric filters (provided that there is no channel **19'**).

Radius of cross section in the outer main distributing channel **13** (R)=1 cm.
Central axes in the main distributing channel forms a circle having a diameter of 8 cm.
Radius of subdistributing channel **15** (r)=0.1 cm.
Length of the subdistributing channel=1 cm.
16 subdistributing channels are arranged in equal intervals on the main distributing channel.
Interval of subdistributing channels
(L)=½π
m=about 7

Spinneret III is substantially the same as the spinneret II, except that radius of the cross section in the main distributing channel (R) is 0.5 cm.

Spinneret IV is substantially the same as spinneret II, except that radius of the cross section in the main distributing channel (R) is 0.4 cm.

Spinneret V is substantially the same as spinneret II, except that radius of the cross section in the main distributing channel (R) is 0.3 cm.

The values calculated the distribution efficiencies by the Equation 5 and the found values in each spinneret are shown in Table I, provided that the found values were determined by removing the spinneret plates and measuring the stream amounts flowed out from each subdistributing channel to determine the maximum value and the minimum value and using the Equation 6.

TABLE I

Spinneret	Calculated value	Found value
I	(100)	
II	99.6	97
III	93	94
IV	83	86
V	46	52

The above described two polymers were conjugate spun by using these spinnerets and the resulting filaments were wound up and then the cross-sectional areas of the individual filaments were checked by microscope and the ununiformities of the conjugate ratio were determined. The result is shown in the following Table II.

TABLE II

Spinneret	Conjugate ratio: Average	Conjugate ratio: Standard deviation, percent
I	1.00/1.00	5.2
II	1.00/1.00	4.8
III	1.00/1.00	6.0
IV	1.00/1.00	11.7
V	100/100	18.1

In this deviation, for example, a filament having a conjugate ratio of 1.05/0.95, is shown as 5% of the deviation from the average value.

As seen from the above table, when the distributor having a higher distribution efficiency is used, uniform filaments can be obtained, but in general, the uniformity of the conjugate ratio in the spun filament also depends upon the structure of the filament, so that it is impossible to calculate directly distribution of the conjugate ratio of the spun filaments from the distribution efficiency of the distributor.

However, it is very easy for the efficiency of the distributor to make more than 90% and it is desirable to

manufacture a distributor having a distribution efficiency, which is fully safe and as high as possible. In the actual filament, it is inevitable for the conjugate ratio to cause for example, 5 to 6% of ununiformity due to accuracy of manufacture and the like, as shown in Table II and further, such as an order of ununiformity is acceptale in practice.

If a distributor having a distribution efficiency of more than 90% is provided, the deviation of polymer streams caused by the distributor is about 5% and even if there is no function for making the conjugate ratio uniform owing to the structure of the spinneret plate, the ununiformity of the conjugate ratio can be controlled to about 5%.

What we claim is:

1. In an apparatus for conjugate spinning, a spinneret comprising a spinneret plate having a plurality of orifices along a circumference thereof and a filter block having two eccentrically arranged filters for two spinning solutions, distributing means comprising a concentric distributing block positioned adjacent the spinneret plate forming a central cavity and a concentric annular chamber therebetween, and an eccentric distributing block positioned between said filter block and the concentric distributing block, said concentric distributing block having a central connecting aperture leading via subdistributing channels to the said center cavity, which opens on the spinneret plate, and an outer main distributing channel, adjacent said eccentric distributing block, surrounding said central connecting aperture, said main channel being annular and being concentric with said central connecting aperture and leading to said annular chamber via subdistributing channels, said eccentric distributing block having two connecting apertures, one of which connects one filter with the outer main distributing channel and the other of which connects the other filter with the central connecting aperture.

2. A spinneret as claimed in claim 1, wherein said center connecting aperture forms an inner main distributing channel and is provided on a central upper portion of the concentric distributing block, said subdistributing channels connecting said inner main distributing channel to said central chamber.

3. A spinneret as claimed in claim 2 further comprising a connecting aperture extending from the filter to the outer main distributing channel, said additional connecting aperture also being connected to the main distributing channel.

4. A spinneret as claimed in claim 1, wherein the outer main distributing channel and the subdistributing channels have circular cross sections.

5. A spinneret as claimed in claim 4, wherein the sizes of circular cross section in said distributing channel and said subdistributing channels are determined in such a manner that the value of the following formula is at least 90%

$$\left\{1-\left(\frac{r}{R}\right)^4 \frac{L}{1} \frac{m(m+1)}{2}\right\} \times 100$$

where R is radius of the main distributing channel, L is a distance between subdistributing channels which are arranged in the same interval, r is radius of the subdistributing channel and l is the length of the subdistributing channel.

6. A spinneret as claimed in claim 1, wherein said outer main distributing channel is noncircular in the cross section and the sizes of noncircular cross section in the main distributing channel and subdistributing channel are determined in such a manner that the value of the following formula is at least 90%

$$\left\{1-\left(\frac{r}{R}\right)^4 \frac{L}{1} \frac{m(m+1)}{2}\right\} \times 100$$

wherein R is radius of circle which inscribes the cross-sectional shape of the noncircular channel, L is a distance between the subdistributing channels which are arranged in the same interval, r is radius of the subdistributing channel and l is the length of the subdistributing channel.

7. A spinneret for conjugate spinning, comprising a spinning solution supplying block having two spinning solution inlets; an eccentric filter block having two filters connected to said two inlets, respectively; an eccentric distributing block having connecting apertures connected to said two filters, respectively; a concentric distributing block having an outer main distributing channel and an inner main distributing channel connected to said connecting apertures, respectively, outer subdistributing channels and inner subdistributing channels connected to said main distributing channels, respectively, a concentric spinneret plate having a plurality of orifices along a circumference thereof, forming an outer space and an inner space, said subdistributing channel being connected to said spaces, respectively, two spinning solutions being delivered from the outer subdistributing channels and the inner subdistributing channels into the outer space and the inner space on the spinneret plate and being bonded through top of an annular separating plate and extruded through the orifices.

8. A spinneret for conjugate spinning, comprising a spinning solution supplying block having two spinning solution inlets; an eccentric filter block having two filters connected to these two inlets, respectively; a distributor having a connecting aperture connected to one of said filters, an outer main distributing channel connected to necting aperture connected to the other of said filter said connecting aperture, subdistributing channels connecting said main distributing channel to a further connecting aperture connected to the other of said filters, a concentric spinneret plate having a plurality of orifices long the circumference thereof defining an outer space and an inner space, said further connecting aperture being connected to said inner space, a portion of the spinning solution being delivered from the outer subdistributing channel into said outer space on the spinneret plate and a further portion of the spinning solution being delivered from the connecting aperture into the inner space on the spinneret plate and said two spinning solutions being bonded through top of an annular separating plate and extruded through the orifices.

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