SPINNERET FOR CONJUGATE SPINNING

Filed Feb. 2, 1968

4 Sheets-Sheet 1

Fig. 1

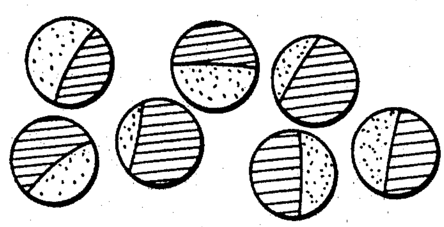
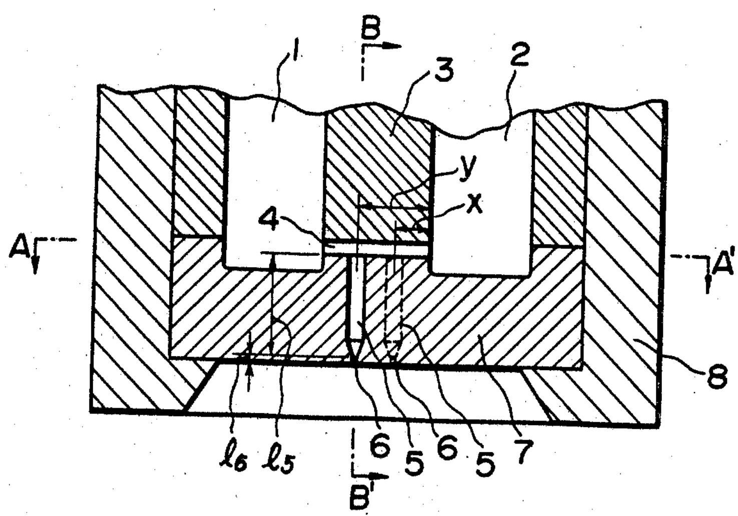


Fig. 2



INVENTOR
MASAO MATSUI

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

Fig. 3

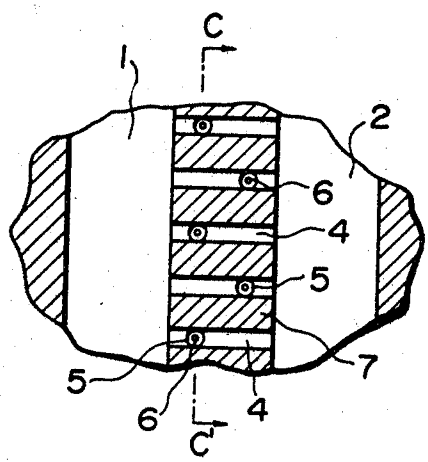
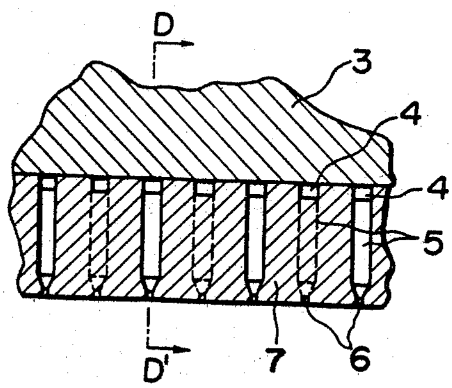


Fig. 4



INVENTOR
MASAO MATSUI

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

Fig. 5

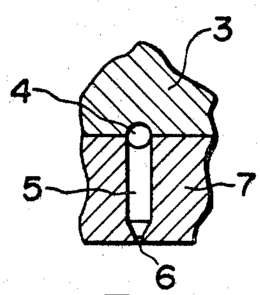


Fig. 6

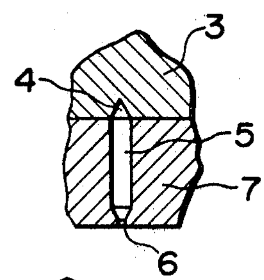
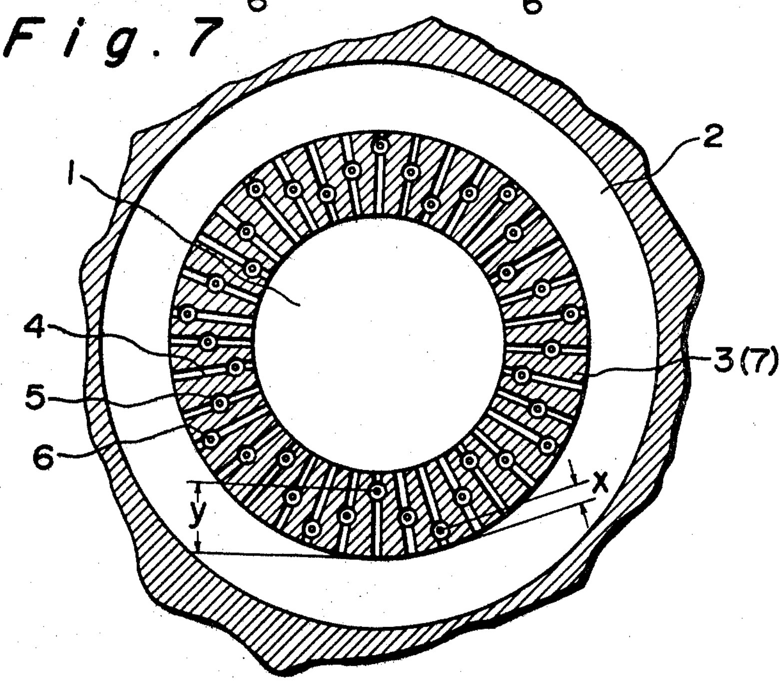


Fig. 7



INVENTOR
MASAO MATSUI

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

Dec. 2, 1969 MASAO MATSUI 3,480,996

SPINNERET FOR CONJUGATE SPINNING

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Fig. 8

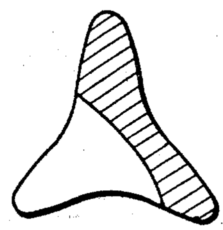


Fig. 9

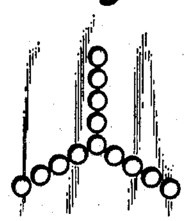
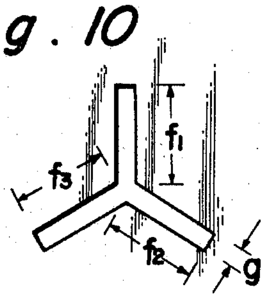


Fig. 10



INVENTOR

MASAO MATSUI

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

United States Patent Office

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3,480,996

SPINNERET FOR CONJUGATE SPINNING

Masao Matsui, Takatsuki, Japan, assignor to Kanegafuchi Boseki Kabushiki Kaisha and SNIA Viscosa Societa Nazionale Industria Applicazioni Viscosa S.p.A., Tokyo, Japan, and Milan, Italy

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Claims priority, application Japan, Feb. 10, 1967, 42/8,732
Int. Cl. D01d 3/00
U.S. Cl. 18—8 22 Claims

ABSTRACT OF THE DISCLOSURE

An improved spinneret for producing side-by-side type conjugate filament having a uniform conjugate ratio in a high productivity comprises a first and second reservoir for the molten two polymeric materials, a partition wall of uniform thickness between said first and second reservoirs, a plurality of straight channels connecting to said first and second reservoirs respectively, a plurality of ducts perpendicular to said channels, each having an inlet in said channel and an outlet at one orifice, and a large number of orifices, connecting said ducts respectively and arranged in a zig-zag form, the cross sectional area of said channel being sufficiently larger than those of said duct and said orifice to make the difference in the pressure loss between said two polymeric materials which flow along said passages in opposite directions until they meet at the inlet of said duct considerably smaller than the pressure loss which the polymeric materials suffer, while conjugately travelling along said duct and said orifice.

The present invention relates to a spinneret for conjugate spinning, more particularly an improved apparatus for spinning two components in a side-by-side relation to obtain a conjugate filament.

Spinnerets for conjugate spinning are known in the art. Said spinnerets comprise a plurality of spinning orifices wherein two differing molten polymeric materials are concurrently and meteredly fed and simultaneously spun to provide a two-component conjugate filament. According to the art, such spinnerets comprise two reservoirs arranged in side-by-side or in concentrical relationship, and passages by which each spinning orifice communicates with both said reservoirs, said orifices being arranged at even intervals along a straight line or respectively a circumference. Certain limits have been found critical for such intervals. The number of the orifices is therefore limited by the length of said straight line or of said circumference, divided by said interval at least 2 mm. (preferably more than 3 mm.). Such limitation leads to an undesirably low density of orifices, that is to a low number of orifices and consequent production, in terms of number of conjugate filaments which can be simultaneously spun through one spinneret.

Spinnerets having a greater orifice density have been heretofore proposed, wherein the orifices are located in a zig-zig arrangement in respect to a straight line or a circumference. Such zig-zig arrangement, however, leads to a structural ununiformity in the spacings between orifices and the reservoirs, that is in such structures a part of the orifices are located nearer to one reservoir whilst another part of orifices are located nearer to the other reservoir and farther from said one reservoir. Therefore, the molten material is caused to travel along paths of different lengths from said reservoirs and orifices appertaining to one or respectively said other part.

Said high orifice density spinnerets have been proved to provide conjugate filaments having various conjugate

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ratios in U.S. Patent specification No. 2,931,091. Such uneven filaments are suitable for certain particular applications, whilst conjugate filaments having a substantially uniform and predetermined ratio are generally desired and actually made use of in a very wide field.

The principal object of this invention is to provide a new and improved spinneret having a high orifice density, wherein a great plurality of zig-zag arranged orifices are provided and wherefrom substantially uniform conjugate filaments of equal conjugate ratio are simultaneously spun.

A further object of the present invention is to provide a spinneret for conjugate spinning which is very simple in structure, and easy in the manufacture and the operation and which can produce conjugate filaments in a high productivity.

According to the invention, it has been surprisingly found that a given conjugate ratio, predetermined by meteredly feeding a first and a second reservoirs with first and respectively second molten polymeric materials, can be provided and maintained at each spinning orifice, in a spinneret as referred to above, irrespective of the length of the path which each individual polymeric material is caused to travel from one reservoir to any individual spinning orifice, provided that:

(i) Each orifice communicates with both first and second reservoirs by means of channels having inlets in the said first and in the said second reservoirs and wherein the said first and second polymeric materials travel in opposite directions until they meet at a location intermediate between said inlets, and of a common duct having its inlet at said location and its outlet in said orifice;

(ii) The different spacing of said orifices from said first and second reservoirs, due to the said zig-zag arrangement, is provided for by the provision of passages of different lengths, as measured from their inlets and said location; and

(iii) The dimensional parameters of said channel, duct and orifice, influencing the pressure loss, which the polymeric materials suffer while conjugately travelling along said common duct and orifice, are selected so that said pressure loss is so great in comparison of the pressure loss, which the individual polymeric materials suffer when travelling along said passages, that the difference of said latter pressure loss, due to different lengths of said passages, does not essentially modify the total pressure loss which the polymeric materials suffer in their entire travel from said reservoirs to outside said orifice, the selection of said dimensional parameters being ensured when the following formula is satisfied.

$$\frac{y}{2(y-x)}+\frac{K_1 l_5}{(y-x)}+\frac{K_2 l_6}{(y-x)}\geqq 10 \qquad (1)$$

wherein l_5 is a length of the duct (mm.), l_6 the depth of the orifice (mm), x the length of the passage from the nearby reservoir to an inlet of the duct (mm.) y the length of the passage from the farther reservoir to the inlet of the duct (mm.), K_1 a shape factor of the channel and the duct and K_2 is a shape factor of the orifice and the channel.

The left side of the above Formula 1 is referred to as a uniformity factor and abridged as U.F. hereinafter. Namely, the Formula 1 can be shown by $U.F.\geqq 10$.

In production of a spinneret for conjugate spinning, it is required that the production and the operation are easy, the durability is high and the cost is low, but in practical use, it is necessary that the orifice density (number of orifices/area of spinneret plate) of the spinneret is increased to improve the productivity and that uniformity of filaments spun through each orifice is kept.

A spinneret for conjugate spinning is complicated in structure as compared with a usual spinneret for spinning one-component filament, so that the increase of the orifice density has a problem in view of construction and production cost, and this is one cause for raising the production cost of the conjugate filament.

It has been proposed that orifices are arranged in a zig-zag form in order to increase the orifice density. For example, if orifices are arranged in such a zig-zag form that two orifices constitute one cycle as shown in FIG. 3, it is possible to arrange the orifices in the maximum two times more than when orifices are arranged on a straight line. However, when two components are spun through a spinneret for conjugate spinning in which orifices are arranged in such a zig-zag form as described above, the conjugated ratio in the obtained two component filament is liable to be considerably uniform as shwon in FIG. 1 due to the difference of the distance from two reservoirs to orifice.

The inventor has made various investigations with respect to a spinneret for conjugate spinning which has a simple structure and has orifices arranged in a zig-zag form, in which the ununiformity based on the difference of the distances from each reservoir to each orifice is decreased so that uniform conjugate filaments are extruded through each orifice and the present invention has been accomplished.

The present invention consists in an improved spinneret for simultaneously extruding in side-by-side relationship a first and a second molten polymeric material through a plurality of orifices, for simultaneously producing a corresponding plurality of conjugate filaments, comprising, in combination:

(a) A first and a second reservoir for said first and said second materials respectively, meteredly and pressurizedly supplied thereinto;

(b) A partition wall of uniform thickness between said first and second reservoirs;

(c) A purality of straight channels perpendicular to said wall, arranged at uniform intervals along said wall and each consisting of two passages, one of which has its inlet in said first reservoir and the other of which in said second reservoir;

(d) A plurality of ducts, perpendicular to said channels, each having an inlet in one of said channels and an outlet at one orifice, said inlets being located so that a part of said inlets is farther from said first reservoir than from said second reservoir and another part is farther from said second reservoir, and the interval between the axes of adjacent orifices being greater than the inter-axial interval between adjacent channels;

(e) The cross-sectional area of said channel being sufficiently larger than those of said duct and said orifice to make the difference in the pressure loss between said two polymeric materials which flow along said passages in opposite directions until they meet at the inlet of said duct considerably smaller than the pressure loss which the polymeric materials suffer while conjugately traveling along said duct and said orifice.

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

FIG. 1 are cross-sectional views of a plurality of two component filaments in which conjugate ratio is ununiform;

FIG. 2 is a longitudinal-sectional view of one embodiment of the spinnert of the present invention;

FIG. 3 is a cross-sectional view of the spinneret shown in FIG. 2 taken on line A–A′;

FIG. 4 is a longitudinal-sectional view of the spinneret shown in FIG. 2 taken on line B–B′ and also is a sectional view taken on line C–C′ in FIG. 3;

FIGS. 5 and 6 show two embodiments of channels having circular and triangle cross-sections, respectively;

FIG. 7 is a cross-sectional view of the spinneret in which orifices are arranged in a zig-zag form along the circumference of the spinneret plate;

FIG. 8 is a cross-sectional view of a so-called tri-lobal type two component filament;

FIG. 9 shows one embodiment of orifices applicable for spinning a tri-lobal filament; and

FIG. 10 shows one embodiment of an orifice consisting of Y-type slit.

Referring to the accompanying drawings, the spinneret of the present invention consists essentially of reservoirs **1** and **2**, channels **4** for connecting said two reservoirs, orifices **6** arranged in a zig-zag form and ducts **5** for connecting the channels **4** to the orifices **6** as shown in FIG. 2.

In FIG. 3, the channel **4** is groove provided in the spinneret plate **7** and connects two reservoirs **1** and **2.** The ducts **5** and the orifices **6** are arranged in a zig-zag form wherein two form one cycle unit. In FIG. 4, the groove provided in the spinneret plate at a contact face of the partition wall **3** with the spinneret plate **7** is the channel and in this case the cross-section thereof is a tetragon. FIG. 2 is a cross-sectional view taken on line D–D′ in FIG. 4.

FIG. 5 shows a channel **4** having a circular cross-section which is formed by assembling two grooves having a semi-circular cross-section engraved on the partition wall **3** and the spinneret plate **7**. FIG. 6 shows a channel **4** which is a groove having a triangular cross-section formed in the partition wall **3**.

Generally speaking, the cross-sectional configuration of the channel to be applicable to the present invention may be circular, semi-circular, polygonal or other irregular forms, but the nearer to a circle the cross-sectional configuration, the less the stagnation.

Referring to FIG. 7, two reservoirs **1** and **2** arranged concentrically are separated by the partition wall **3**. The channels **4** provided in a contact face of the partition wall **3** and the spinneret plate **7** are arranged radially. The ducts **5** and the orifices **6** are arranged in such a zig-zag form that four form one cycle.

FIG. 9 shows a plurality of small holes arranged in Y-type, which are used to extrude a tri-lobal filament as shown in FIG. 8.

FIG. 10 shows an orifice consisting of a Y-type slit.

When these spinnerets satisfy the Formula 1, it has been experimentally found that the uniformity of the extruded two component filaments is more than 95%. Even in a usual "uniform" spinneret, the ununiformity of about 5% is often observed due to the constructive inaccuracy of the spinneret, etc., so that if the ununiformity is less than 5%, it can be considered as uniform.

It will be explained hereunder that if the Formula 1 is satisfied, the uniformity is more than 95%.

When a fluid having a viscoseity of η flows through a cylinder having a radius of R and a length of l according to a Newton's law, the relation between the pressure difference P in both ends of the cylinder and flow Q is shown in Hagen-Poiseuille's Formula 2.

$$P=\frac{8\eta l}{\pi(R)^4}Q \qquad (2)$$

When the above formula is applied to spinning of two viscous fluids (spinning materials) by the spinneret for conjugate spinning of the present invention, the fluidity of each material to be conjugated is shown by the following Formulae 3 and 4, respectively. In order to show fundamentally both the Formulae 3 and 4, it is assumed that all of the channel, the duct and the orifice are cylindrical, and further the following assumptions are made:

(a) The pressure in the reservoir is a constant value P_0.

(b) The viscosities of two spinning solutions are equal (η_0) and their flows are equal (conjugate ratio 1:1), and therefore the flow Q in the duct and the orifice is two times the flow in the channel.

Accordingly, if the flow, when the length of the passage is y, is Q_1, the following equation is obtained.

$$\pi P_0 = 8\eta_0 Q_1\left(\frac{y}{2(R_4)^4}+\frac{l_5}{(R_5)^4}+\frac{l_6}{(R_6)^4}\right) \qquad (3)$$

On the other hand, if the flow, when the length of the passage is x, is Q_0, the following equation is obtained.

$$\pi P_0 = 8\eta_0 Q_0\left(\frac{x}{2(R_4)^4}+\frac{l_5}{(R_5)^4}+\frac{l_6}{(R_6)^4}\right) \qquad (4)$$

In the above equations, R_4, R_5 and R_6 represent radii of the channel, the duct and the orifice respectively and l_5, l_6, x and y have the same meanings as described in the Formula 1.

The ununiformity of the flow resulting from the difference in length between two passagess in the same channel, that is $(y-x)$, is shown by the following Formula 5.

$$\text{the ununiformity} = \frac{Q_0-Q_1}{Q_0} \qquad (5)$$

In order to make the uniformity in the flow of both components more than 95%, the value in the Formula 5 should be less than $5/100$. From the Formulae 3, 4 and 5, the ununiformity is shown by the following Formula 6, so that the value in the Formula 6 should be less than $5/100$.

$$\frac{Q_0-Q_1}{Q_0} = \frac{(y-x)}{2(R_4)^4}\Big/\left[\frac{y}{2(R_4)^4}+\frac{l_5}{(R_5)^4}+\frac{l_6}{(R_6)^4}\right] \leqq \frac{5}{100} \qquad (6)$$

The reciprocal of the Formula 6 is the following Formula 7.

$$\frac{Q_0}{Q_0-Q_1} = \frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\left(\frac{R_4}{R_6}\right)^4\cdot\frac{l_6}{(y-x)} \geqq 10 \qquad (7)$$

The Formula 7 is applicable to the case wherein in the Formula 1 the channel, the duct and the orifice have the configuration and the dimension of the above described condition, and in this case,

$$K_1 = \left(\frac{R_4}{R_5}\right)^4$$

and

$$K_2 = \left(\frac{R_4}{R_6}\right)^4$$

Thus, when the channel, the duct and the orifice are cylindrical, the conjugate filament having an ununiformity of less than 5% can be obtained by using the spinneret in which dimensions and the requirement of arrangement of the duct satisfy the Formula 7. It is apparent that even if the cross-section of the channel is not circular but is polygonal or semicircular or other irregular form, if the radius of the circle which inscribes said channel, satisfies the Formula 7 (or the Formula 1), the satisfactory result can be obtained. Furthermore, even if the viscosities of both the spinning materials are different from each other and the extrusion ratio of said materials is other than 1/1, it has been found that substantially the same relation is established, so that if the structure of the spinneret satisfies the Formula 1, conjugate filaments having an excellent uniformity can be spun by using said spinneret, even when the viscosities of two spinning materials and the extrusion rates of both the materials are different respectively.

In the spinneret shown in FIGS. 2 to 4, one example in which lengths and radii of the channel **4**, the duct **5** and the orifice **6** (radius of the channel is one of cylinder inscribing said channel) satisfy the Formula 7, is shown in the following Table 1.

TABLE 1

The orifice **6**	Radius $(R_6)=0.1$ mm., length $(l_6)=0.2$ mm.
The duct **5**	Radius $(R_5)=1$ mm., total length=16 mm.
The channel **4**	Rectangular section having height of 2 mm. and width of 2.2 mm., radius (R_4) of a cylinder inscribing the channel=1 mm., minimum length (x) of the passage=4 mm., maximum length (y) of the passage=12 mm.

When U.F. is calculated according to the Formula 7 by using numerical values in Table 1, U.F. is about 253, and the object of the present invention can be satisfactorily attained. When the conditions of the orifice and the duct are the same as described above and radius (R_4) of the cylinder inscribing the channel is 0.3 mm., U.F. is 2.7 which unsuitable for the object of the present invention.

By the way, the main object of the present invention is to increase the orifice density as mentioned before. Accordingly, it is required that the width of the channel is narrow as far as possible. In order to increase the uniformity of the conjugate ratio which is the other main object of the present invention by using the above channel having the narrower width, it is necessary that the height of cross-section of the channel is large. In such a case, it should be considered that the channel has a plurality of cylinders inscribing the channel. For example, when a cross-section of the channel is a rectangle having a width of $2W$ and a height of approximately $2W\times N$ (N: a natural number), it should be considered that there are N cylinders inscribing the channel, the radius of which is W. In this case, considering the development of the Formula 7 derived from the Formula 2, the flow of the spinning solution flowing through one cylinder having a radius of W, is $1/N$ of the total amount, so that the Formula 1 is approximately shown by the following Formula 8.

$$U.F. = \frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)} + N\left(\frac{W}{R_6}\right)^4\cdot\frac{l_6}{(y+x)} \geqq 10 \qquad (8)$$

The Formula 8, is applicable to the case wherein in the Formula 1 the cross-section of the channel is rectangular and the conditions of the duct and the orifice are the same as those of the Formula 7, and in this case K_1 and K_2 are as follows:

$$K_1=N(W/R_6)^4,\ K_2=N(W/R_6)^4$$

The Formula 8 is effective for not only the channel having a rectangular section but also that having a form similar to a rectangle.

Although the single circular orifice corresponding to a unit duct has been heretofore considered, it is well known that two component filament having noncircular cross-section is useful, and a method of spinning such filament from a plurality of small holes provided at the bottom of single duct, is publicly known. FIG. 9 shows a plurality of small holes arranged in Y-type which are used to extrude a tri-lobal filament as shown in FIG. 8. A group of small holes arranged closely for spinning unitary filament is hereinafter called as "a unit orifice group." Furthermore, the unit orifice group consisting of small holes having two or more different radii can be similarly used.

The present invention is applicable to said orifices. In this case, as the formula corresponding to the Formula 3, the following Formula 9 can be obtained.

$$\pi P_0=8\eta_0 Q_1\left\{\frac{y}{2(R_4)^4}+\frac{l_5}{(R_5)^4}+\frac{l_6}{[m_1(r_1)^4+m_2(r_2)^4]}\right\} \quad (9)$$

wherein m_1 and m_2 are number of small holes having radii of r_1 and r_2 respectively, and the depth of all holes is l_6.

FIG. 8 shows a cross-section of a so-called tri-lobal two component filament having three lobes.

Accordingly, the flow Q_1 is led from the Formula 9 as in the case wherein the Formula 9 is derived from the Formulae 3 and 4, and the flow Q_2 is led similarly, whereby the following Formula 10 is obtained. Thus, in this case the Formula 1 is shown by the Formula 10.

$$U.F.=\frac{y}{2(y-x)}=\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l^5}{(y-x)}+\frac{(R_4)^4}{\{m_1(r_1)^4+m_2(r_2)^4\}}\cdot\frac{l^6}{(y-x)}\leqq 10 \quad (10)$$

The Formula 10 is applicable to the case wherein the conditions of the channel and the duct in the Formula 1 are the same as those in the Formula 7 and the unit orifice group is composed of m_1 small holes having a radius of r_1 and m_2 small holes having a radius of r_2, and in this case K_1 and K_2 are as follows:

$$K_1=\left(\frac{R_4}{R_5}\right)^4, K_2=\frac{(R_4)^4}{m_1(r_1)^4+m_2(r_2)^4}$$

As seen from the Formula 10, this formula corresponds to the Formula 8 when m_1 is 1 and m_2 is 0 (or m_1 is 0 and m_2 is 1).

Furthermore, in the same manner as derived the Formula 7, the following Formula 11, which is applicable to the case wherein the width of the cross-section of the channel is 2W and the height is about 2NW (N: natural number), can be obtained.

$$U.F.=\frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+N\frac{(W)^4}{\{m_1(r_1)^4+m_2(r_2)^4\}}\cdot\frac{l_6}{(y-x)}\geqq 10 \quad (11)$$

The Formula 11 is applicable to the case wherein the conditions of the channel and the duct in the Formula 1 are the same as those in the Formula 8 and the condition of the orifice is the same as that in the Formula 10, and in this case K_1 and K_2 are as follows:

$$K_1=N\left(\frac{W}{R_5}\right)^4, K_2=N\frac{(W)^4}{m_1(r_1)^4+m_2(r_2)^4}$$

In another method of extruding filament having non-circular cross-section, the orifice in a slit form can be used. When the width g of the silt is sufficiently smaller than the length f thereof (for example, less than 1/10), the influence at the end of the slit is negligible and the following Formula 12 corresponding to the Formula 2 is obtained.

$$P=\frac{12\eta l}{(g)^3 f}Q \quad (12)$$

The Formula 12 shows the relation between the back pressure and the flow from the slit having a width of g, a length of f and a depth of l_6. The following Formula 13 is similarly obtained from the Formula 12 in the same manner as in the Formula 3.

$$\pi P_0=8\eta Q_1\left(\frac{y}{2(R_4)^4}+\frac{l_5}{(R_5)^4}+\frac{12\pi l_6}{8f(g)^3}\right) \quad (13)$$

Accordingly, the flow Q_1 is led from the Formula 13 in the same manner as in the case wherein the Formula 7 is led from the Formulae 3 and 4 and the flow Q_2 is similarly led, whereby the following Formula 14 is obtained. Thus, in this case the Formula 1 is shown by the Formula 14.

$$U.F.=\frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\frac{3\pi(R_4)^4}{2f(g)^3}\cdot\frac{l_6}{(y-x)}\geqq 10 \quad (14)$$

The Formula 14 is applicable to the case wherein the conditions of the channel and the duct in the Formula 1 are the same as those in the Formula 8 and the orifice is a slit having a width of g and a length of f, and in this case K_1 and K_2 are as follows:

$$K_1=\left(\frac{R_4}{R_5}\right)^4, K_2=\frac{3\pi(R_4)^4}{2f(g)^3}$$

As the slit, use may be made of ones having various cross-sectional configurations, for example, I-type, V-type, C-type, L-type, T-type, Y-type, X-type, H-type, etc., but the Formula 14 is applicable to the slit when the total length of the slit is longer than the width thereof.

The term "total length of the slit" used herein means the sum of lengths of every portion in the slit. For example, the orifice shown in FIG. 10 is the Y-type slit, in which the width is g, and the lengths of three branched portions are f_1, f_2 and f_3 respectively, and in this case the total length f of said slit approximates $(f_1+f_2+f_3)$. Even in a slit, wherein each portion is separated, if the length of each portion is sufficiently longer than the width thereof, the sum of length of each portion may be the total length of the slit. When the slit constitutes a curve, for example, C-type, the length of the center line may be the total length of the slit. The Formula 12 is obtained herein by ignoring the influence at the end of the slit, but said influence appears in a tendency of increase of the left side P in the Formula 12, so that the uniformity factor (U.F.) obtained by the Formula 14 is liable to become smaller than a true value. Namely, in order to realize the Formula 12, the length f of the slit should be sufficiently larger than the width g, for example, 10 times of g, but the Formula 14 is applicable to even the case wherein the influence at the end of the slit cannot be ignored (for example, the length f of the slit is 3 to 10 times the width g), because the influence at the end of the slit appears in the tendency of increase of the uniformity in two component filaments, so that this tendency is more safe and advantageous for the object of the present invention.

When the orifice is a slit and the width 2W of the cross-section of the channel is narrow and the depth is large and can approximate to 2NW (N: a natural number), the following Formula 15 is obtained in the same way as in the Formula 8.

$$U.F.=\frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+N\frac{3\pi(W)^4}{2f(g)^3}\cdot\frac{l_6}{(y-x)}\geqq 10 \quad (15)$$

The Formula 15 is applicable to the case wherein conditions of the channel and the duct in the Formula 1 are the same as those in the Formula 8 and the orifice is a slit shape and in the same condition as that in the Formula 14, and in this case K_1 and K_2 are as follows:

$$K_1=N\left(\frac{W}{R_5}\right)^4, K_2=N\frac{3\pi(W)^4}{2f(g)^3}$$

U.F., when the configuration and the dimensions of the channel, the duct and the orifice in the spinneret for conjugate spinning of the present invention are different respectively, has been concretely shown by the Formulae 7, 8, 10, 11, 13 and 14, but they have been confirmed by various spinning experiments. The Formula 1 represents the general equation of the above described formulae, and the manner for calculating each shape factor will be apparent from the above described explanation.

The dimensional parameters of the channel, duct and orifice of the preferable embodiments according to the invention will be shown in the following.

(a) The channel is a groove having a width of 0.5–4 mm., a height of 0.5–4 mm., a product of said width and height of 2–16 mm.^{2}, and a length of 6–25 mm.

(b) The channel is a cylinder having a diameter of 2–4 mm. and a length of 6–25 mm.

(c) The duct is a cylinder having a diameter of 0.8–4 mm. and a length of 5–30 mm.

(d) The orifice is a circular hole having a diameter of 0.1–0.4 mm.

(e) The orifice is a circular hole having a diameter of 0.15–0.3 mm.

(f) The unit orifice group corresponding to one duct is composed of a plurality of small circular holes each having a diameter of 0.05–0.2 mm.

The spinneret of the present invention has the above described structure, so that not only the orifice density is increased to improve the productivity, but also the uniformity of the conjugate filament can be maintained at a high level. Furthermore, the structure is simple, so that the production operation, and the maintenance are very easy.

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

EXAMPLE 1

Nylon-6 having a number average polymerization degree of 126, which contained no pigment, and the nylon-6 containing 0.6% of powdery titanium oxide as a pigment were melted separately and extruded simultaneously through common orifice of the concentric spinneret as shown in FIG. 7 with an extrusion ratio of 1/1 to form unitary filaments. After quenched, the filaments were taken up according to a conventional method. The cross-section of the obtained filament was checked by a microscope to determine the uniformity of the conjugate ratio. Spinneret A had the constitution as shown in Table 2 and spinneret B had the constitution as shown in Table 3.

TABLE 2.—SPINNERET A

Partition wall 3	A cylinder having an inner diameter of 50 mm. and a thickness of 16 mm.
Channel 4	A square groove having a width of 0.8 mm., a depth of 0.8 mm. and a length of 16 mm. (R_4=0.4 mm.), x=4 mm., y=12 mm.
Duct 5	A cylinder having a radius (R_5) of 1 mm. and a length (l_5) of 14 mm.
Orifice 6	A circular hole having a radius (R_6) of 0.2 mm. and a depth (l_6) of 0.4 mm.
U.F. by the Formula 7	1.6.

TABLE 3.—SPINNERET B

Partition wall 3	A cylinder having an inner diameter of 50 mm. and a thickness of 16 mm.
Channel 4	A rectangular groove having a width of 0.8 mm., a depth of 1.6 mm. and a length of 16 mm. (W=0.4 mm., N=2), x=4 mm., y=12 mm.
Duct 5	A cylinder having a radius (R_5) of 0.8 mm. and a length (l_5) of 14 mm.
Orifice 6	A circular hole having a radius (R_6) of 0.1 mm. and a depth (l_6) of 0.2 mm.
U.S. by the Formula 8	13.8.

The cross-section of two component filament extruded through the spinneret A was checked by a microscope and as the result the mean value of the conjugate ratio was 50/50, the maximum deviation was 67/33 and the standard deviation was 15.2%. On the other hand, the cross-section of two component filament extruded through the spinneret B was checked by a microscope and as the result the mean value of the conjugate ratio was 50/50, the maximum deviation was 53/47 and the standard deviation was 3.3%.

In the Formulae 7 and 8 the lowest limit of the uniformity has been safely calculated and the uniformity of two component filament obtained practically is often extremely higher than the lowest uniformity anticipated from these formulae, because, for example, the fluid resistance of a cylinder inscribing the channel is usually higher than that of the channel (fluid resistance is equal when the channel is cylindrical). When U.F. is more than 50, the uniformity is more than 99%, and it is considered to be completely uniform in practice.

EXAMPLE 2

The spinneret, in which the configuration and the dimension are substantially similar to those of the spinneret A in Example 1 and the unit orifice group was composed of 13 small circular holes having a radius (r_1) of 0.1 mm. and a depth (l_6) of 0.2 mm., which were arranged as shown in FIG. 9, was used as the spinneret C. The spinneret in which the configuration and the dimension were substantially similar to those of the spinneret B in Example 1 and the unit orifice group was composed of 13 small circular holes having a radius (r_1) of 0.05 mm. and a depth (l_6) of 0.2 mm., which were arranged as shown in FIG. 9, was used as the spinneret D. U.F. of the spinneret C from the Formula 10 was 1.3 and U.F. of the spinneret D from the Formula 11 was 16.7. The uniformity of the conjugate ratio in two component filament extruded through the spinnerets C and D in the same manner as described in Example 1 was measured to obtain the result as shown in the following Table 4.

TABLE 4

Spinneret	U.F. calculated	Two component filament: Mean conjugate ratio	Maximum deviation	Standard deviation, percent
C	1.3	50/50	57/43	8.9
D	16.7	50/50	53/47	3.5

EXAMPLE 3

The spinning was effected by means of a spinneret having a configuration as shown in FIG. 2, the orifice of which was Y-type slit as shown in FIG. 10, in the same manner as described in Example 1, provided that the conjugate ratio was 3/2 (the ratio of amounts of liquids of two components fed by gear pump was 3/2), and the uniformity of the conjugate ratio of the resulting conjugate filament was determined. The constitutions of the used spinnerets E and F are shown in Tables 5 and 6.

TABLE 5.—SPINNERET E

Partition wall 3	A flat board having a thickness of 25 mm.
Channel 4	A circular groove having a radius (R_4) of 10 mm., x=5 mm., y=20 mm.
Duct 5	A cylinder having a radius (R_5) of 2.0 mm. and a length (l_5) of 15 mm.
Orifice 6	A Y-type slit having a width (g) of 0.2 mm., a total length ($f_1+f_2+f_3$) of 4 mm. and a depth (l_6) of 0.2 mm.

TABLE 6.—SPINNERET F

Partition wall 3	A flat board having a thickness of 25 mm.
Channel 4	A rectangular groove having a width of 2 mm. and a depth of 4 mm. (W=1 mm., N=2), x=5 mm., y=20 mm.
Duct 5	A cylinder having a radius (R^5) of 1 mm. and a length (l_5) of 15 mm.
Orifice 6	A Y-type slit having a width (g) of 0.1 mm., a total length ($f_1+f_2+f_3$) of 2 mm. and a depth (l_6) of 0.2 mm.

The calculated values of U.F. of the spinnerets E and F from the Formulae 14 and 15 and the measured results of the uniformity of two component filaments extruded are shown in Table 7.

TABLE 7

		Two component filament		
Spinneret	U.F. calculated	Mean conjugate ratio	Maximum deviation	Standard deviation, percent
E	2.7	60/40	48/52	14.5
F	65.5	60/40	61/39	1.7

What is claimed is:

1. An improved spinneret for simultaneously extruding in side-by-side relationship a first and a second molten polymeric spinnable materials through a plurality of orifices, for simultaneously producing a corresponding plurality of conjugate filaments, comprising, in combination:

(a) a first and a second reservoir for said first and said second materials respectively meteredly and pressurizedly supplied thereinto;

(b) a partition wall of uniform thickness between said first and second reservoirs;

(c) a plurality of straight channels perpendicular to said wall, arranged at uniform intervals along said wall and each consisting of two passages, one of which has its inlet in said first reservoir and the other of which in said second reservoir;

(d) a plurality of ducts, perpendicular to said channels, each having an inlet in one of said channels and an outlet at one orifice, said inlets being located so that a part of said inlets is farther from said first reservoir than from said second reservoir and another part is farther from said second reservoir, and the interval between the axes of adjacent orifices being greater than the inter-axial interval between adjacent channels;

(e) the cross-sectional area of said channel being sufficiently larger than those of said duct and said orifice to make the difference in the pressure loss between said two polymeric materials which flow along said passages in opposite directions until they meet at the inlet of said duct considerably smaller than the pressure loss which the polymeric materials suffer while conjugately travelling along said duct and said orifice.

2. The spinneret as claimed in claim 1, wherein said first reservoir and said second reservoir are arranged in a side-by-side relation and the configuration of said partition wall is a flat board.

3. The spinneret as claimed in claim 1, wherein said first and second reservoirs are arranged concentrically, and said partition wall is annular.

4. The spinneret as claimed in claim 1, wherein the dimensional parameters of said channels, ducts and orifices satisfy the following formula:

$$\frac{y}{2(y-x)}+\frac{k_1 l_5}{(y-x)}+\frac{k_2 l_6}{(y-x)}\geqq 10 \qquad (1)$$

where, l_5 is a length of the duct (mm.), l_6 the depth of the orifice (mm.), x the length of the passage from the nearer reservoir to an inlet of the duct (mm.), y the length of the passage from the farther reservoir to the inlet of the duct (mm.), k_1 a shape factor of the channel and the duct and k_2 is the shape factor of the orifice and the channel as hereinbefore calculated.

5. The spinneret as claimed in claim 4, wherein the cross-sections of the channels, the ducts and the orifices are circular, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\left(\frac{R_4}{R_6}\right)^4\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, and R_4, R_5 and R_6 are radii of the passage, duct and orifice respectively.

6. The spinneret as claimed in claim 4, wherein the cross-section of the channels is polygonal and those of the ducts and the orifices are circular, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\left(\frac{R_4}{R_6}\right)^4\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, and R_4, R_5 and R_6 are radius of the circle inscribing the polygonal channel, and radii of the duct and the orifice respectively.

7. The spinneret as claimed in claim 4, wherein the cross-section of the channels is similar to a rectangle and those of the ducts, and the orifices are circular, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+N\left(\frac{W}{R_6}\right)^4\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, and R_5 and R_6 are radii of the duct and the orifice respectively, and said rectangular channel has a width of 2W and a height of $2W\times N$.

8. The spinneret as claimed in claim 4, wherein the cross-sections of the channels and the ducts are circular and the orifices are various shapes composed of a plurality of small holes, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\frac{(R_4)^4}{\{m_1(r_1)^4+m_2(r_2)_4\}}\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, R_4 and R_5 are the radii of the channel and the duct respectively, m_1 is the number of small holes having a radius of r_1, and m_2 is the number of small holes having a radius of r_2.

9. The spinneret as claimed in claim 4, wherein the cross-section of the channels is similar to a rectangle, that of the ducts is circular and the orifices are various shapes composed of a plurality of small holes, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+N\frac{(W)^4}{\{m_1(r_1)_4+m_2(r_2)^4\}}\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, said rectangular channel has a width of 2W and a height of $2W\times N$, R_5 is the radius of the duct, m_1 is the number of small holes having a radius of r_1 and m_2 is the number of small holes having a radius of r_2.

10. The spinneret as claimed in claim 4, wherein the cross-sections of the channels and the ducts are circular and the orifices are various shapes of slits, and the

dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+\left(\frac{R_4}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+\frac{3\pi(R_4)^4}{2f(g)_3}\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, R_4 and R_5 are the radii of the channel and the duct respectively, and f and g are length and width of the slit respectively.

11. The spinneret as claimed in claim **4**, wherein the cross-section of the channels is similar to a rectangle, that of the ducts is circular and the orifices are Y-type slits, and the dimensional parameters thereof satisfy the following formula:

$$\frac{y}{2(y-x)}+N\left(\frac{W}{R_5}\right)^4\cdot\frac{l_5}{(y-x)}+N\frac{3\pi(W)^4}{2f(g)^3}\cdot\frac{l_6}{(y-x)}\geqq 10$$

in which l_5, l_6, x and y have the same meanings as described above, said rectangular channel has a width of 2W and a height of $2W\times N$, R_5 is radius of the duct, and g and f are width and total length of the slit respectively.

12. The spinneret as claimed in claim **1**, wherein the channel is a groove having a width of 0.5–4 mm., a height of 0.5–4 mm., a product of said width and height of 2–16 mm.^{2}, and a length of 6–25 mm.

13. The spinneret as claimed in claim **1**, wherein the channel is a cylinder having a diameter of 2–4 mm. and a length of 6–25 mm.

14. The spinneret as claimed in claim **1**, wherein the duct is a cylinder having a diameter of 0.8–4 mm. and a length of 5–30 mm.

15. The spinneret as claimed in claim **1**, wherein the orifice is a circular hole having a diameter of 0.1–0.4 mm.

16. The spinneret as claimed in claim **1**, wherein the orifice is a circular hole having a diameter of 0.15–0.3 mm.

17. The spinneret as claimed in claim **1**, wherein the unit orifice group corresponding to one duct is composed of a plurality of small circular holes each having a diameter of 0.05–0.2 mm.

18. The spinneret as claimed in claim **1**, wherein the orifice is a slit having a width of 0.05–0.2 mm. and a length of more than 3 times as large as said width.

19. The spinneret as claimed in claim **1**, wherein the orifice is a slit having a width of 0.05–0.2 mm. and a length of more than 10 times as large as said width.

20. A spinneret for manufacturing conjugate filament having a circular cross-section comprising two reservoirs connected mutually by a plurality of channels through a partition wall, orifices corresponding to each channel, which are arranged in a zig-zag form and ducts connecting the above described channels to the corresponding orifices, which comprises said partition wall being a cylinder having an inner diameter of 50 mm. and a thickness of 16 mm., said channel being a rectangular groove having a width of 0.8 mm., a depth of 1.6 mm. and a length of 16 mm., said duct being a cylinder having a radius of 0.8 mm. and a length of 14 mm., said orifice being a circular hole having a radius of 0.1 mm. and a depth of 0.2 mm., a part of said ducts being positioned at a distance of 4 mm. and 12 mm. from the first and the second reservoirs respectively, and another part of said ducts being positioned at the reverse relation to said first part of the ducts.

21. A spinneret for manufacturing tri-lobal conjugate filament comprising two reservoirs connected mutually by a plurality of channels through a partition wall, orifices corresponding to each channel and composed of a plurality of small holes as shown in FIG. 9, which orifices are arranged in a zig-zag form and ducts connecting the above described channels to the corresponding orifices, which comprises said partition wall being a cylinder having an inner diameter of 50 mm. and a thickness of 16 mm., said channel being a rectangular groove having a width of 0.8 mm., a depth of 1.6 mm. and a length of 16 mm., said duct being a cylinder having a radius of 0.8 mm. and a length of 14 mm., the orifice being composed of 13 small circular holes having a radius of 0.05 mm. and a depth of 0.2 mm., a part of said ducts being positioned at a distance of 4 mm. and 12 mm. from the first and the second reservoirs respectively, and another part of said ducts being positioned at the reverse relation to said first part of the ducts.

22. A spinneret for manufacturing tri-lobal conjugate filament comprising two reservoirs connected mutually by a plurality of channels through a partition wall, orifices of Y-type slits as shown in FIG. 10 corresponding to each channel which are arranged in a zig-zag form and ducts connecting the above described channels to the corresponding orifices, which comprises said partition wall being a flat board having a thickness of 25 mm., said channel being a rectangular groove having a width of 2 mm. and a depth of 4 mm., said duct being a cylinder having a radius of 1 mm. and a length of 15 mm., said orifice being a Y-type slit having a width of 0.1 mm., a total length of 2 mm. and a depth of 0.2 mm., a part of said ducts being positioned at a distance of 5 mm and 20 mm. from the first and the second reservoirs respectively, and another part of said ducts being positioned at the reverse relation to said first part of the ducts.

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