

June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 1

Fig. 1 Fig. 2 Fig. 3 Fig. 4

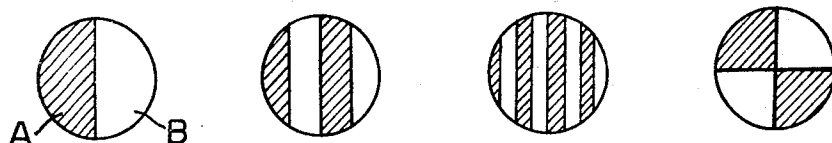


Fig. 5 Fig. 6 Fig. 7 Fig. 8

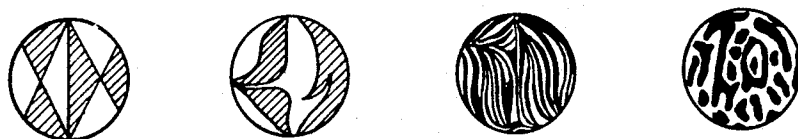
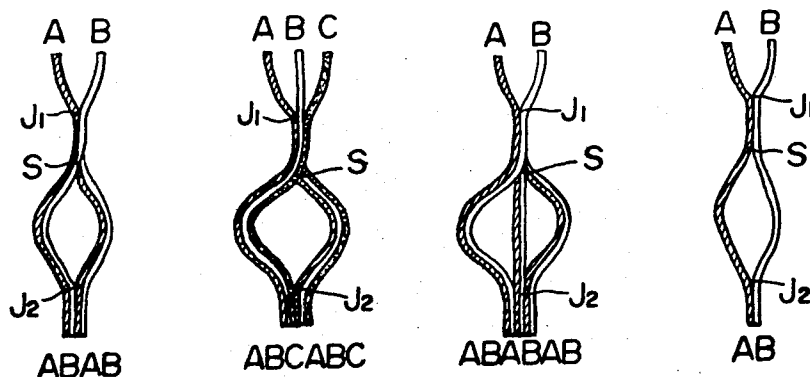


Fig. 9 Fig. 10 Fig. 11 Fig. 12



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 2

Fig. 13



Fig. 14



Fig. 15



Fig. 47

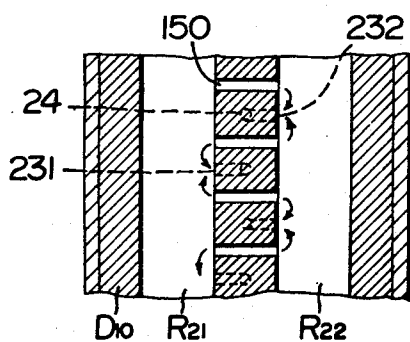
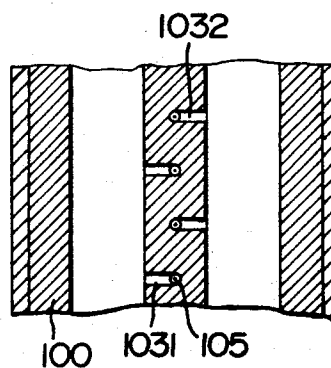


Fig. 49



June 27, 1972

MASO MATSUI ET AL

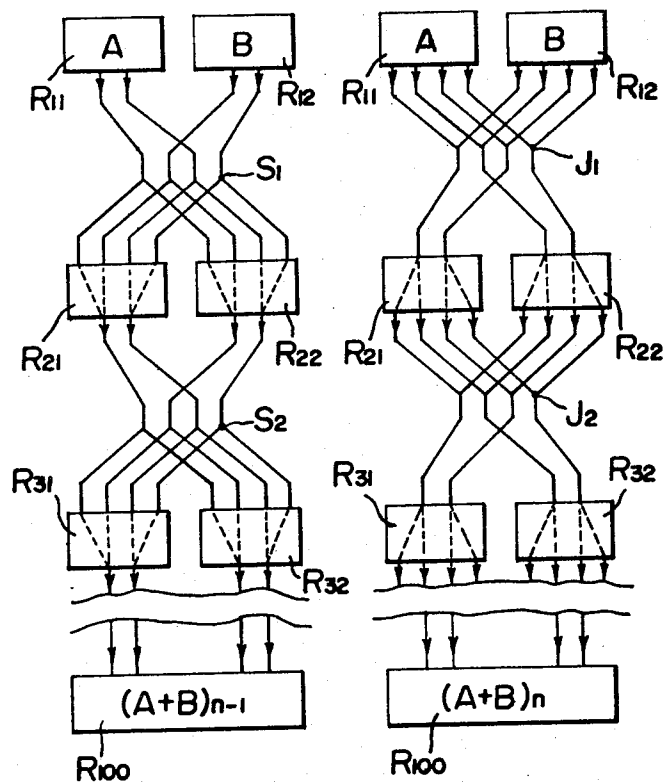
3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 3

Fig. 16 **Fig. 17**



June 27, 1972

MASO MATSUI ET AL

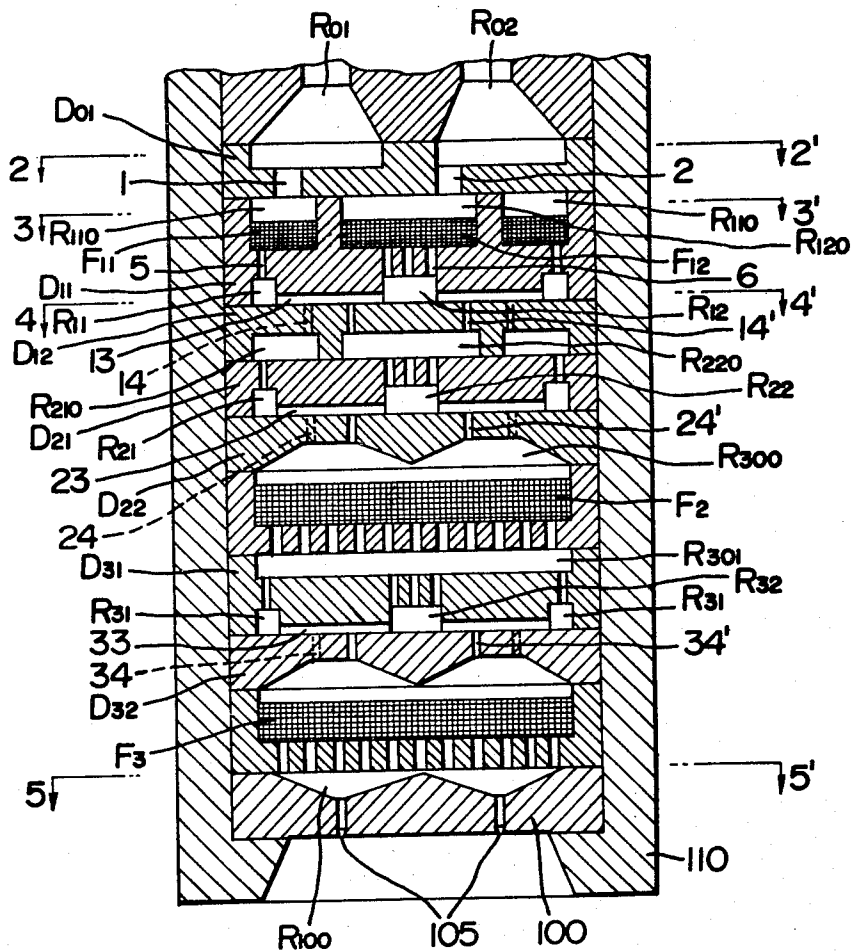
3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 5

Fig. 20



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 6

Fig. 21

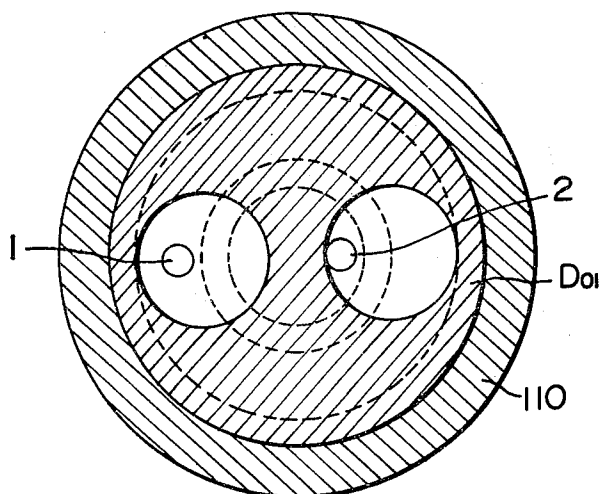
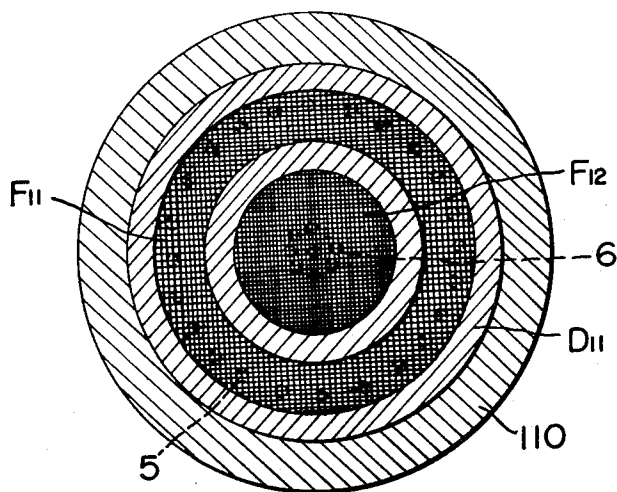


Fig. 22



June 27, 1972

MASO MATSUI ET AL
APPARATUS FOR PRODUCING MULTILAYER FILAMENT

3,672,802

Original Filed March 6, 1968

26 Sheets-Sheet 7

Fig. 23

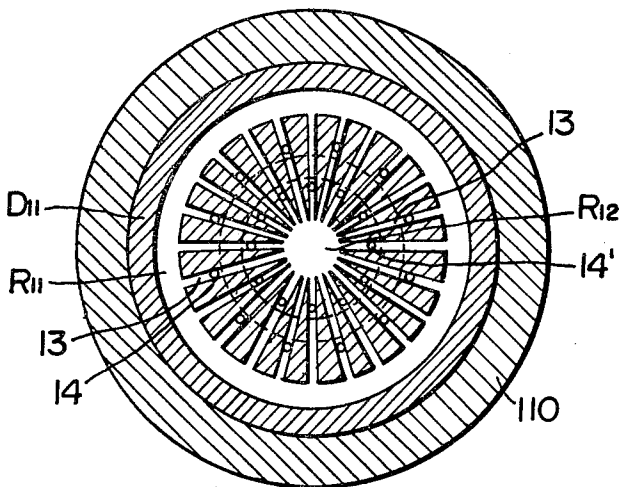
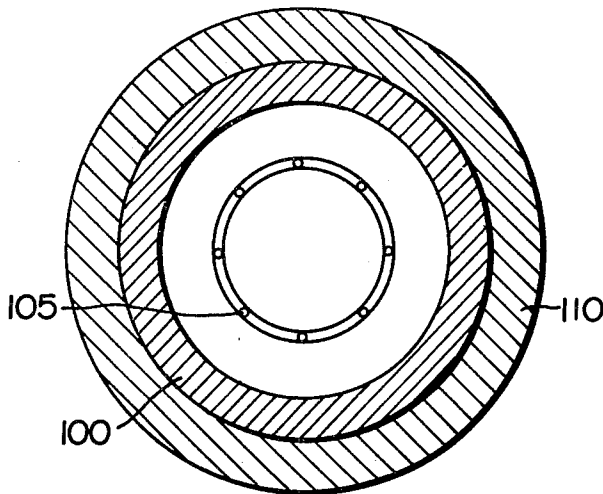


Fig. 24



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 8

Fig. 25

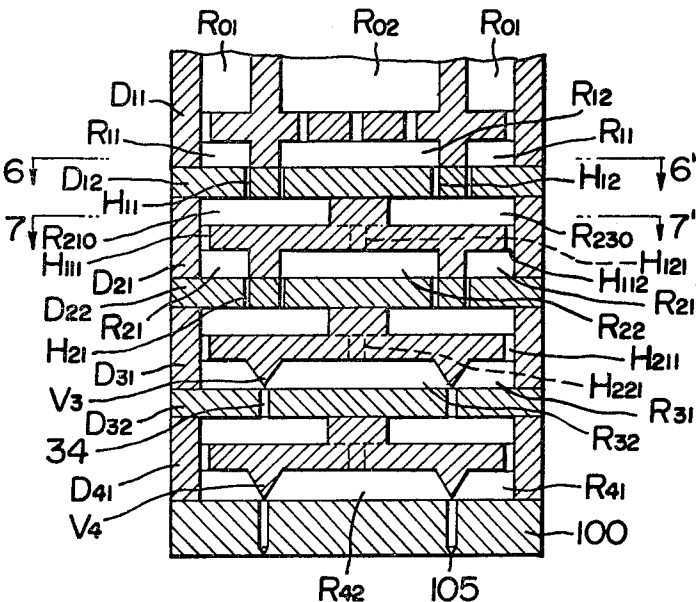


Fig. 26

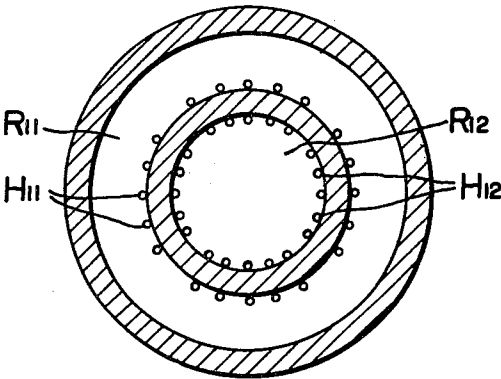


Fig. 27

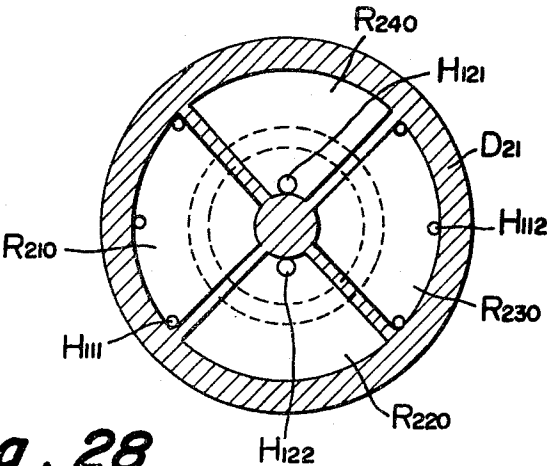


Fig. 28

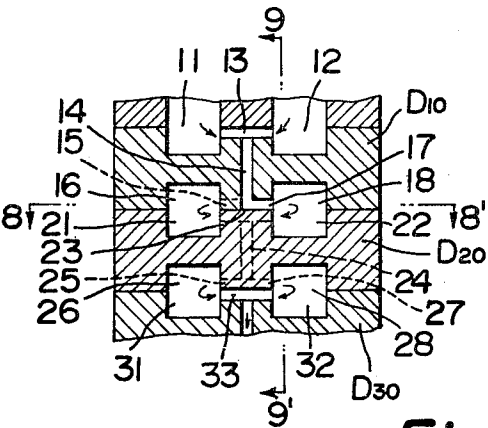


Fig. 29

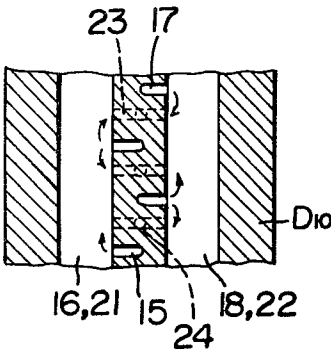


Fig. 30

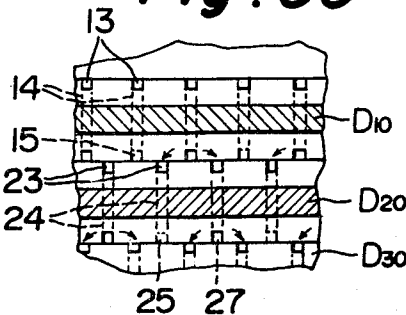


Fig. 31

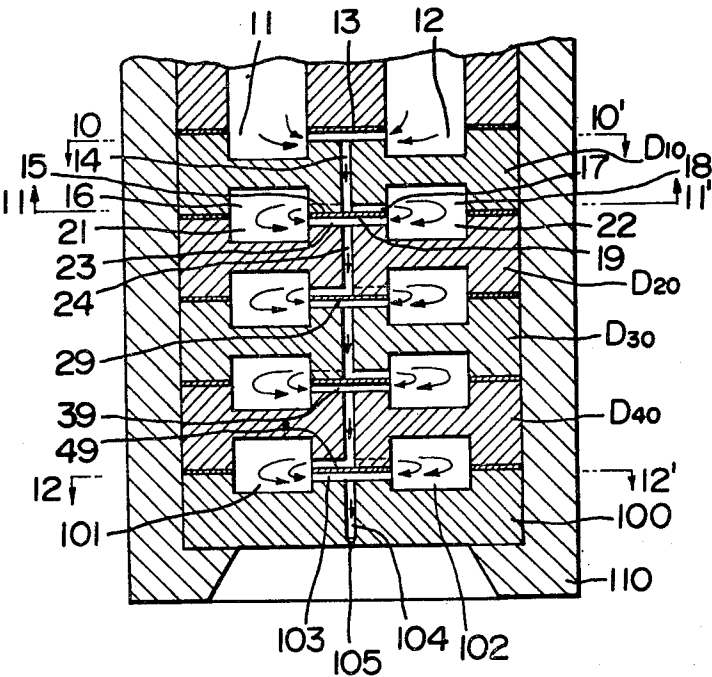
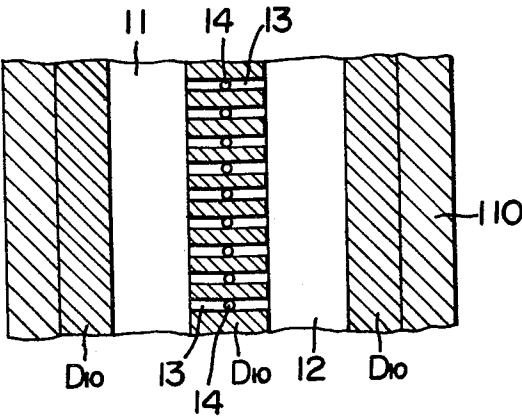


Fig. 32



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 11

Fig. 33

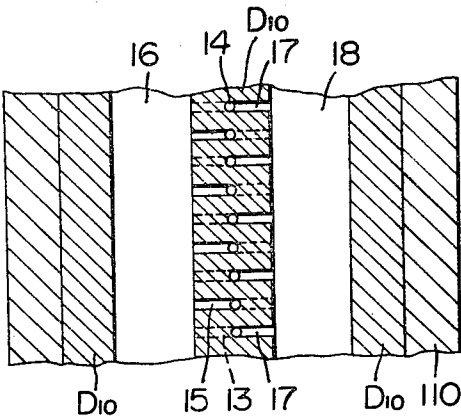
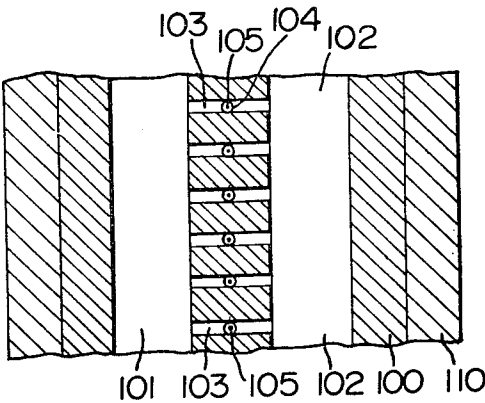


Fig. 34



APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 12

Fig. 35

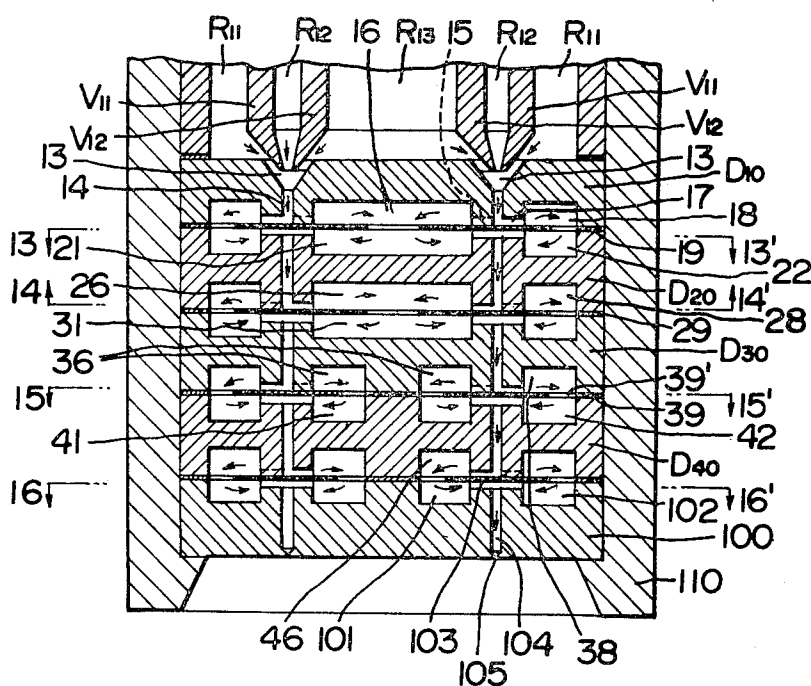
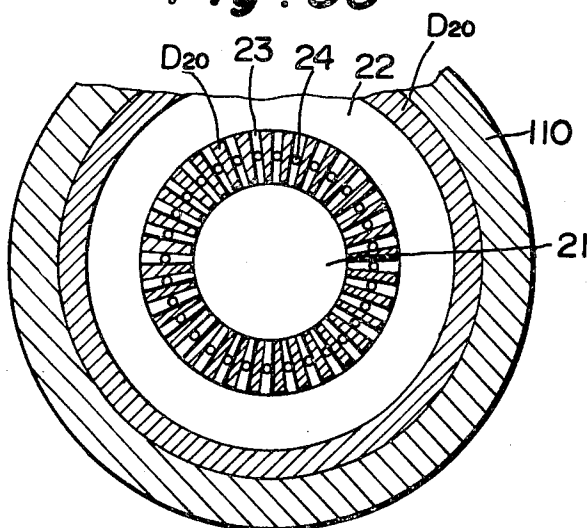


Fig. 36



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 13

Fig. 37

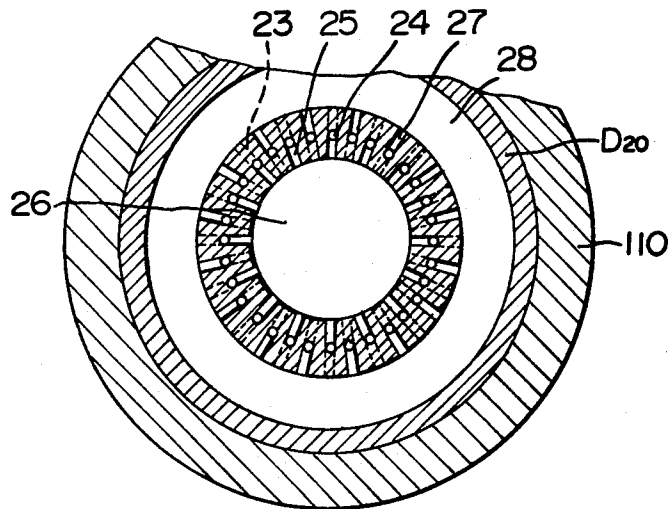
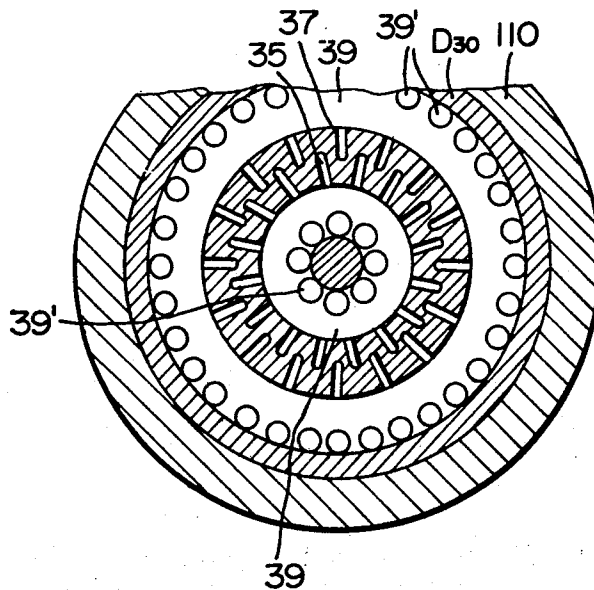


Fig. 38



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 14

Fig. 39

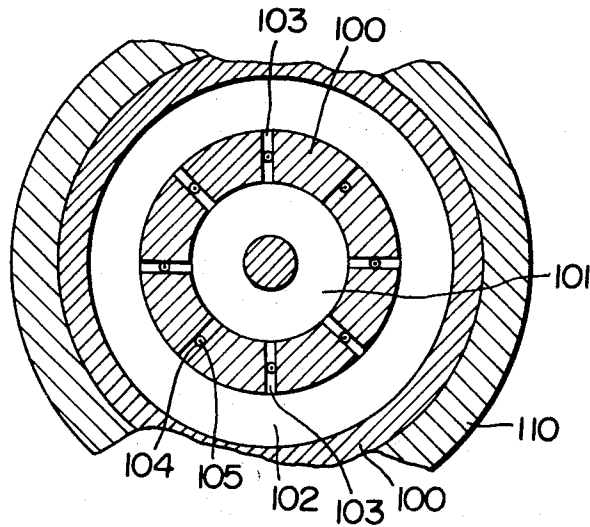
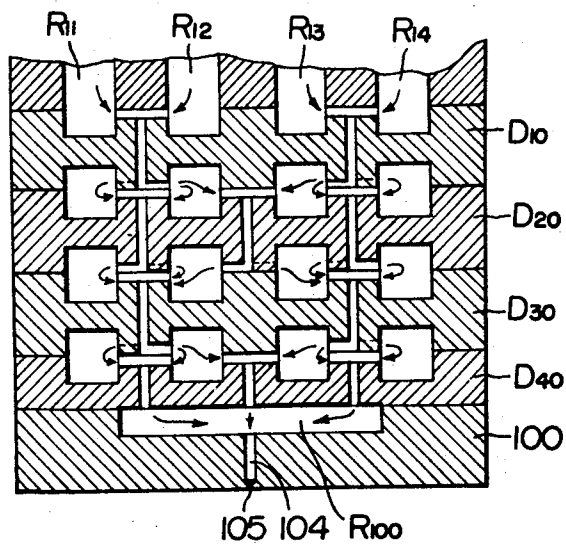


Fig. 40



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 15

Fig. 41

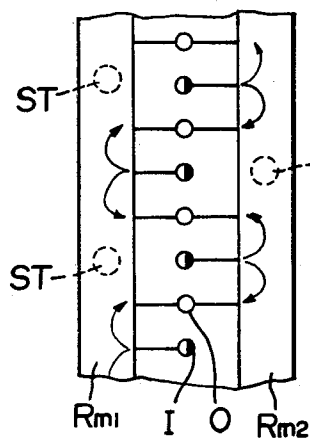


Fig. 42

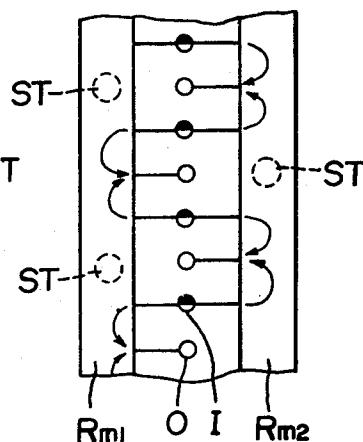


Fig. 43

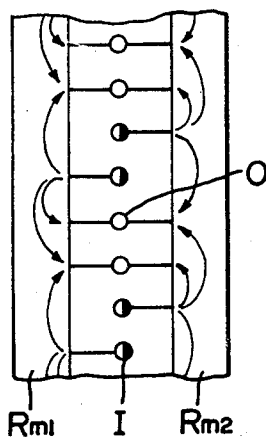
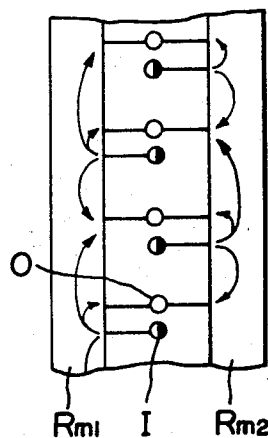


Fig. 44



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 16

Fig. 45

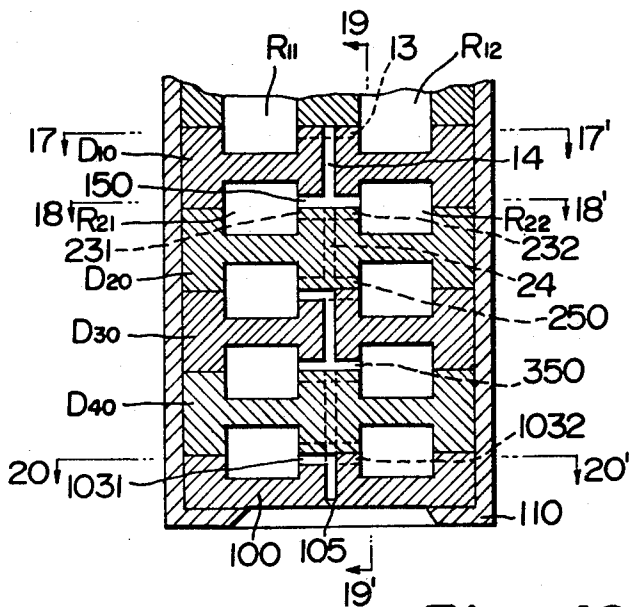


Fig. 46

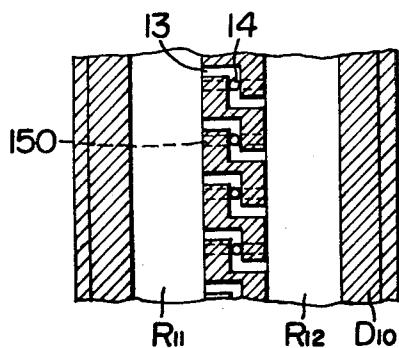
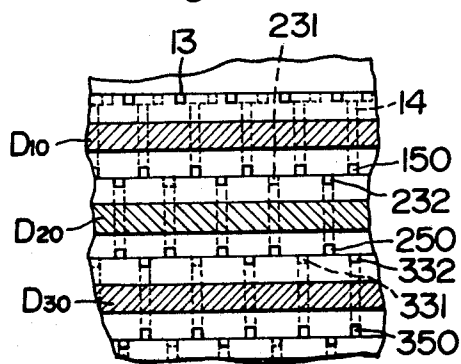


Fig. 48



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 17

Fig. 50 **Fig. 51** **Fig. 52**

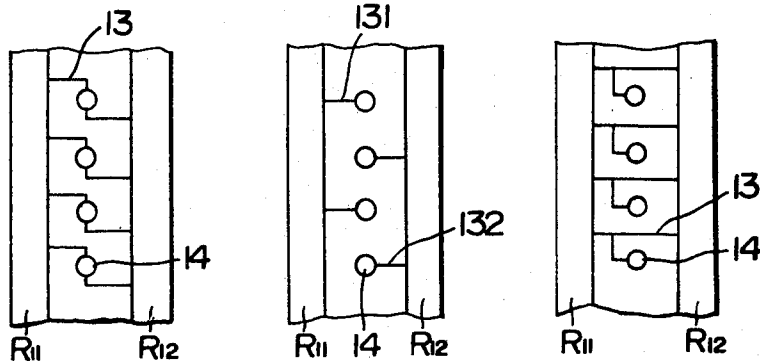


Fig. 53 **Fig. 54** **Fig. 55**

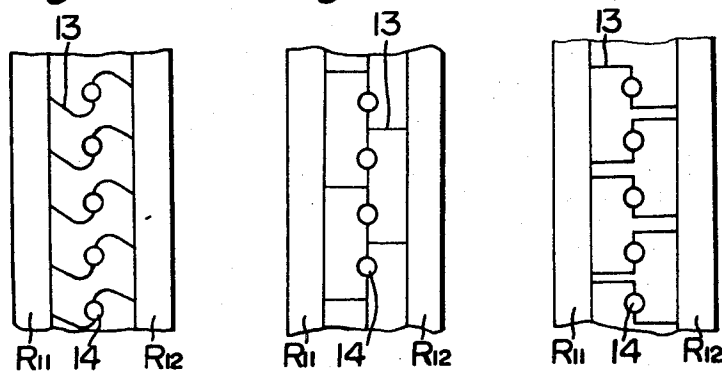
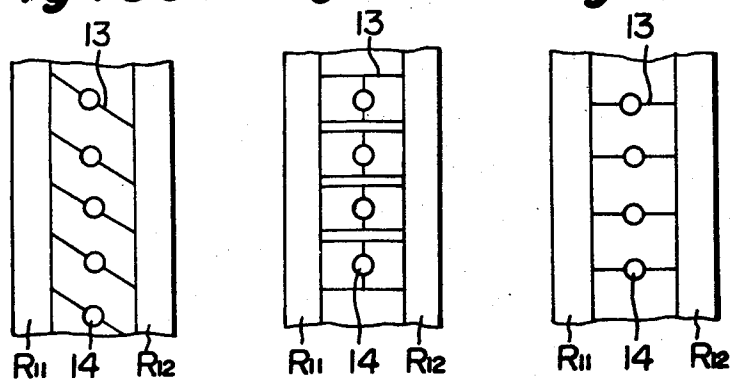


Fig. 56 **Fig. 57** **Fig. 58**



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 18

Fig. 59

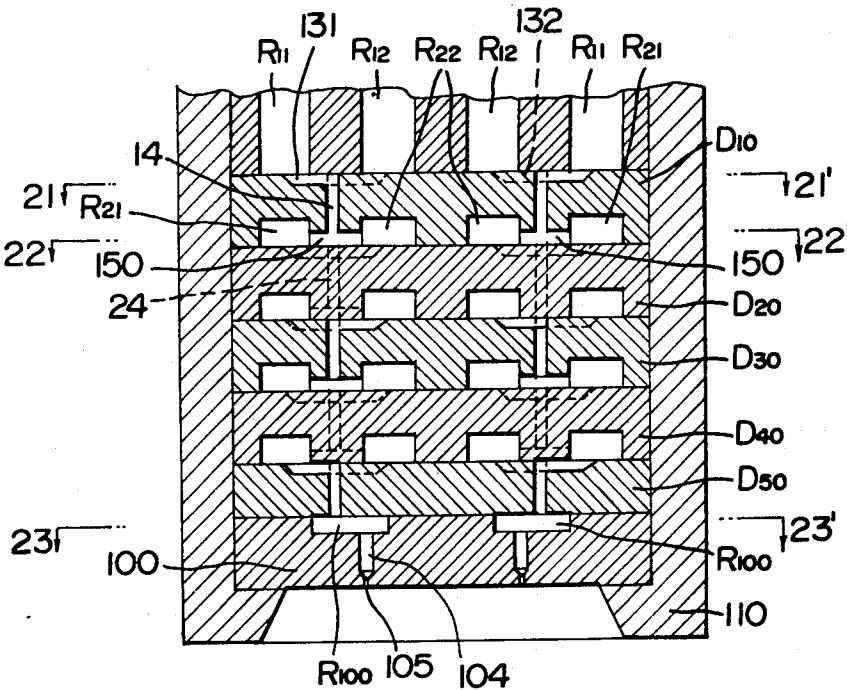
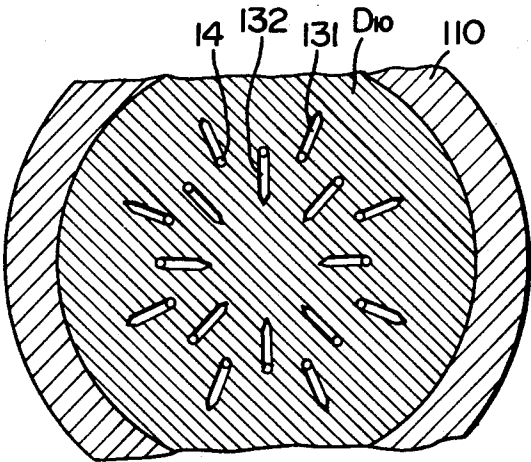


Fig. 60



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 19

Fig. 61

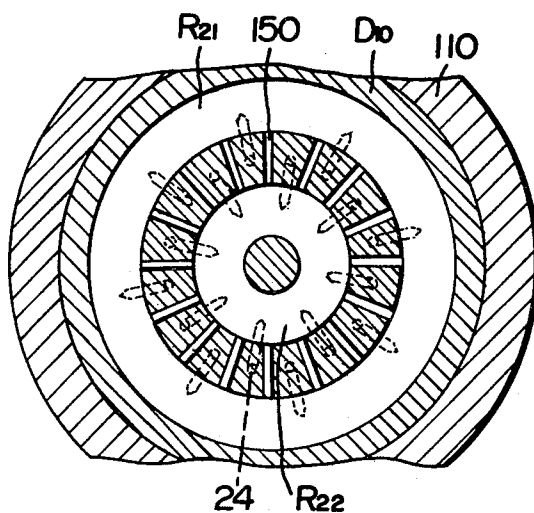
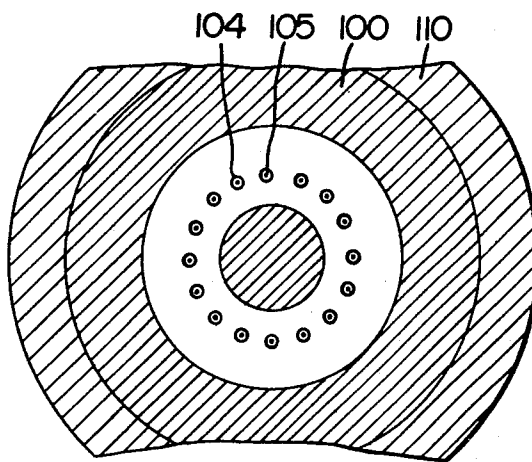


Fig. 62



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 20

Fig. 63 Fig. 64 Fig. 65 Fig. 66



Fig. 67 Fig. 68 Fig. 69 Fig. 70

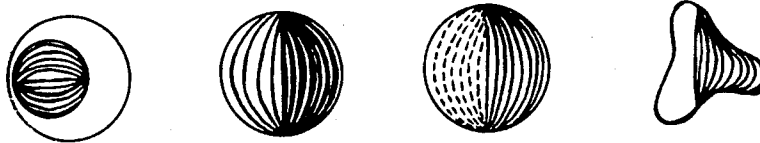


Fig. 71 Fig. 72 Fig. 73 Fig. 74



Fig. 75

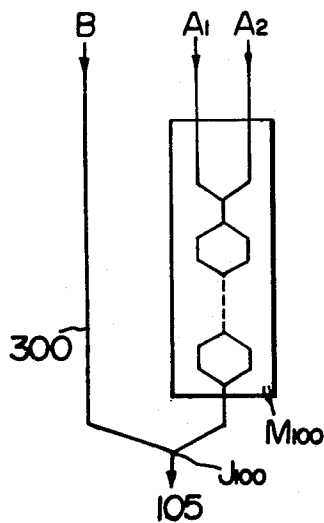
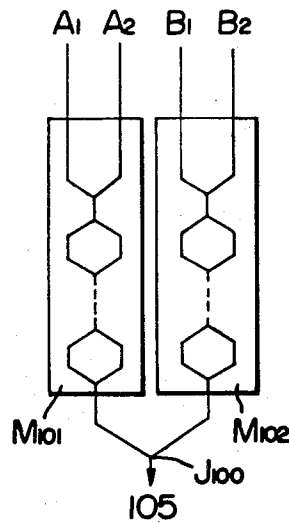


Fig. 76



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 21

Fig. 77

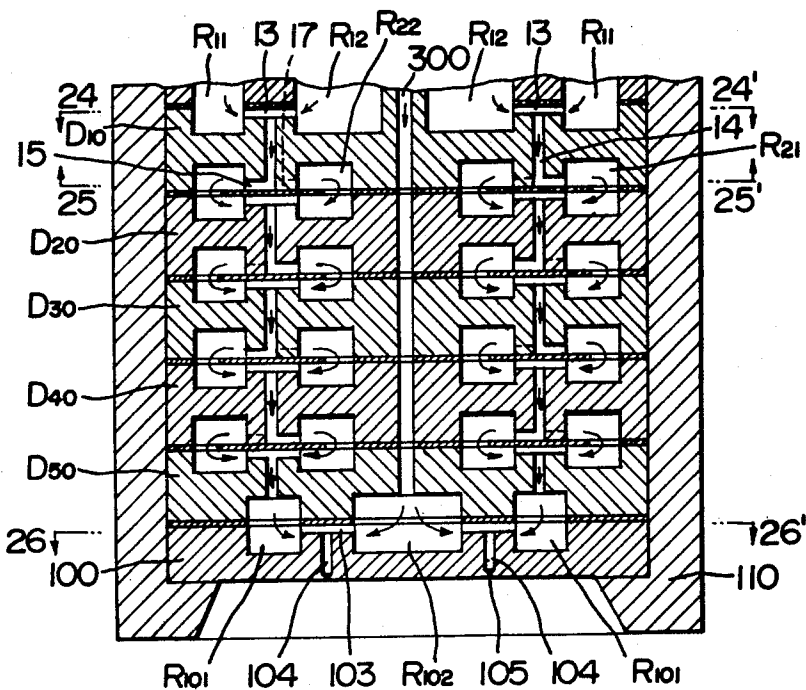
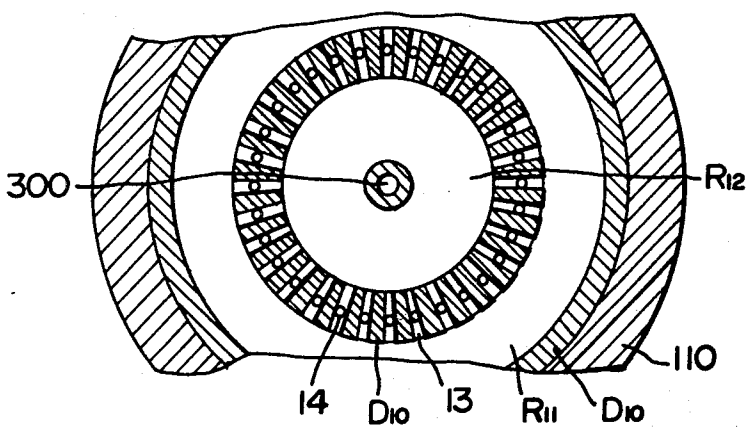


Fig. 78



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 22

Fig. 79

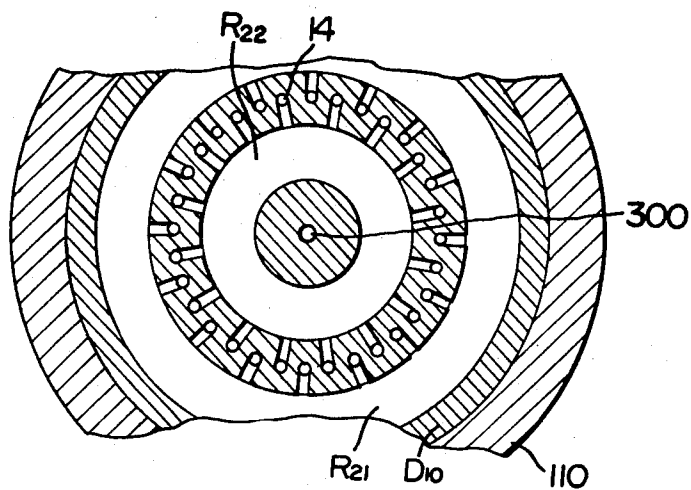
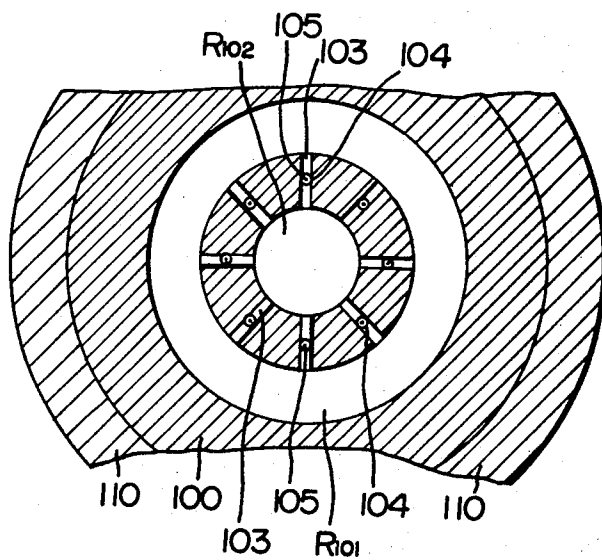


Fig. 80



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 23

Fig. 81

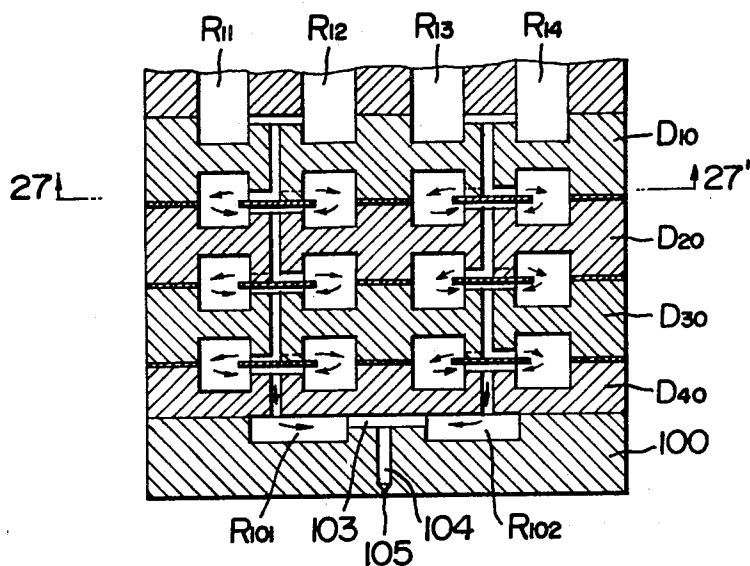
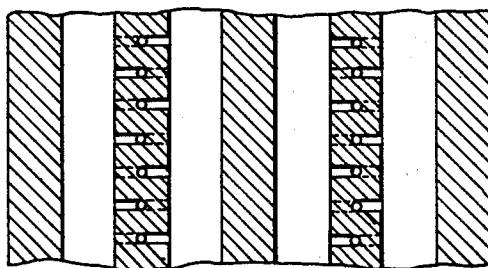


Fig. 82



June 27, 1972

MASO MATSUI ET AL

3,672,802

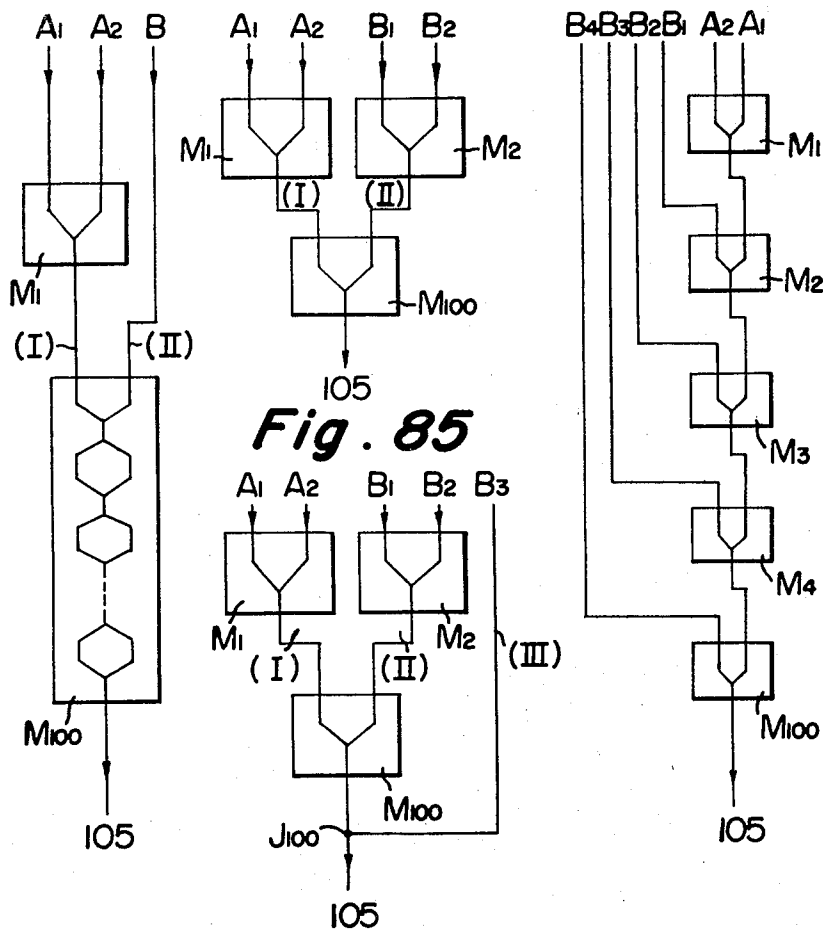
APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 24

Fig. 83 Fig. 84

Fig. 86



June 27, 1972

MASO MATSUI ET AL

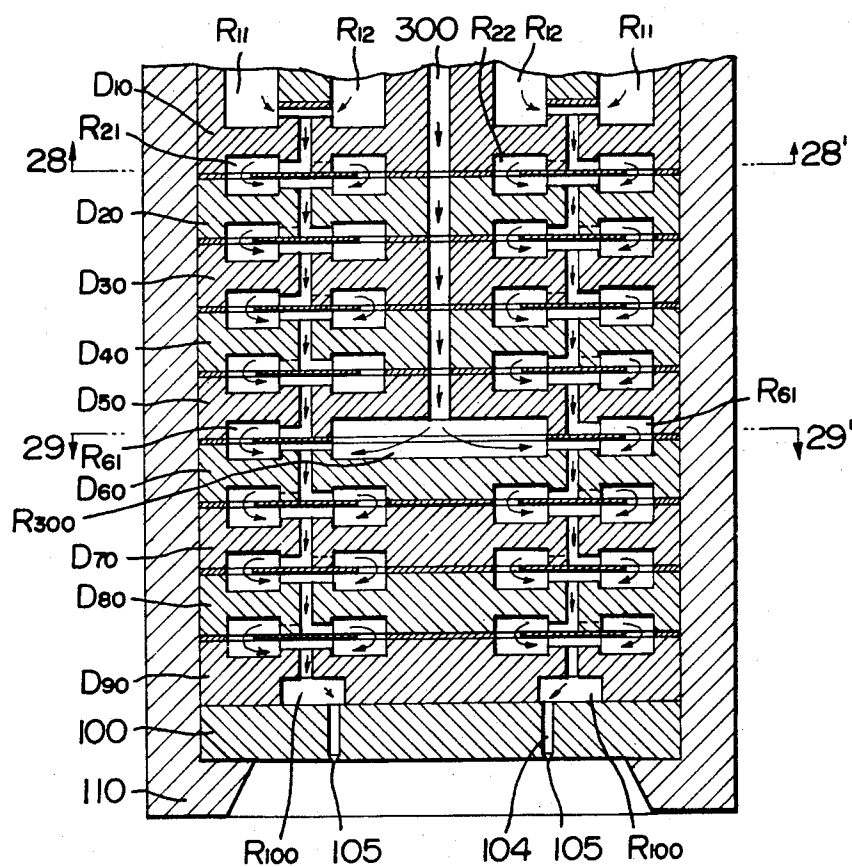
3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 25

Fig. 87



June 27, 1972

MASO MATSUI ET AL

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Original Filed March 6, 1968

26 Sheets-Sheet 26

Fig. 88

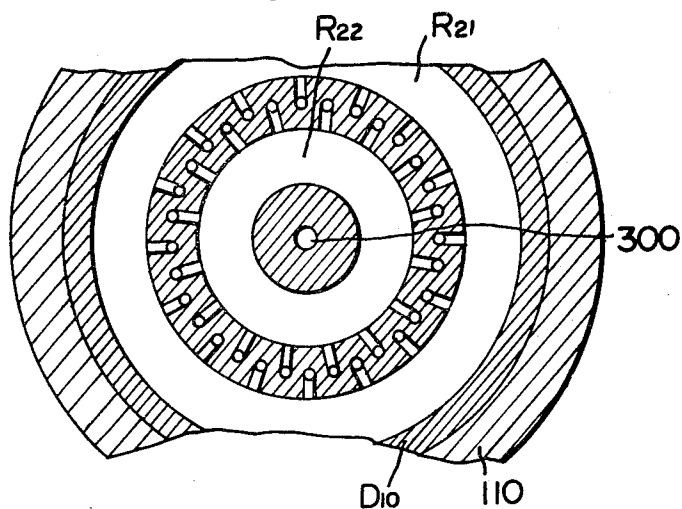
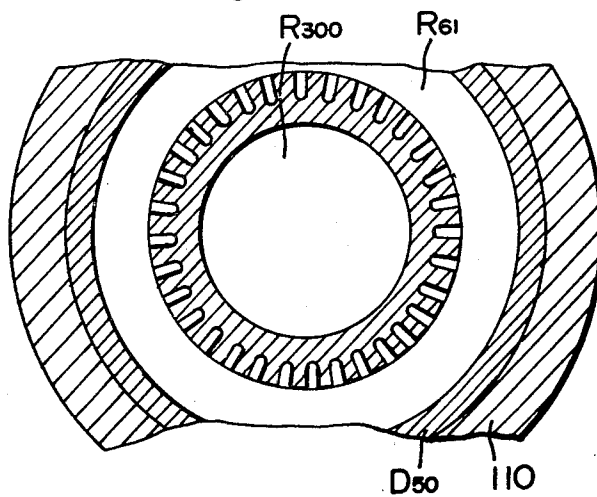


Fig. 89



1

3,672,802

APPARATUS FOR PRODUCING MULTILAYER FILAMENT

Maso Matsui, Takatsuki, Yutaka Utsuhara, Higashi-Osaka, Masahiro Yamabe, Neyagawa, and Susuma Tokura, Osaka, Japan, assignors to Kanegafuchi Boseki Kabushiki Kaisha, Tokyo, Japan
Original application Mar. 6, 1968, Ser. No. 711,070.
Divided and this application May 25, 1970, Ser. No. 48,683

Claims priority, application Japan, Mar. 15, 1967, 42/16,501

Int. Cl. D01d 3/00

U.S. Cl. 425—131

7 Claims

ABSTRACT OF THE DISCLOSURE

A spinneret is disclosed for the production of mixed filaments which are made from at least two spinning materials extending substantially continuously along the filament axis having at least ten thin layers in arbitrary cross section. The spinneret contains a plurality of layer multiplying mixers for separation and joining of the filament components in different phase.

This application is a division of our co-pending application Ser. No. 711,070, filed Mar. 6, 1968, now abandoned.

The present invention relates to a spinneret for forming a mixed filament, which is composed of at least two components mixed therein. Such a mixed filament can be obtained by mixing two or more spinning materials (components) and then spinning the resulting mixture.

Heretofore, a method has been well-known, in which two or more spinning materials are mix-spun to obtain filaments having improved physical or chemical properties. Particularly, recently a production of composite filaments having latent crimpability by spinning at least two spinning materials simultaneously through a common orifice into a unitary filament has been developed. In the resulting composite filament, at least two components are joined in an eccentric relation to one another along the filament axis, so that the cross-section has, for example, the configuration as shown in FIG. 1 and it can be said that the mixed state of the components in the composite filament is macroscopic. The composite filament has various excellent characteristics, as well as many defects to be improved. The composite filaments heretofore in use are of a macroscopic mixture as mentioned above, so that when a microscopic mixture is required, for example, in order to improve dyeability, property of electrification and hygroscopicity, said composite filaments are not still satisfactory. For example, a polymer having property of non-electrification or hygroscopicity is used as a component, only a limited effect is obtained. Furthermore, even if two spinning solutions having different dyeabilities are employed, the resulting composite filament cannot be provided with a satisfactory mixed color upon dyeing. Moreover, every component for the spinning materials needs fiber-forming ability except a particular case. In the composite filament, if the bonding property between the components is low, each component is readily separated from others and the tenacity of the filament is sometimes lowered. On the contrary, the mixed filament according to the present invention has more finely divided components and microscopically mixed structure, the embodiments of the cross-sectional structures of which are shown in FIGS. 7 and 8 and FIGS. 63-74.

Heretofore, the spinning of multicomponent filament having the structure of microscopic mixture has been

2

often effected by utilizing a mechanical action (stirring), for example, by mixing powders or pellets of two spinning materials, melting and kneading the mixture by means of a single- or multiscrew extruder and then spinning the melts. However, such a mechanical stirring needs a complicated apparatus and the uniformity of the mixture is poor. For example, when mixed pellets are melted by a screw extruder and spun through a large number of orifices simultaneously, it has been often observed that a filamentary yarn having different mixture ratios and mixed states between individual filaments are obtained. In order to improve the mixed state of the components and to make the mixture more fine and homogeneous, a perforated plate (breaker plate) or a filter (meshes or sand layer) may be used, but such means attain only small mixing effect. The above-described defects in the mechanical stirring are noticeable particularly as the viscosity of the spinning solution is high. In order to produce a microscopically homogeneous mixture of two spinning solutions, it is necessary to form a turbulent flow in the spinning solutions, but it is very difficult to produce the turbulent flow in a high viscous fluid, because in many cases the spinning solutions flow in a laminar flow.

The inventors have made various studies in order to solve the above-described problems and the present invention has been accomplished. Namely, the inventors have found novel methods and apparatuses for producing novel filaments having a multilaminated structure by dividing and mixing the laminar flows of the spinning solutions.

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

FIG. 1 is a cross-sectional view of two layer filament;
FIGS. 2 and 4 are cross-sectional views of four layer filament;

FIGS. 3 and 5 are cross-sectional views of eight layer filament;

FIG. 6 is a cross-sectional view of distorted four layer filament;

FIG. 7 is a cross-sectional view of distorted "grainy" multilaminar filament;

FIG. 8 is a cross-sectional view of mixed filament having an "archipelagic cross-section";

FIG. 9 is a model diagram of fundamental type for stratifying the spinning material flows into multilayers;

FIGS. 10 and 11 are modifications of the fundamental type as shown in FIG. 9;

FIG. 12 is a model diagram of a type, incapable of layer-multiplying the spinning material flows;

FIGS. 13 and 14 show perspective views of longitudinal section of the mixed filaments obtained by the present invention;

FIG. 15 shows a perspective view of longitudinal section of "granularly" mixed filament;

FIGS. 16 and 17 show flow diagrams of the spinning material flows in the spinning method and apparatus of the present invention;

FIG. 18 shows a longitudinal-sectional view of an embodiment of the spinneret of the present invention;

FIG. 19 is a cross-sectional view of the spinneret as shown in FIG. 18 taken on line 1-1';

FIG. 20 shows a longitudinal-sectional view of another embodiment of the filament of the present invention;

FIGS. 21, 22, 23 and 24 are cross-sectional views of the spinneret as shown in FIG. 20 taken on lines 2-2', 3-3', 4-4', and 5-5', respectively,

FIG. 25 shows a longitudinal-sectional view of a further embodiment of the spinneret of the present invention;

FIGS. 26 and 27 are cross-sectional views of the spin-

neret as shown in FIG. 25 taken on lines 6-6' and 7-7' respectively;

FIG. 28 shows a longitudinal-sectional view of a layer-multiplying mixer of the present invention;

FIGS. 29 and 30 are cross-sectional views and a longitudinal view of the spinneret as shown in FIG. 28 taken on lines 8-8' and 9-9', respectively;

FIG. 31 shows a longitudinal-sectional view of an embodiment of the spinneret of the present invention;

FIGS. 32, 33 and 34 are cross-sectional views of the spinneret as shown in FIG. 31 taken on lines 10-10', 11-11' and 12-12', respectively;

FIG. 35 shows a longitudinal-sectional view of an embodiment of the spinneret of the present invention;

FIGS. 36, 37, 38 and 39 are cross-sectional views of the spinneret as shown in FIG. 35 taken on lines 13-13', 14-14', 15-15', and 16-16', respectively;

FIG. 40 shows a longitudinal-sectional view of another embodiment of the spinneret of the present invention;

FIGS. 41, 42, 43 and 44 are plan views of model diagrams (flow diagrams) of distributors used in the present invention;

FIG. 45 shows a longitudinal-sectional view of an embodiment of the spinneret of the present invention;

FIGS. 46, 47, 48 and 49 are cross-sectional views of the spinneret as shown in FIG. 45 taken on lines 17-17', 18-18', 19-19' and 20-20', respectively;

FIGS. 50, 51, 52, 53, 54, 55 and 56 are model diagrams of structure suitable for joining in the first stage of the spinneret as shown in FIG. 45;

FIGS. 57 and 58 are model diagrams of structures unsuitable for joining at the first stage of the spinneret as shown in FIG. 45;

FIG. 59 shows a longitudinal-sectional view of a further embodiment of the spinneret of the present invention;

FIGS. 60, 61 and 62 are cross-sectional views of the spinneret as shown in FIG. 59 taken on lines 21-21', 22-22' and 23-23', respectively;

FIG. 63 shows a cross-sectional view of uniformly "grainy" multilayer filament of the present invention;

FIG. 64 shows a cross-sectional view of mixed filament having an archipelagic cross-section of the present invention;

FIGS. 65, 66, 67, 68, 69 and 70 show cross-sectional views of the composite multilayer filaments of the present invention;

FIGS. 71, 72, 73 and 74 show partially enlarged views of cross-sections of the filaments having double multilayer structure according to the present invention;

FIGS. 75 and 76 show flow diagrams of methods for producing the composite multilayer filament of the present invention;

FIG. 77 shows a longitudinal-sectional view of a spinneret for spinning the composite multilayer filament of the present invention;

FIGS. 78, 79 and 80 are cross-sectional views of the spinneret as shown in FIG. 77 taken on lines 24-24', 25-25' and 26-26', respectively;

FIG. 81 shows a longitudinal-sectional view of another spinneret for spinning the composite multilayer filament of the present invention;

FIG. 82 is a cross-sectional view of the spinneret as shown in FIG. 81 taken on line 27-27';

FIGS. 83, 84, 85 and 86 show flow diagrams of methods for spinning the filaments having double multilayer structures of the present invention;

FIG. 87 shows a longitudinal-sectional view of the spinneret for spinning the filament having another double multilayer structure; and

FIGS. 88 and 89 are cross-sectional views of the spinneret as shown in FIG. 87 taken on lines 28-28' and 29-29', respectively.

As mentioned above, FIG. 13 shows a longitudinal-sectional structure for one embodiment of the multilayer fila-

ment, in which each layer is continuous along the filament axis. FIG. 14 shows an embodiment of a longitudinal-section of the multilayer filament having a discontinuous layer structure. FIG. 15 shows an embodiment of a longitudinal-section of the mixed filament of granular mixture. Mixed filament obtained by the mechanical stirring shows a structure containing granules as shown in FIG. 15 or a structure having elongated fine granules, that is, needles mixed therein. The structure containing needles has been disclosed in, for example, Belgian Pat. No. 661,784 as a mixture having microfibers dispersed therein and the diameter of the microfibers is less than 1μ and the length is about 100μ . In the above-described mixed filaments, granules or microfibers contained are sufficiently microscopic, but said mixed fibers have defects due to the discontinuous structure. The filaments having the discontinuous structure are generally low in the strength or in the resistance against tensile. This tendency is further promoted when said filaments suffer bending or stretching stress repeatedly. Furthermore, in said filament an irreversible shift of structural units is caused in the structure owing to elongation and the elastic recovery lowers. In addition, if the mixture of the starting polymers is stirred for a long time in order to obtain such mixed filaments, the polymers react mutually in many cases and depolymerization or decomposition occurs and the polymer is deteriorated. Moreover, the mixing is effected by the mechanical stirring, no that non-uniformity occurs readily.

The first object of the present invention is to provide an apparatus for forming multilayer filaments having novel structure, in which the above-described various defects have been improved.

Namely, the filament of this invention is characterized in that at least two components are joined mutually in thin layers, each of which extends substantially uniformly along the longitudinal direction of the filament and that the number of layers in an arbitrary cross-section of the unitary filament is at least 10.

The first feature of the filament according to the present invention consists in that the filament forms substantially continuous structure along the longitudinal direction of the filament. The term "substantially continuous structure" used herein means that each layer has enough length to be considered as practically continuous and may involve partially discontinuous structure. Each layer constituting the filament according to the present invention continues along at least several centimeters, normally, from several meters to several hundred meters. Accordingly, the filament according to the present invention does not substantially have such defects resulting from the discontinuous structure possessed by the mixed filament containing granular or microfibrinous components. Namely, the filament according to the invention has an improved resistance against repeated tensile and bending stress.

The second feature of the filament according to the invention consists in that each component is in the form of very thin layer, namely, super thin layer. The first advantage resulted from this characteristic is that every component is multistratified into extremely fine and microscopic layers. The second advantage is that the contact area between components is large. Accordingly, the filament of the present invention is extremely strong in bonding of components and is high in the resistance against elongation and bending stress. Namely, said filament is high in the tensile strength at break, the recovery from elongation and bending strength. Furthermore, the structure is composed of microscopic layers (it is possible to produce filament, in which the layers cannot be observed even by a microscope), so that uniformity can be sufficiently maintained throughout the filament and this advantage is particularly effective when components different in coloration degree, dyeability, electric conductivity or hydrophilic property, are combined. As the spinning material of the filament according to the invention, polymers which cannot be used solely, namely, have no fiber-forming ability

5

can be used in part. This is also due to the fact that the filament has microscopic and continuous thin stratiform structure.

In order to obtain such advantages, that is, to attain the object of the present invention, it is preferable that the thickness of the layer is as thin as possible and that the number of the layers is as large as possible. In general, the properties of the filament vary dependently upon the number and the thickness of the layers, so that such number and thickness may be selected according to the object, but when the number of layers in the cross-section of the unitary filament is at least 10, preferably at least 20, or the average thickness of the layers is at most 5μ , preferably, at most 1μ , desirable super multilayer effect can be obtained.

A method of producing the filament according to the present invention will be explained more in detail in the following:

FIG. 9 is a model diagram of a fundamental type for showing process of layer-multiplying the spinning materials. Two spinning materials (A) and (B) are joined at a point (J_1) to form two layer structure (AB), which is separated at a point (S) and then again joined at a point (J_2) to form four layer structure (ABAB). The cross-section of the two layer structure obtained at the point (J_1) is, for example, as shown in FIG. 1 and the four layer structure obtained at the point (J_2), for example, as shown in FIG. 2. Such joining and separation are repeated in multistages (in series), whereby the spinning materials are layer-multiplied. In such a case as shown in FIG. 9, the number of the obtained layers is calculated by 2^n , where n is the number of stages for joining and separation. The feature of such joining and separation is that the separation at the point (S) is carried out, while maintaining the joined state at the point (J_1) at least in part, preferably in whole and that the joining at the point (J_2) is carried out so as to add the number of layers at least in part, preferably, in whole. Such joining and separation are called as "joining and separation in different phase," because the directions of joining and separation are different (preferably, at right angles to each other).

On the contrary, when the joining and the separation are carried out in same phase (on the same straight line), the flow of the spinning materials are not layer multiplied. A model diagram of the joining and separation in the same phase is shown in FIG. 12. The flow in a breaker plate and a filter bed is such a flow. FIG. 9 is a fundamental type of the joining and separation in different phase and there are many modifications and applications thereof. FIG. 10 is an embodiment of its application, in which the joining (J_1) of three components in a side-by-side relation is carried out in the first stage and the number of layers obtained in a process as shown in FIG. 10 is $3 \times 2^{n-1}$ (n : number of stages for joining and separation). FIG. 11 is also one embodiment of the application of FIG. 9, in which at the point (S) the flow is separated into three and the number of the obtained layers is $2 \times 3^{n-1}$.

The joining and separation in the different phase and those in the same phase can be shown as follows:

$$\left(\frac{A}{B}\right) + \left(\frac{A}{B}\right) \rightarrow \left(\frac{A}{B}\right) \quad (1)$$

$$(A|B) + (A|B) \rightarrow (A|B|A|B) \quad (2)$$

$$\left(\frac{A}{B}\right) + \left(\frac{B}{A}\right) \rightarrow \left(\frac{A|B}{B|A}\right) \quad (3)$$

$$\left(\frac{A}{B}\right) \rightarrow \left(\frac{A}{B}\right) + \left(\frac{A}{B}\right) \quad (4)$$

$$(A|B) \rightarrow (A) + (B) \quad (5)$$

6

In the foregoing formulae, $(A|B)$ shows a joined state as shown in FIG. 1 and $(A|B|A|B)$ shows the joined state as shown in FIG. 2 and

$$\left(\frac{A|B}{B|A}\right)$$

shows the joined state as shown in FIG. 4.

$$\left(\frac{A}{B}\right)$$

is different by 90° in the phase from $(A|B)$.

Formula 1 shows the joining in the same phase and Formulae 2 and 3 show the joining in different phase. Formula 4 shows the separation in the different phase and Formula 5 shows the separation of the same phase. Of course, types shown by FIGS. 9 to 12 and Formulae 1 to 5 are examples and there are more complicated cases.

The multilayer structure obtained by effecting the joining and separation in the different phase in multistages is in practice disturbed or distorted more or less. It is difficult to obtain geometrically regular structures as shown in FIGS. 2 to 5. For example, according to the process in FIG. 9, it is expected that the structure as shown in FIG. 2 is obtained by two stages of joining and separation, but the filament actually obtained has often the distorted structure as shown in FIG. 6.

Embodiments of cross-section of the filaments composed of a very large number of layers according to the present invention are, for example, those as shown in FIGS. 7 and 63 and have "grainy" multilayer structure. The layers are sometimes divided into many round fractions owing to surface tension or are aggregated owing to turbulence of flow of the spinning materials in the spinning apparatus. FIG. 7 shows a distorted grainy structure and FIG. 63 shows a relatively regular grainy structure. FIG. 8 shows an embodiment of multilayer structure wherein the layers are divided into pieces in the cross-section and such a structure is called as "archipelagic" one. FIG. 64 shows a archipelagic structure similar to a grain structure. The spinning materials may be divided and dispersed more finely. However, it has an effect for increasing the contact area of each component with others that the layers are distorted in the cross-section and such a fact is rather desirable for the object of the present invention. In view of increase of the contact area of mutual layers, the grainy structures as shown in FIGS. 7 and 63 are particularly preferable. Of course, the grainy structure may be not so regular as an annual ring of wood, but may have irregular distortion and further may be not completely continuous.

The structure having an archipelagic cross-section is modified grainy structure and is also useful. However, when the cross-section of the divided component is circular, the contact area is minimum, so that such circular cross-section of the component is not preferable (of course, a part of the divided components may have circular cross-section, but it is preferable that the major part comprises layers).

The filament according to the present invention is characterized by that the number of layers is many. The number of layers constituting the unitary filament of this invention is at least 10, preferably, at least 20. Usually, the filaments having several tens to several hundreds of layers are most preferable. When the number of layers is too large, said layers cannot be identified by an optical microscope, and said identification can be effected by electron microscope. The number of layers cannot always be measured exactly. Namely, in FIGS. 1 to 5, each layer is completely distinct, so that it is easy to figure the number, but the complicated structure as shown in FIG. 7 the layers are joined and connected mutually and many of them are not clearly distinguishable. In such a case, a straight line pq as shown in FIG. 63 is drawn in the cross-section of the filament so as to cross the layers as many as possible

and the number of layers can be shown by the number of layers crossed by the straight line. In general, actual number of layers is more than said number. However, even if the straight line *pq* crosses two or more times a smoothly continued layer, which is considered as the same layer apparently, such a case is figured as one time. For example, in case of concentrically circular multi-layer structure, the straight line passing through the center crosses each layer two times respectively.

In any case, in order to attain the object of the present invention, the number of layers should be at least 10 and to this end, in the system as shown in FIG. 9 it is sufficient to effect four stages of joining and separation and in the systems of FIGS. 10 and 11 it is sufficient to effect three-stages of joining and separation respectively. In general, the larger the number of layers constituting the unitary filament is, the larger the contact area of each component is and the greater the bonding force of mutual components is. When the number of layers constituting the unitary filaments is less than 10, this bonding force is small and the mixed state becomes macroscopic and the object of the present invention cannot be attained. Of course, as the number of layers increases, the property of the resulting filament is gradually varied and it does not mean that if the number of the layers reaches to 10 a sudden change occurs.

FIGS. 7 and 8 show the case, wherein the cross-section of the filament is circular, but the cross-section of the filament may be any known the configuration. For example, the cross-section of the filament may be a multi-lobal, polygonal, stellar, hollow or irregular type. FIG. 70 shows a tri-lobal type.

An application of multilayer filament according to the present invention involves composite multilayer filament, the cross-section of which is, for example, shown in FIGS. 65-70. The multilayer structure includes the grainy structure as shown in FIGS. 7 and 63 and the structure having an archipelagic cross-section as shown in FIGS. 8 and 64. However, in FIGS. 65 to 70, only the grainy structures are shown as the multilayer structure in order to show said composite multilayer structure briefly. As well-known, the composite filament includes a side-by-side type and a sheath-core type. FIGS. 65, 68, 69 and 70 show the side-by-side type and FIGS. 66 and 67 the sheath-core type. FIGS. 66 and 67 show the cases, wherein the core is multilayer structure, but of course the sheath may be multilayer structure. In any event, the composite multilayer filament has non-uniform stratiform structure.

According to the different classification, the composite multilayer filaments can be divided into two groups in one of which both of the bonded two components have multilayer structures and in the other of which only one of the bonded two components has a homogeneous structure. FIGS. 65, 66, 67 and 70 show the cases, wherein one component of the composite filament is a homogeneous structure and it can be considered that in these cases on particular layer in the multilayer filament is particularly magnified. FIGS. 68 and 69 show embodiments, wherein one multilayer structure is bonded with the other multilayer structure and in FIG. 68, layers in the right half are different from those in the left half in the thickness, density of layer, etc. and in FIG. 69 the right half and the left half are same in the multi-layer structure but different in the spinning components and namely, the component of which the layers shown by dotted lines consist is different from the component for the layers shown by solid lines. Both the core and sheath may be multilayer structure.

According to the further different classification, the composite filaments can be divided into an eccentric type and a concentric type. The eccentric types are shown in FIGS. 65, 67-70 and the concentric type in FIG. 66. The eccentric type composite multilayer filament has latent crimpability. An object of the present invention is to provide mixed filament having an improved crimpability.

Heretofore, it has been attempted that a polymer mixture is used for one or all of components of the composite filament. However, the mixture in these attempts, contains the above-described granule- or needle-like components. Accordingly, the composite filament composed of the conventional mixture has essential drawbacks. These drawbacks are based on the discontinuous structure of such granular or needle-like components. The stability of the crimps of composite filament comprising the mixture containing microfibers as one component is fairly improved, but is still unsatisfactory.

The features of the mixed filament having improved latent crimpability according to the present invention lie in the following points:

(1) At least two components extend in a large number of layers substantially uniformly along the filament axis.

(2) The number of layers in an arbitrary cross-section of the filament is at least 10, preferably, at least 20.

(3) The layers form eccentric and non-uniform multilayer structure laterally.

The term "eccentric or non-uniform" used herein means the expression when the filament is observed as the whole, namely, macroscopically. The structure as shown in FIG. 7 is microscopically (locally) non-uniform and eccentric and is not completely concentric structure, but it has essentially no latent crimpability. In order to provide a high latent crimpability, it is necessary to have macroscopically non-uniform and eccentric structure. FIGS. 65, 67-70 show filaments having macroscopically eccentric and non-uniform structure. In order to enhance the latent crimpability, it is desirable to increase the eccentricity.

As well known, in order to provide the composite filament with latent crimpability, it is necessary for the bonded components the composite filament to have different shrinkabilities. Accordingly, the selection of the components to be bonded to each other is also an important problem. Furthermore, it is possible to improve properties of the filament, for example, dynamic property, dyeability, property of electricification, hydrophobic property, heat resistance, etc. by combining two or more spinning materials as the components of the multilayer portion of the filament.

In the above-described composite multilayer filament, when one component to be bonded is a homogeneous structure, the multilayer structure portion in the composite filament should not be too small. The favourable characteristic of the filament of this invention is based on the multilayer structure, so that if the multilayer structure portion is too small, the effect is lowered.

As another type of application of the multilayer filament according to the present invention, there is a double multilayer structure. The term "double multilayer structure" means one having further several fine layers in one layer. FIGS. 71-74 are embodiments of partially enlarged views of cross-section of such double multilayer structure. FIG. 71 shows a cross-section having grainy layers in the grainy layer, FIG. 72 shows a cross-section consisting of homogeneous layers and composite layers having an archipelagic structure and FIG. 73 shows a cross-section having grainy layers in the archipelagic structure and FIG. 74 shows a cross-section having a micro-archipelagic structure contained in the macro-archipelagic structure. The cases in which cross-sections are similar to those as shown in FIGS. 72 and 74, and in which the fine structure in the layer is granule- or needle-like mixed structure, are also useful.

The spinning materials to be used as the components of the filaments according to the invention may be any well-known spinning materials the melt or solution of which has fluidity. Usual fiber-forming polymers, for example, polyamides, polyesters, polyester-ethers, polyethers, polyureas, polyolefins, polyvinyl series polymers, such as polyvinyl chloride, polystyrene, polyvinyl alcohol, polyacrylonitrile, polycarbonates, casein, regenerated cellulose, copolymers or modified polymers thereof are very useful.

Moreover, as spinning materials which are generally not used solely but can be employed as the component of the filament of the present invention, mention may be made of initial polymer of phenol-formaldehyde, polyethylene oxide, polyethylene-imine and most of surfactants. The above-described spinning materials may be added with organic or inorganic substances, such as delustrants, pigments, dyestuffs, light-stabilizers, plasticizers, if desired. Mutual compatibility of the components to be mixed is not necessarily required and the combination of incompatible components is useful. When components incompatible with each other are used, a fibrillated yarn, such as a modified yarn can be obtained.

The multilayer structure portion of the filaments according to the invention is composed of a plurality of components. The selection or combination of these components is an important problem. Useful combinations of two components are explained as follows:

Firstly, the combination of two components having different dyeabilities is useful. It is useful that a spinning material having poor dyeability is mixed with a spinning material having excellent dyeability to improve the dye-receptivity of the filament. For example, in general, a copolymer is often superior in the dyeability to a homopolymer. Furthermore, a polyamide is superior in the dye-receptivity for acid dye to a polyester. Polymers having functional groups, such as amine groups, carboxyl groups, hydroxyl groups, sulfo groups, imino groups, urea bonds and groups having high affinity with dyestuffs are excellent in the dyeability. The materials having excellent dyeability are generally inferior in the dynamic property, but in the filament according to the invention having super multilayer structure, the dynamic property of filament is less deteriorated even if the spinning material having poor dynamic property is mixed. For example, materials having no fiber-forming ability solely, can be used for the component of the filament according to the invention. Such materials used for improving the dyeability include polyalkyleneimine, such as polyethyleneimine.

Secondly, the combination of components having different properties of electrification or electric conductivity is useful.

Many of synthetic fibers have drawbacks that the electric resistance is high and they are electrically charged readily, and therefore various anti-static methods for synthetic fibers have been known. A method for incorporating a substance having a property of nonelectrification or a high electric conductivity in a spinning material having property of electrification, has also been well known. However, the material incorporated with the substance having the property of non-electrification is often deteriorated in the dynamic property. The filament having super multilayer structure according to the present invention is decreased in such a tendency and due to a sufficiently layer-multiplied and continuous structure, it can be provided with a sufficient anti-static property. Particularly, the continuous structure of the layer is convenient in order to enhance the electric conductivity. Materials, having no fiber-forming ability solely, for example, most of surfactants which have a high electric conductivity can be used.

Surfactants, for example, imidazole derivatives, phosphoric acid esters of higher alcohols and the salts thereof, such as alkyl phosphate amine salts and alkyl phosphate metal salts, sulphuric acid esters and phosphoric acid esters of higher alcohols, polyalkylene oxides, such as polyethylene oxide (polyethylene glycol) and the derivatives thereof have anti-static property and are useful for the present invention.

Thirdly, the combination of components having different hydrophilic properties is useful. Many of the synthetic fibers have defect in view of poor hydrophilic property. Hydrophilic materials are generally inferior in the dynamic property, but the filament according to the present invention has less reduced dynamic property even

though hydrophilic materials are mixed therewith. Hydrophilic materials include a large number of copolymers and polymers having many hydrophilic groups, such as amino groups, hydroxyl groups or carboxyl groups. The hydrophilic homopolymers include, for example, polyhexamethyleneisophthalamide, polymetaxylenesecbacamide, polybispropylpiperazineadipamide, polyethylene oxide, etc. Many of hydrophilic materials have low crystallinity and the filament obtained therefrom is low in the strength, but such materials are useful for the component of the filament of this invention.

Fourthly, the combination of components having different dynamic properties is also useful. Novel filaments can be obtained by combining polymers having different Young's moduli, tenacities, elongations and elasticity recovering percentages. For example, by combining a rigid polymer (with a high Young's modulus) with a flexible polymer (a Young's modulus), a filament having unique flexibility and rigidity can be obtained. The filament obtained by combining these two polymers according to the present invention has the structure similar to that of natural fiber. Silk, wool, cotton, wood and leather have microfibril structure. The feature of these natural structures consists in that fibrils having high tenacity and Young's modulus (in many cases, they are high in crystallinity and have a highly oriented structure) and flexible components (in many cases, they are hydrophilic and non-crystalline and have a high dyeing affinity) are mixed in a multilayer state.

The filament obtained by combining suitable components according to the present invention approaches to the natural fiber.

The combination of components having different chemical resistances, shrinkabilities latent adhesive properties, heat resistances or coloration degrees is also useful. The heat resistance can be enhanced by incorporating a material having a high softening point in a material having a low softening point. Filaments having novel coloring and lustrous effects can be obtained by combining components having different colors or shades or two components having and not having delustrant. This is due to the fact that the filaments according to the present invention are microscopically mixed ones.

The filaments obtained according to the present invention can be used for known use of fibers as continuous filaments or staple fibers and further can be used by mixing with the other fibers or filaments. The usually produced filaments have a fineness ranging about 1-100 deniers per unitary filament, but, of course, the fineness may exceed such a range, if necessary. The filaments according to the present invention are usually used in a drawn and oriented state, but can be utilized in an undrawn or lowly oriented state, if required.

Then the method and apparatus for spinning the multilayer filaments according to the present invention will be explained hereinafter. The fundamental method for spinning the multilayer filaments, namely the method wherein the spinning materials are joined and separated in the different phase at many stages and layer-multiplied, has been already explained. Such joining and separation may be effected in passages, such as fine pipes. However, the inventors have found very simple and improved method and apparatus. These improved method and apparatus are characterized by that at least two spinning materials are joined and/or separated in a plurality of reservoirs, while flowing through said reservoirs and the passages for connecting said reservoirs. In the improved method and apparatus, the reservoirs have very important and essential function and further, the passages for connecting the reservoirs are also very important and particularly, the combination system must be constituted in such a manner that as mentioned above the flows of the spinning materials are joined and separated in the different phase at many stages.

11

FIGS. 16 and 17 show flow diagrams or improved layer-multiplying mixers, by which means for connecting reservoirs R with passages are shown. In the figures, a rectangle shows a reservoir R and a line shows a passage. In FIG. 16 the separation is effected in the passage and the joining is effected in the reservoir. In FIG. 17 the joining is effected in the passage and separation is effected in the reservoir. Namely, the joining and the separation are effected in different phases each other. For example, in FIG. 16 the joining in the second stage reservoirs R_{21} and R_{22} , and the separation at the second stage separating point S_2 are effected in different phases. In the same manner, in FIG. 17 the joining at the first stage joining point J_1 , and the separation in the second stage reservoirs R_{21} and R_{22} should be effected in different phases. Further, both the joining and the separation may be effected in the reservoir. When the joining is effected in the reservoir, the number of outlet through which the spinning solution is flown out from the reservoir is smaller than that of inlet through which the spinning solution is flown into the reservoir. When the separation is effected in the reservoir, the number of the outlet is larger than that of the inlet. As a general rule, the joining and the separation are effected alternately, and one joining and one separation constitute a pair, and said pair may be in order of either joining-separation or separation-joining.

In FIGS. 16 and 17, two spinning solutions A and B are subjected to the repetitions of the joining-separation in different phase, layer-multiplied and introduced into the last reservoir R_{100} . In FIGS. 16 and 17, n shows the number (of stage) of the joining-separation and is a positive integer. The last reservoir R_{100} may be omitted in order to introduce the spinning solutions into the spinning orifice directly.

As described above, the layer-multiplying of the spinning solutions can be effected by interposing at least one distributing plate between the supplying portion for the spinning solutions and the spinning plate.

The present invention will be explained with reference to some spinnerets as shown in the drawings.

FIG. 18 is a vertical-sectional view of the essential part of the spinneret according to the invention. The mixing system of this spinneret is the same with that shown in FIG. 17. Two spinning solutions to be mixed are fed to the reservoirs R_{11} and R_{12} respectively at a predetermined mixing ratio. The two spinning solutions in the reservoirs R_{11} and R_{12} are joined at the center of channels 13 and extruded into the left reservoir R_{21} of the second stage through a parts of ducts 14, distributing channels 15 and inlets 15'. Another part of the ducts 14 is connected with the right reservoir R_{22} of the second stage by another distributing channels 16 and inlets 16'. FIG. 19 is a cross-sectional view of the spinneret taken along the line 1—1' in FIG. 18 in the arrow direction, in which the arrangement of the channels 13, the ducts 14, and the distributing channels 15 and 16 is shown. The joining direction of the two spinning solutions at the center of the channel 13 agrees with the longitudinal direction of the channel 13. The joined line is shown by a straight line PQ and the joining direction is perpendicular to the direction of the straight line PQ. While, the separation direction agrees with the arrangement direction of the channels 13 or the ducts 14, that is, the direction of the straight line PQ. For example, the spinning solutions are fed into channels 23 while being separated in the direction of straight line PQ in the reservoir R_{22} . Therefore, in the spinneret shown in FIGS. 18 and 19 the joining direction and the separation direction are different by 90° each other. In the spinneret shown in FIG. 18, two spinning solutions repeat 4 times of joining-separation, and then extruded through the orifice 105 provided on the spinneret plate 100. In the spinneret shown in FIG. 18, the last reservoir R_{100} in FIG. 17 is omitted, and six distributing plates D_{12} , D_{21} , D_{22} , D_{31} , D_{32} and D_{41} are interposed between the supplying

12

portion D_{11} for the spinning solutions and the spinneret plate 100. One time of joining-separation is effected by a pair of distributing plates, for example, D_{21} and D_{22} .

FIG. 20 is a vertical-sectional view of a somewhat complicated spinneret according to the invention. The first spinning solution is fed into a reservoir R_{01} , and then introduced into an outer reservoir R_{11} through an inlet 1, a reservoir R_{110} , a filter F_{11} and ducts 5. The second spinning solution is introduced into an inner reservoir R_{12} from a reservoir R_{02} through a duct 2, a reservoir R_{120} , a filter F_{12} and ducts 6. The two spinning solutions flown out from the reservoirs R_{11} and R_{12} respectively are joined at an intermediate point on the channels 13. A part of the joined spinning solutions is introduced into the outer reservoir R_{21} of the second stage through ducts 14 and a reservoir R_{210} and another part of them is introduced into the inner reservoir R_{22} of the second stage through ducts 14' and a reservoir R_{220} . Thus, the spinning solutions are joined in the channels 13, 23 and 33. In the spinneret shown in FIG. 20, a pair of joining-separation is effected by using distributing plates D_{11} and D_{12} . In the same manner, a pair of joining-separation is effected by using distributing plates D_{21} and D_{22} , or D_{31} and D_{32} . In the layer-multiplying mixer shown in FIG. 20, the structure of the distributing plate and the distributing mechanism are different from those of the mixer shown in FIG. 18. Further, in the spinneret shown in FIG. 20, filters F_2 and F_3 are placed in the layer-multiplying mixer, and reservoirs R_{300} and R_{301} consist respectively of a unitary space. The numeral 100 represents a spinneret plate and 110 a holding cylinder. The flow in the spinneret shown in FIG. 20 is complicated, and the filament extruded through this spinneret has a complicated structure. Particularly, the laminar flow of the spinning materials may be disturbed by the filters placed in the layer-multiplying mixer at the back of the spinneret plate 100, resulting discontinuous layer structure. However, granularly mixed filaments may be inferior to continuous stratiform mixed filaments in the tensile strength, so that filaments having longitudinal-sectional views as shown in FIGS. 13 and 14 are preferable in many cases.

FIG. 21 is a cross-sectional view of the spinneret taken along the line 2—2' in FIG. 20 in the arrow direction and shows the arrangement of the ducts 1 and 2. FIG. 22 is a cross-sectional view taken along the line 3—3' in FIG. 20 in the arrow direction and shows filters F_{11} and F_{12} . FIG. 23 is a cross-sectional view taken along the line 4—4' in FIG. 20 in the arrow direction and shows the arrangement of the outer reservoir R_{11} , the inner reservoir R_{12} , the channels 13, the ducts 14 and the ducts 14'. The joining direction agrees with the direction of the longitudinal axis of the channel 13, that is, the direction of the diameter of the spinneret, and the separation direction agrees with the arrangement direction of the ducts 14, that is, the direction of the periphery of the spinneret, so that it can be seen that the joining direction and the separation direction are perpendicular each other. FIG. 24 is a cross-sectional view of the spinneret taken along the line 5—5' in FIG. 20 and shows the arrangement of the orifices 105.

FIG. 25 is a vertical-sectional view of another spinneret according to the invention. The first spinning solution is introduced into a reservoir R_{11} from a reservoir R_{01} and the second spinning solution is introduced into a reservoir R_{12} from a reservoir R_{02} . The first spinning solution in the reservoir R_{11} is extruded into a reservoir R_{210} through ducts H_{11} , and the second spinning solution in the reservoir R_{12} is extruded into the reservoir R_{210} through ducts H_{12} . The two spinning solutions are joined in the reservoir R_{210} and then introduced into the outer reservoir of the second stage R_{21} through ducts H_{111} . The joining is effected in the reservoir R_{210} and the separation is effected in the reservoir R_{21} . The joining in the lower two stages is effected at the tip of annular partitions V_3 and V_4 . The

13

number of stages of the joining-separation in this spinneret is 4. In this spinneret, a pair of joining-separation is effected by using, for example, distributing plates D_{21} and D_{22} , and D_{31} and D_{32} respectively. FIG. 26 is a cross-sectional view of the spinneret taken along the line 6—6' in FIG. 25 in the arrow direction and shows the arrangement of the ducts H_{11} and H_{12} . FIG. 27 is a cross-sectional view taken along the line 7—7' in FIG. 25 in the arrow direction and shows the arrangement of reservoirs R_{210} , R_{220} , R_{230} and R_{240} , and ducts H_{111} , H_{122} , H_{121} and H_{112} . In the spinneret shown in FIG. 25, the flows of the spinning solutions are very complicated, so that the resulting filament also has very complicated layer structure.

When the phase of joining is different from that of separation, the object of the present invention is attained, but it is most advantageous that the angle made by those two phases is 90° in view of the production of the spinneret and the layer-multiplying efficiency. According to the invention, it is necessary that the joining and the separations are effected alternately and in series. The larger the number of the stages for the joining-separation is, the more finely divided layer is obtained.

As described above, the feature of the spinneret according to the invention lies in effecting the joining and the separation in the reservoir. This is very advantageous in the production of the spinneret. It can be seen from the above-description that the spinneret according to the invention is very simple in the structure and easy in the production and maintenance.

When the layer-multiplying is effected in the reservoir and in the channel connecting the reservoirs, an effective function is brought about on the resulting filament. This is due to the fact that the layer structure in the filament is distorted owing to disturbance of flow of the spinning solutions. FIGS. 6 and 7 show the distorted grainy structure. Such distortion of the layer increases the contact area between layers, and strengthens the bonding between components. In addition, the formation of distortion results into cutting of layer. In a filament having cut layer structure as shown in FIG. 8, for example, even when the spinning materials are poor in mutual bonding property, layers in the resulting filament show a tendency not to be readily separated from the one another. Owing to the disturbance of the flow of spinning solutions in the reservoir, the number of layers in the resulting filament may be larger or smaller than that calculated in the above.

As described above, the spinneret according to the invention is easy in the manufacture and maintenance because of its simple structure, so that the spinneret can be manufactured in a smaller size. Such an improved spinneret can be produced by superposing distributing plates in multi-stage, which are provided with a plurality of reservoirs on their upper surface and lower surface, respectively, and with ditches and ducts whereby the reservoirs are connected with one another.

FIG. 28 is a part of the vertical-sectional view of an improved layer-multiplying mixer according to the invention. The same type of distributing plates D_{10} , D_{20} and D_{30} are superposed. The distributing plate D_{10} is provided with reservoirs 11 and 12 which are connected by ditches 13 on its upper surface, and further provided with ducts 14 passing through the distributing plate D_{10} , which are connected to an intermediate point of the ditches 13 at one end and to a distributing ditches 15 or 17 on the lower surface of the plate at the other end. The other ends of the distributing ditches 15 and 17 are connected to a left reservoir 16 and a right reservoir 18 respectively on the lower surface of the distributing plate D_{10} . The ditches 15 and 17 on the lower surface of the distributing plate D_{10} are separated from ditches 23 on the upper surface of the distributing plate D_{20} of the next stage. FIG. 29 is a cross-sectional view of the mixer taken along the line 8—8' of FIG. 28 in the arrow direction and shows the arrangement of the distributing ditches 15 and 17 on the lower surface of the distributing plate D_{10} of the first stage and

14

ditches 23 on the upper surface of the distributing plate D_{20} of the second stage. FIG. 30 is a vertical-sectional view of the mixer taken along the line 9—9' in FIG. 28 in the arrow direction and shows the arrangement of the ditches on the upper surface and on the lower surface of the distributing plates D_{10} , D_{20} and D_{30} . The arrows in FIGS. 28, 29 and 30 show the direction of the flow of spinning solutions.

The reservoir and the ditch on the upper surface of the distributing plate are abridged as "the upper reservoir" and "the upper ditch" respectively and those on the lower surface of the distributing plate are abridged as "the lower reservoir" and "the lower ditch" respectively herein-after.

FIG. 31 is a longitudinal-sectional view of an improved spinneret according to the invention. In the spinneret, the mixer or the distributing plate is fundamentally the same with those shown in FIG. 28. The only different point is that, for example, a partition plate 19 is interposed between two distributing plates D_{10} and D_{20} in order to separate the lower ditches of a distributing plate from the upper ditches of another distributing plate positioned under the former distributing plate. The numerals 29, 39 and 49 represent similar partition plates. The partition plates 19, 29, 39 and 49 serve additionally as a gasket plate and they can be interposed very easily, so that the spinneret is not complicated. FIG. 32 is a cross-sectional view of the spinneret taken along the line 10—10' in FIG. 31 in the arrow direction and shows the arrangement of the upper ditches 13 and the ducts 14. FIG. 33 is a cross-sectional view taken along the line 11—11' in FIG. 31 in the arrow direction and shows the arrangement of distributing ditches 15 and 17. FIG. 34 is a cross-sectional view taken along the line 12—12' in FIG. 31 in the arrow direction and shows the arrangement of the upper ditches 103, ducts 104 and orifices 105 of the spinneret plate 100. The number of the orifices 105 may be the same as or different from that of the ducts 14. In the same manner, the number of the ducts 14 in the distributing plate D_{10} may be the same as or different from that of the ducts 24 in the distributing plate D_{20} . As described above, it is considerably advantageous in the combination of the elements of spinneret that the distributing plate has reservoirs, so that an element, for example the distributing plate, can be combined with the other kinds of elements easily. This is a remarkable merit of the present invention, which has been illustrated in FIGS. 20 and 25. It can be seen that the spinneret shown in FIG. 31 is an embodiment of a flow system shown in FIG. 17. The reservoir R_{11} shown in FIG. 17 corresponds to the reservoir 11 in FIG. 31, and in the same manner R_{12} corresponds to 12 and the joining point J_1 corresponds to the joining point of ditch 13 and duct 14. R_{21} corresponds to 16 and 21. The part corresponding to the reservoir R_{100} in FIG. 17 is omitted.

FIG. 35 is a vertical-sectional view of another improved spinneret according to the invention. Firstly, the difference between the spinneret shown in FIG. 35 and that shown in FIG. 31 lies in that in FIG. 35 three components are joined in the first stage of the layer-multiplying mixers. The spinning solutions in the three reservoirs R_{11} , R_{12} and R_{13} are joined with each other at the tips of annular partitions V_{11} and V_{12} . This joining is the same as that shown in FIG. 10. Secondly, the partition plates 19, 29 or 39 additionally used as gaskets are different from those in FIG. 31 and each of them is composed of a piece of plate having a plurality of holes. Thirdly, among the inner reservoirs, reservoirs 36 and 101 are annular. In the spinnerets shown in FIGS. 31 and 35, the number n of the stages for joining-separation is 5, and the angle made by the phase at the joining and that at the separation is 90° . FIG. 36 is a cross-sectional view of the spinneret taken along the line 13—13' in FIG. 35 in the arrow direction and shows the arrangement of upper ditches 23 and ducts

24 of the distributing plate D_{20} . FIG. 37 is a cross-sectional view taken along the line 14-14' in FIG. 35 in the arrow direction and shows lower ditches 25 and 27 of distributing plate D_{20} . FIG. 38 is a cross-sectional view taken along the line 15-15' in FIG. 35 in the arrow direction and shows that the separating plate 39 is provided with ducts 39' in order to connect reservoir 38 with reservoir 42, and reservoir 36 with reservoir 41 respectively. The ducts 39, may be whole or slit. FIG. 39 is a cross-sectional view taken along the line 16-16' in FIG. 35 in the arrow direction and shows the arrangement of ditches 103, ducts 104 and orifices 105.

FIG. 40 is a spinneret having more complicated mixing system. It is the merit of the present invention that a spinneret having such a very complicated mixing system can be produced easily.

As described hereinbefore, it can be seen that the spinnerets shown in FIGS. 28-40 are very simple in the structure and are very easy in the manufacture and the maintenance. Furthermore, these spinnerets can be manufactured in small size, so that they are extremely excellent. For example, as the separating plates D_{10} , D_{20} , D_{30} and D_{40} in FIG. 31, those having the upper ditches 13, 23, 33 and 43 and the lower ditches 15, 17, 25, 27, etc., each width and depth of which being about 0.5-3 mm. respectively, the ducts 14, 24, 34, 44, 54, etc., each diameter of which being about 0.5-3 mm., and the reservoirs 16, 18, 21, 22, 26, 28, etc., each depth of which being about 0.5-5 mm. are often used. Therefore, it is very easy to manufacture a distributing plate having a thickness of not more than 20 mm., and for example a distributing plate having a thickness of about 5 mm. is often used. Therefore, even when five, ten or fifteen pieces of the distributing plates are superposed, the resulting layer-multiplying mixer is very small, and is very easy in handling. In order to obtain a multilayer filament, at least one distributing plate (the number of the stages for joining-separation: $n=2$), generally three or more distributing plates are used. For example, the spinneret shown in FIG. 31 has four distributing plates, (the number of the stages for joining-separation: $n=5$), so that the number of the resulting layer is expected to be $2^5=32$. Furthermore, when ten distributing plates are used in the spinneret shown in FIG. 31, the number of the resulting layers is expected to be $2^{11}=2048$. Of course, these values are only calculated values, but they may be considered as an indication.

The essential feature of the spinnerets shown in FIGS. 28-40 lies in the structure and the type of combination of the distributing plates. The feature will be described hereunder. In order to make the understanding easy, the numeral of each portion in the distributing plate in FIG. 28 is shown in the brackets [], but it should be noted that the numeral is none but an example.

(a) The feature of the distributing plate [D_{10}]:

(a-1) There are at least two reservoirs [11 and 12] on the upper surface, and at least two reservoirs [16 and 18] on the lower surface.

(a-2) There are a plurality of upper ditches [13] connecting a pair of adjacent reservoirs [11 and 12] among the upper reservoirs.

(a-3) There are ducts [14], each of which connects an intermediate point of the upper ditch [13] with the lower surface.

(a-4) A part of the openings of the ducts [14] at the lower surface is connected with one lower reservoir [16] by the lower distributing ditches [15], and another part of said openings is connected with another lower reservoir [18] by another lower distributing ditches [17].

(b) The feature of the type of combination of distributing plates [D_{10} and D_{20}]:

(b-1) The lower ditches [15 and 17] of the distributing plate [D_{10}] of the upper stage are separated from the upper ditches [13] of the distributing plate [D_{20}] of the lower plate, and both of those ditches are connected by

the reservoirs [16, 21, 18, 22], to which both ditches are opened.

(b-2) The lower reservoirs [16 and 18] of the upper distributing plate [D_{10}] are faced and united to the upper reservoirs [21 and 22] of the lower distributing plate [D_{20}].

It can be seen that the mixing system of the layer-multiplying mixer in the spinnerets shown in FIGS. 28, 31 and 35 is fundamentally the same as that shown in the flow diagram of FIG. 17. FIG. 41 is an embodiment of the plan view of the flow diagram shown in FIG. 17, wherein m is a positive integer. The structure of the actual spinneret shown in FIG. 41 will be understood easily with reference to FIG. 29. The liquidized spinning materials are fed into reservoirs R_{m1} and R_{m2} at the m th stage through the inlet I, separated in the reservoirs R_{m1} and R_{m2} in the arrow direction, joined at the outlet O and then are flown out. The inlet I is shown by a circle divided into black and white semicircles by a straight line which shows the joining direction at the upper stage. Replacement of the inlet I with the outlet O in FIG. 41 results FIG. 42. It will be evident that FIG. 42 is a plan view of an embodiment of the flow diagram shown in FIG. 16. A distributing plate constituting the system shown in FIG. 16 or FIG. 42 can be manufactured.

The spinneret constituting such a system will be explained with reference to the drawings.

FIG. 45 is a vertical-sectional view of an improved spinneret according to the invention. It can be seen that the distributing plates D_{20} , D_{30} and D_{40} constituting the layer-multiplying mixer of the spinneret shown in FIG. 45 are extremely similar to those shown in FIG. 28. They are different in the upper and lower ditches.

When the distributing plate in FIG. 28 is placed invertedly, the distributing plate in FIG. 45 is obtained. In FIG. 45, the first stage distributing plate D_{10} has a particular structure, which will be explained later. In FIG. 45, the spinning materials in the duct 14 are separated and flown into two reservoirs R_{21} and R_{22} of the second stage through the lower distributing ditch 150 of the distributing plate D_{10} of the first stage. The spinning material in the reservoir R_{21} is introduced into ducts 24 through the upper collecting ditches 231 of the distributing plate D_{20} of the second stage. While, the spinning material in the reservoir R_{22} is introduced into the ducts 24 through another upper collecting ditches 232. FIG. 46 is a cross-sectional view of the spinneret taken along the line 17-17' in FIG. 45 in the arrow direction, and shows the arrangement of the upper ditches 13, ducts 14 and the lower distributing ditches 150 of the distributing plate D_{10} of the first stage. FIG. 47 is a cross-sectional view taken along the line 18-18' in FIG. 45 in the arrow direction and shows the arrangement of the lower distributing ditches 150 and the upper collecting ditches 231 and 232. Correspondence of FIG. 47 to FIG. 42 may be understood easily. FIG. 48 is a vertical-sectional view taken along the line 19-19' in FIG. 45 and shows the arrangement of the lower distributing ditches 150, 250 and 350, and the upper collecting ditches 232 and 332. FIG. 49 is a cross-sectional view taken along the line 20-20' in FIG. 45 and shows the arrangement of orifices 105 and collecting ditches 1031 and 1032.

As shown in FIG. 46, the distributing plate D_{10} of the first stage in FIG. 45 has a particular structure. The object of such a structure is to make the joining phase of the spinning materials fed into the duct 14 equal to the joining phase at the inlet I of FIG. 42. The ditch 13 and the duct 14 in FIG. 46 can be written with a plain as shown in FIG. 50. In lieu of a structure of the upper ditch 13 of the distributing plate D_{10} of the first stage in FIG. 45, either a structure shown in FIG. 50 or those shown in FIGS. 51-58 may be used. The mixing system shown in FIG. 51 is the same as that from R_{11} and R_{12} to S_1 shown in FIG. 16. When the structure of the distributing plate D_{10} of the first stage is the same as that of the distribut-

ing plate D_{20} of the second stage in FIG. 45, the upper surface of the distributing plate D_{10} is the same as the structure shown in FIG. 51. Structures shown in FIGS. 50, 52 and 53 are most useful. When the upper ditches of the first distributing plate shown in FIG. 51 are used, the number n of joining stages is less than that of distributing plates by one, and the efficiency is somewhat low. When the first distributing plates having ditches shown in FIGS. 54-56 are used, the efficiency for layer-multiplying is somewhat low. When the first distributing plates having ditches shown in FIGS. 57 and 58 are used, the number n of joining stages is less than that of the distributing plates by two, and the efficiency is the lowest. However, in the mixer shown in FIG. 28, the upper ditch of the first distributing plate has same structure as that shown in FIG. 58, and in the mixers shown in FIGS. 28-40, the structure shown in FIG. 58 is most effective.

The essential feature of the structure and the type of combination of the distributing plates D_{20} , D_{30} and D_{40} shown in FIG. 45 is as follows:

(a') The feature of the distributing plate:

(a'-1) There are at least two reservoirs on the upper and lower surfaces respectively.

(a'-2) There are a plurality of ducts connecting the upper surface with the lower surface.

(a'-3) A part of the upper openings of the ducts is connected with one upper reservoir by collecting ditches, and another part of the upper openings of the ducts is connected with another upper reservoir by another collecting ditch.

(a'-4) The lower openings of the ducts are connected with a pair of adjacent lower reservoirs by the lower distributing ditches.

(b') The feature of the type of combination of a plurality of distributing plates:

(b'-1) The lower distributing ditch of the distributing plate of the upper stage is separated from the upper collecting ditch of the distributing plate of the lower stage, and both the lower distributing ditch and the upper collecting ditch are connected mutually by the reservoir, to which both of them are opened.

(b'-2) The lower reservoir of the upper distributing plate is faced and united to the upper reservoir of the lower distributing plate.

By the above description, the conception of the layer-multiplying mixer which is the essential feature according to the present invention has been generally explained, but the present invention is applicable more widely, and will be explained hereinafter.

As seen from FIGS. 41 and 42, stagnation (ST) of flow is formed in reservoirs R_{m1} and R_{m2} . Method for preventing stagnation are shown in FIGS. 43 and 44, and such prevention may be attained by irregularizing the disposition of the inlet I with respect to the outlet O. The irregularization as shown in FIG. 44 may be attained only by slightly shifting the distributing plates with each other when the distributing plates are superposed. The arrangement of the inlets I or outlets O was exemplified by that arranged along the straight line or circle, but more complicated arrangement, for example, an arrangement in a zig-zag fashion may be adopted. In FIGS. 41 and 42, passages are rectangular to the arrangement direction of the inlets I or the outlets O, but such passages may be, for example, as shown in FIG. 56, not rectangular to the arrangement direction of the inlets I or the outlets O. However, care must be taken in order that the joining and the separation are not effected in the same phase.

FIG. 59 is a vertical-sectional view of the spinneret according to the invention, which has essentially the mixing system of FIG. 16. The distributing plates D_{10} , D_{20} , D_{30} or D_{40} , in FIG. 59 are the same as, for example, that D_{20} in FIG. 45. However, the distributing plate D_{20} in FIG. 45 has rooms for the reservoirs on its upper and lower surfaces respectively, while the distributing plate in FIG. 59 has rooms for the reservoir only on the lower surface.

Inversely, the distributing plate may be provided with the rooms for the reservoir only on the upper surface thereof. In the same manner, in the distributing plates in FIGS. 28 and 35, the rooms on the upper surface or on the lower surface can be omitted. Furthermore, when a partition plate is interposed between the distributing plates as shown in FIG. 31, if the thickness of the partition plate is sufficient, for example, not less than 1 mm., the rooms for the reservoirs on both the upper and lower surfaces of the distributing plate can be omitted.

When the combination of the reservoir with the passage is selected properly, the stagnation of flow in the reservoir can be decreased, and further when the passage and the reservoir have a smoothly streamlined structure, stagnation and disturbance in the flow can be also decreased. The layer-multiplying mixer of the spinneret according to the invention may be constructed by superposing various kinds of distributing plates, and moreover it can be constructed by superposing only one kind of distributing plates, if required (for example, refer to FIG. 31).

As methods for connecting the supplying portion with the layer-multiplying mixer, conventional connecting methods can be used.

The joining of the spinning materials in the first stage can be effected by method used for spinning a conventional composite filament. In the drawings, side-by-side type joining is shown, but sheath-core type joining may be also used. However, the side-by-side type joining is most useful and effective.

A method for combining the layer-multiplying mixer with the spinneret plate having spinning orifices can be effected in various manners as explained above. The orifice may be either circular or non-circular. All types of conventional orifices can be used. Among non-circular orifices, T-shape, Y-shape, H-shape and star-shape orifices are most applicable.

The feature of the spinneret according to the invention lies in that the spinneret is provided with a layer-multiplying mixer, in which reservoirs and passages connecting the reservoirs are connected in multi-stage (at least two stages) between supplying portion of the spinning materials and the spinneret plate, whereby joining-separation in the different phase is effected in multi-stage.

By the above explanation and embodiments, it would be apparent how the joining-separation in the different phase is effected. However, additional explanation will be made hereinafter. When the joining and the separation are effected in the passage (ditches and ducts), directions of the joining and the separation are self-evident. However, when the joining and the separation are effected in the reservoir the abovementioned directions may be considered as follows:

(a) Separation in the reservoir (for example, refer to FIG. 41): When the number of outlets from a reservoir is larger than that of the inlets to the reservoir, spinning materials are separated in the reservoir. The separation direction agrees with arrangement direction of the outlets.

(b) Joining in the reservoir (for example, refer to FIG. 42): When the number of inlets to a reservoir is larger than that of the outlets from the reservoir, spinning materials are joined in the reservoir. The joining direction agrees with the arrangement direction of the inlets.

It is noted that when flow of joined spinning materials pass through curved passage, the joining direction may be sometimes varied. For example, in FIGS. 50 and 52, such a case occurs and the joining phase is varied by 90° . Further, for example, in FIG. 28, the joining direction of spinning materials in the duct 14 is right-to-left direction, but that in the distributing ditch 17 is up-to-down direction. Further, the joining direction of said spinning materials in the ditch 23 of the next stage is different from that in said distributing ditch 17 by 180° .

Herebefore, there have been explained fundamental and improved spinning processes and spinnerets of the invention, but further, there will be explained with their application. In the following novel spinning process and spinneret, all types of layer-multiplying mixer can be used. In general, the fundamental type of layer-multiplying mixers has two forms, one of which is composed only of passages and the other of which is above-described improved type that is composed of reservoirs and passages connecting the reservoirs. In the following drawings, only layer-multiplying mixer having reservoirs is exemplified, but the following novel spinning process and spinneret are not limited thereto.

The first application consists in a method and spinneret for producing the above-mentioned composite multilayer filament. Such a composite multilayer filament can be obtained by bonding at least one flow of layer-multiplied spinning materials with another flow of spinning material just before the spinneret plate, and then extruding the bonded spinning materials through orifice.

FIG. 75 shows that two spinning materials A_1 and A_2 are layer-multiplied by the layer-multiplying mixer M_{100} and then a flow of the layer-multiplied spinning solution is bonded with a flow of another spinning material B at a point J_{100} just before orifice 105. The spinning material B may be the same as the spinning material A_1 , but A_1 must be different from A_2 . By the method of FIG. 75 filaments as shown in FIGS. 65, 66, 67 and 70 are obtained.

In FIG. 76, a flow of layer-multiplied spinning material is bonded with another flow of layer-multiplied spinning material, and M_{101} and M_{102} are both layer-multiplying mixers. When the spinning materials B_1 and B_2 are the same as the spinning materials A_1 and A_2 respectively, M_{101} must be different from M_{102} . In such a case, a filament as shown in FIG. 68 is obtained. When the solution A_1 or A_2 is different from the spinning solution B_1 or B_2 respectively, a filament as shown in FIG. 69 is obtained. In the composite multilayer filament, when the property, such as dynamic property, of the multilayer structure portion of said filament is poor, such a property can be reinforced by homogeneous structure portion. The bonding at the point, J_{100} is effected in conventional side-by-side type or sheath-core type. Eccentric bonding at J_{100} results a filament having latent crimpability. There has already been described in detail with respect to the filament having latent crimpability, so that hereinafter the advantages of the composite multilayer filament will be explained from a different point of view. For example, when a component for improving dyeability, hydrophilic property or property of electrification, and a conventional fiber-forming component are layer-multiplied, the resulting multilayer filament is apt to be lowered in the dynamic properties, such as tenacity, elongation, initial modulus and the like. In order to prevent such disadvantages, it is possible to bond a portion (specific thick layer) consisting of one component with the multilayer structure portion. Furthermore, in the production of a sheath-core type composite multilayer filament, when a multilayer structure portion compose of a component having large affinities for dyestuff and water and a hydrophobic component, is used in the sheath portion, it is preferable to use a hydrophobic component having excellent dynamic properties in the core portion. On the other hand, when one component in the multilayer structure portion is water soluble, it is preferable to arrange the multilayer structure portion in the core portion and to arrange a water insoluble component in the sheath portion as shown in FIG. 66. According to the process as shown in FIG. 76 the combination of spinning materials can be effected over an extremely wide range, whereby novel filaments having improved various properties can be apparently obtained. Therefore, particular explanation with respect to the combination of spinning materials would not be made, but such embodiments will be exemplified in the following examples.

FIG. 77 is a vertical-sectional view of a spinneret illustrating an embodiment of a spinning process shown in FIG. 75. Two spinning materials previously fed into reservoirs R_{11} and R_{12} are layer-multiplied, and introduced into a reservoir R_{101} . Another flow of spinning material is introduced into a reservoir R_{102} through a passage 300. The two spinning materials in the reservoirs R_{101} and R_{102} are bonded in a ditch 103 and spun through orifice 105. FIG. 78 is a cross-sectional view of the spinneret taken along the line 24-24' in FIG. 77 in the arrow direction and shows the position of the passage 300. FIGS. 79 and 80 are cross-sectional views taken along the lines 25-25' and 26-26' respectively in FIG. 77 in the arrow direction. The bonding in the ditch 103 is effected in side-by-side type, while sheath-core type bonding may be used. Conventional spinning apparatus can be used, and particularly a spinneret having a cylindrical structure is most applicable. As shown in FIG. 77, in the cylindrical spinneret it is most practicable and effective to arrange a passage 300 in the center of the cylinder and a layer-multiplying mixer around the passage 300, because such concentric structure is most symmetric, and uniform filaments can be extruded concurrently through a plurality of orifices 105.

FIG. 81 is a vertical-sectional view of a spinneret showing an embodiment of the spinning process shown in FIG. 76. The bonding at the last stage is effected in the ditch 103 in side-by-side type. FIG. 82 is a cross-sectional view of the spinneret taken along the line 27-27' in FIG. 81 in the arrow direction.

The second application lies in connecting two layer-multiplying processes in series. By such a mix spinning process mixed filaments having a double multilayer structure or multiple multilayer structure can be obtained, and further mixed filaments having an improved uniformity can be obtained. The feature of this improved mix spinning process lies in interstratifying the first flow I of one spinning material, which is a mixture of at least two components, with the second flow II of the other spinning material, and then spinning the resulting layer-multiplied spinning materials.

FIG. 83 is the fundamental flow diagram showing the spinning materials according to the improved spinning process. In FIG. 83, M_{100} represents a layer-multiplying mixer. Another mixer M_1 may be a conventional mixer or a layer-multiplying mixer. The conventional mixer includes, for example, those which can stir the spinning material mechanically, such as propeller, screw and the like. Powders or pellets of spinning materials may be mixed and then dissolved or melted. When powders or pellets are mixed, a rotating drum is often employed. In the layer-multiplying mixer M_{100} , the joining-separation in the different phase is repeated at least 2 times, usually at least 3 times.

Applications of the fundamental type of layer-multiplying the spinning solutions of the present invention are shown in FIGS. 84-86.

FIG. 84 shows a case when flows I and II of two spinning materials are both mixture. M_{100} represents layer-multiplying mixer, and in M_1 and M_2 any mixer or any mixing process may be used.

FIG. 85 shows a more complicated application. Two flows I and II, each of them being a mixture, are layer-multiplied in a layer-multiplying mixer M_{100} , further bonded at a point J_{100} with the third flow III of spinning material (B_3) and then extruded simultaneously through an orifice 105. Filaments obtained by bonding a layer-multiplied flow with another flow composed of one component and by extruding the bonded spinning materials has partially layer-multiplied structure, for example, as shown in FIGS. 65-67.

FIG. 86 shows a case, wherein five mixers M_1 , M_2 , M_3 , M_4 and M_{100} are connected to series. All of them may be the layer-multiplying mixer, or a part of them may be a conventional mixer. However, the last mixer M_{100} must be a layer-multiplying mixer. Of course, the conception

of "mixing or mixer" in the present invention, does not include joining (bonding). In this case, the joining means only one confluence. Accordingly, for example, in FIG. 85 the last mixer should be the layer-multiplying mixer M_{100} .

Filaments obtained in the above method have double multilayer structure. Embodiments of such a double multilayer structure are shown in FIGS. 71-74, and they show that more finely divided layers are present in a layer.

The advantage of the present invention lies in that the uniform layer-multiplying can be effected easily. The layer-multiplying process is excellent in the uniformity among mixing processes, but there are some problems. The first one of the defects of the layer-multiplying process is that when the mixing ratio is 1:1, the mixing is relatively easy, but when the ratio is 10:1 or 20:1, the mixing is apt to be non-uniform.

The second of the defects is that it is difficult to interstratify two spinning materials which are extremely different in the viscosity. Of course, it is difficult to mix such two spinning materials by means of a conventional mechanical mixing in many cases. Liquidized spinning materials to be used for the production of conventional fiber have a viscosity of 300-3,000 poises, usually about 1,000 poises. It is often difficult to interstratify such a spinning material with another liquidized spinning material having a viscosity of 100 poises. Difficulty in mixing depends largely upon the compatibility between the two components and their interfacial tensions.

When sufficient mixing effect is not attained by means of one layer-multiplying process, a process wherein a plurality of layer-multiplying methods of the present invention are connected in series, is extremely effective. For example, most of spinning materials can be mixed to uniform and finely divided state, when they are layer-multiplied, mixed by mechanical stirring and layer-multiplied in said order. (The use of mechanical stirring results a filament having partially discontinuous layer structure.)

For example, when two spinning materials are mixed in a mixing ratio of 1/1 (by volume), they are mixed extremely uniformly. However, when they are layer-multiplied in a mixing ratio of 1/10 or 1/100, the mixing is apt to be non-uniform. The present invention solves the above-mentioned problem completely. For example, in FIG. 86, when all of the mixers are layer-multiplying mixer and all of the spinning materials B_1 , B_2 , B_3 and B_4 are the same as A_1 , even if the mixing ratio at each layer-multiplying mixer is 1/1, the mixing ratio of spinning material A_2 to A_1 is 1/32 as a whole. As described above, several percents or a very small amount of not more than 1 percent of the second component can be added to the first component.

In the above-mentioned process, each of the mixing steps can be discontinuously performed by separating from other step, but it is most advantageous that all of the steps are effected continuously. It is very easy to perform all or a part of the steps continuously. The mixer capable of effecting the continuous mixing most easily is the layer-multiplying mixer. A plurality of mixers forming flow systems of spinning materials as shown in FIGS. 83-86 can be housed in a spinning apparatus or spinneret. FIG. 87 shows a spinneret having two layer-multiplying mixers housed therein. Another mixer capable of effecting the continuous mixing easily is the screw extruder. Single-or multiscrew extruder can be employed as the mixer of the present invention.

Another advantage of the above process lies in that spinning materials not suitable for one layer-multiplying can be layer-multiplied thereby.

The process and apparatus according to the invention can be used for any of wet spinning, dry spinning and melt spinning.

A plurality of spinning materials are fed into supplying portions of spinning material respectively, by feeding

means, for example, by metering gear pumps at feed rates corresponding to the mixing ratio. For example, the supplying portions of spinning materials are R_{11} and R_{12} in FIG. 18, R_{01} and R_{02} in FIG. 20, 11 and 12 in FIG. 31, and R_{11} , R_{12} and R_{13} in FIG. 35. Of course, any mixing ratio can be used. The extruded filament is taken up on a bobbin by means of a conventional method.

The spinning apparatus of the present invention can be fixed wholly in the spinning head, but it is also possible to put only the spinneret plate in the spinning head or spinneret and to install the mixer in a separate place. It has been explained that the cross-sectional shape of the spinning orifice may be non-circular. As shown in FIG. 20, a filter composed of sand, wire meshes or sintered material may be housed in the spinning apparatus of the present invention. When a filter is placed in the interior of the layer-multiplying mixer or between the mixer and the spinneret plate 100, disturbance occurs in the flow, and the layer structure in the resulting filament is distorted. In order to obtain a uniform layer structure, it is preferable to place the filter before the mixer. Filters F_{11} and F_{12} shown in FIG. 20 are embodiment of filters placed between the mixer and the supplying portions R_{01} and R_{02} .

The apparatus according to the invention can be used in combination with a conventional mix spinning apparatus or mixing method, and further the conventional apparatus can be contained in the apparatus of the present invention. Spinning materials mixed in pellet or liquid state can be also spun by the apparatus of the present invention. Mechanical stirring apparatus can be also contained in the apparatus of the present invention. For example, in FIG. 20 when a stirring propeller or stirring screw is used instead of filter F_3 , a granularly mixed filament can be obtained. It is noted that the spinning process of the present invention can be used for spinning not only multilayer filaments having continuous structure but also mixed filaments having discontinuous structure. Depending upon the kind of the spinning material (for example, a material having a very low viscosity) the layers may be cut naturally, resulting discontinuous layer structure in the direction of filament axis.

The invention will be explained in detail with reference to the following examples.

EXAMPLE 1

Nylon-6 having a number average polymerization degree of 160 and polyethylene terephthalate (hereinafter abridged as PET) having an intrinsic viscosity of 0.61 in o-chlorophenol at 30° C. were melted separately and fed by gear pumps in a feeding ratio of 1/1 and passed through filters and introduced into the spinneret as shown in FIG. 18 having the number (n) of stages for joining-separation of 4 and spun from orifices, a diameter of said orifices being 0.2 mm. and an interval between said adjacent orifices being 4 mm., at a temperature of 270° C.

The spun filaments were quenched in air and wound up on a bobbin at a take-up velocity of 700 m./min. after oiling. The undrawn filaments obtained were drawn 3.4 times their original length at 80° C. and further heat-set at 140° C. under a tension to obtain drawn filaments Y_1 of 70 d./36 f. Furthermore, drawn filaments Y_2 were obtained in the same manner and through the same spinneret as described above, except that the number of the stages for joining-separation was 8. Other drawn filaments Y_3 were prepared only from nylon-6 by means of the same spinneret and under the same condition as in the drawn filaments Y_2 , and another drawn filaments Y_4 were obtained only from PET by means of the same spinneret and under the same condition as described in production of the drawn filaments Y_2 .

Each sample of the drawn filaments was measured with respect to initial modulus and dye receptivity for acid dye and the results as shown in the following Table

1 were obtained. The measurement of the dye receptivity was made under the condition as shown in Table 2.

TABLE 1

Sample	Initial modulus (g./d.)	Dye receptivity (percent)
Drawn filament Y ₁ ..	41.5	92.0
Drawn filament Y ₂ ..	33.9	94.0
Drawn filament Y ₃ ..	18.4	97.0
Drawn filament Y ₄ ..	54.7	1.4

TABLE 2

Duestuff: Roccelline NS (made by Sumitomo Kagaku Kogyo K.K.)	-----Percent O.W.F.---	3
Acetic acid	-----Do-----	3
Temperature	-----° C. (constant)---	80
Bath ratio	-----1:50	1:50
Time (hour)	-----2	2

The tendency of fibrillation of the drawn filament Y₁ was higher than that of the drawn filaments Y₂. When the nylon and PET were spun through the spinneret having the number of stages for joining-separation of 8 in a feeding ratio of 3:1, the resulting filaments had a low tendency of fibrillation and an initial modulus of 28.4 and a dye receptivity of 97%.

Both the drawn filaments Y₁ and Y₂ of the mixed filaments of PET and the polyamide have good dyeability and high initial modulus and are suitable for bulky knitted goods and carpet after texturizing process. The cross-section of the drawn filaments Y₁ was a distorted grainy structure, while the cross-section of the drawn filaments Y₂ was an archipelagic structure as shown in FIG. 64.

EXAMPLE 2

Nylon-6 having a number average polymerization degree of 185 and terminal amino groups of 35 milli-equivalent/kg. and nylon-6 having a number average polymerization degree of 124 and terminal amino groups of 128 milli-equivalent/kg. were spun through the spinneret as shown in FIG. 20 in which the diameter of orifices was 0.2 mm., at a temperature of 270° C. in a mixing ratio of 1/1 and the thus spun filaments were quenched in air and wound up on a bobbin at a take-up velocity of 600 m./min. after oiling, and then drawn 3.9 times their original length at room temperature to obtain drawn filaments Y₅ of 45 d./8 f.

Only from the above-described nylon-6 having terminal amino groups of 35 milli-equivalent/kg. drawn filaments Y₆ of 45 d./8 f. were obtained by means of the same spinneret and under the same condition as described above. Similarly, from the above-described nylon-6 having terminal amino groups of 128 milli-equivalent/kg. drawn filaments Y₇ of 45 d./8 f. were obtained by means of the same spinneret and under the same condition as described above.

Each sample of the drawn filaments was dyed by using 4.0% O.W.F. of dyestuff, Roccelline (made by Sumitomo Kagaku Kogyo K.K.) and 1.0% O.W.F. of acetic acid in a bath ratio of 1:50 at a temperature of 80° C. for 60 minutes and the dye receptivity was measured and the results as shown in the following Table 3 were obtained. Furthermore, the tensile strength was measured with respect to 50 cm. of the filament under a tensile rate of 25 cm./min. to obtain the following results, which are also shown in Table 3.

TABLE 3

Sample	Dye receptivity (percent)	Tensile strength (g./d.)
Drawn filaments Y ₅ ..	92	6.2
Drawn filaments Y ₆ ..	65	6.4
Drawn filaments Y ₇ ..	100	5.1

As seen from Table 3, the drawn filaments Y₅ obtained according to the present invention were superior in dye

receptivity to the drawn filaments Y₆ and further were superior in the strength to the drawn filaments Y₇.

EXAMPLE 3

Various filaments were prepared by using nylon-66 having an intrinsic viscosity of 1.12 in m-cresol at 25° C. and containing no pigment and nylon-6 having an intrinsic viscosity of 1.25 and containing 0.5% of titanium oxide powder as a pigment.

Said polymers were both melted separately at 280° C. and fed by gear pumps to the spinneret as shown in FIG. 18 (the number of the stage n:6) in a feeding ratio of 1/1 and layer-multiplied therein and then spun through circular orifices and the thus spun filaments were quenched in air and wound up on a bobbin at a take-up velocity of 600 m./min. after oiling and then drawn on a draw pin at 80° C. 3.6 times their original length to obtain drawn filaments Y₈ of 70 d./18 f.

Furthermore, drawn filaments Y₉ were obtained in the same manner as in the drawn filaments Y₈, except that the feeding ratio of nylon-66/nylon-6 by gear pumps was 1/3.

On the other hand, both of the polymers were melted separately and spun in a conjugate ratio of 1/1 according to a conventional conjugate spinning method to obtain drawn composite filaments Y₁₀ of 70 d./18 f. having a cross-section as shown in FIG. 1.

Both of the polymers were mixed in a mixing ratio of 1/1 in molten states at 280° C. for 1 hour while stirring and then spun through a spinneret and thereafter treated in the same manner as in the drawn filaments Y₈ to obtain drawn filaments Y₁₁ of 70 d./18 f.

Tensile strength, elongation, initial modulus and luster of each sample of the filaments are shown in Table 4.

TABLE 4

Sample	Tensile strength (g./d.)	Elongation (percent)	Initial modulus (g./d.)	Luster
Drawn filament Y ₈	5.7	35.0	34.9	Dull.
Drawn filament Y ₉	5.5	37.2	31.4	Do.
Drawn filament Y ₁₀	5.6	31.9	36.1	Bright.
Drawn filament Y ₁₁	4.6	45.7	28.1	Dull.

The drawn filaments Y₁₀ have fairly strong luster but are not completely bright. In the drawn filaments Y₁₁ it is considered that a copolymerization reaction occurs between both the components during the mixing process. In spinning of the drawn filaments Y₈, the take-up velocity was considerably lowered without varying the extrusion rate to produce specially thick undrawn filaments, and when the cross-section of said filaments was observed by a microscope, it was found that the pigment-containing nylon-6 and the nylon-66 formed a grainy super multi-layer structure. The number of layers, which was calculated from the structure of the spinneret, was 2⁵, that is, 64 and substantially the same order of layers was found. However, the cross-section of the drawn filaments Y₈ did not show any layer structure by an optical microscope.

Monofilament of each sample of the drawn filaments Y₈ and Y₉ had a fineness of 3.9 deniers and a diameter of about 22μ, so that if the number of layers was 60, the average thickness of the layer was smaller than about 0.4μ. As seen from Table 4, the filament of the present invention had a sufficient delustering effect and a high tensile strength.

EXAMPLE 4

Various mixed filaments were prepared by using PET having an intrinsic viscosity of 0.65 in o-chlorophenol at 30° C. and nylon-6 having an intrinsic viscosity of 1.23 in m-cresol at 30° C., both of which had no mutual bonding property.

Nylon-6 has an excellent dye receptivity, but PET is poor in said property. PET has a high initial modulus (usual drawn filament of PET has an initial modulus of 40-100 g./d.), but nylon-6 has a low initial modulus

(usual drawn filament of nylon-6 has an initial modulus of 10-30 g./d.). The melting point and softening point of PET are high, but those of nylon-6 are low. Both of the polymers are also different in other properties. Various attempts for obtaining filaments having excellent dye receptivity and high tenacity, initial modulus and heat resistance, have been heretofore made by mixing both of the polymers, but satisfactory filaments have not been obtained yet.

A mixed filament described hereinafter was obtained by mixing 2 parts (by weight) of nylon-6 with 1 part (by weight) of PET.

Nylon-6 was melted at 280° C. and PET was added thereto and then the resulting mixture was stirred thoroughly for 30 minutes, extruded through a nozzle, quenched and then cut to obtain mixed chips. These mixed chips were melted by an extruder and spun from orifices having a diameter of 0.25 mm., at 280° C., quenched and wound up on a bobbin at a take-up velocity of 700 m./min. after oiling and drawn 3.6 times their original length on a draw pin at 80° C. and then heat-set at 140° C. under a tension to obtain drawn filaments Y₁₂ of 70 d./36 f. The mixed state of both components in the obtained filaments was intermediate between a granular mixture and a microfibrillar structure and fairly elongated PET granules (the length was 20 to 30 times the diameter) were dispersed in nylon-6.

Powders of both polymers were mixed and melted by an extruder and thereafter treated in the same manner as in the drawn filaments Y₁₂ to obtain drawn filaments Y₁₃. In these filaments, PET was dispersed in microfibrillar state in nylon-6 and the length of the microfiber was about 100 times its diameter.

Both of the polymers were melted separately and fed by gear pumps in a feeding ratio of about 2/1 and introduced into the spinneret as shown in FIG. 18 (the number of the stage *n*:8) and then spun from orifices having a diameter of 0.25 mm., at 280° C. and thereafter treated in the same manner as described in production of the drawn filaments Y₁₂ to obtain drawn filaments Y₁₄.

Drawn filaments Y₁₅ were obtained in substantially the same manner as in the drawn filament Y₁₄, except that the spinneret as shown in FIG. 18 having the number (*n*) of the stage of 2, was used. The number of layers constituting the drawn filaments Y₁₅ was from 4 to 8 (said number was 4 theoretically, but portions wherein the layers were cut and branched due to the disturbance of the flow in the spinneret were observed).

Tensile strength, elongation, initial modulus and fatigues of recovery on elongation of each sample of the filaments are shown in Table 5.

TABLE 5

Sample	Tensile strength (g./d.)	Elongation (percent)	Initial modulus (g./d.)	Fatigue of recovery on elongation (percent)
Drawn filament Y ₁₂ ...	3.0	18.4	33.2	70.5
Drawn filament Y ₁₃ ...	4.2	34.3	33.0	73.7
Drawn filament Y ₁₄ ...	4.7	37.5	34.3	75.2
Drawn filament Y ₁₅ ...	4.6	35.9	35.4	74.6

The term "fatigue of recovery on elongation" used herein means a recovering percentage when the filament was elongated 10% in the length 30 times repeatedly. In the filaments Y₁₂, depolymerization reaction occurred somewhat during the mechanical mixing process of the polymers. The filaments Y₁₅ were fibrillated partially. Each sample of the filaments Y₁₂, Y₁₃, Y₁₄ and Y₁₅ had a good dye receptivity for acid dye.

EXAMPLE 5

An experiment for obtaining anti-static property by mixing a metal salt of alkylphosphate to nylon-6 was carried out. One part by weight of magnesium lauryl phosphate and 2 parts by weight of ε-caprolactam were mixed and dissolved. This solution and a melted nylon-6

having a number average polymerization degree of 180 were separately fed by gear pumps to the spinneret as shown in FIG. 18 in a feeding ratio of 1/10. In this case, the number (*n*) of the stage in the spinneret was 8 and the spinneret temperature was 250° C.

Both of the components were layer-multiplied in said spinneret, extruded through orifices having a diameter of 3 mm. quenched with water and cut into pellets, which were washed with water and dried to obtain mixed pellets.

These mixed pellets were melted, and this melt and a melted nylon-6 having a number average polymerization degree of 180 were separately fed by gear pumps to the spinneret as shown in FIG. 18 (the number of the stage *n*:6) in a feeding ratio of 1/1 and then spun from orifices having a diameter of 0.3 mm., at 270° C. and the spun filaments were quenched and wound up on a bobbin at a take-up velocity of 600 m./min. after oiling and then drawn 3.4 times their original length at room temperature to obtain filaments Y₁₆ of 110 d./28 f.

The tensile strength of the filaments Y₁₄ was 5.3 g./d. When the filament Y₁₆ was run at a velocity of 200 m./min. in air at 25° C. and under 65% RH while repeating four times such an operation that the filament is brought into contact with the arcuate surface which is ¼ circumference of an alumina porcelain having a diameter of 1 cm. and a degree of surface roughness of 39 (an average of the maximum value of roughness is 3μ), the generated static electricity was no more than 85 volts. On the other hand, the filament Y₁₇ obtained only from said nylon-6 in the same manner as described above had a tensile strength of 5.4 g./d. and the generated static electricity was 450 volts.

EXAMPLE 6

Mixed filaments were prepared by using a solution having a viscosity of 820 poises, which was obtained by dissolving 20 parts by weight of polyacrylonitrile (hereinafter abridged as PAN) in 80 parts by weight of dimethylformamide (hereinafter abridged as DMF), and a solution having a viscosity of 790 poises, which was obtained dissolving 20 parts by weight of a copolymer of 85 mole of acrylonitrile and 15 mole of vinyl acetate (hereinafter abridged as PAN/PVAc) in 80 parts by weight of DMF.

One part by weight of said PAN solution and 1 part by weight of said PAN/PVAc solution were mechanically mixed while stirring and extruded through orifices having a diameter of 0.12 mm. into water mixed with DMF and solidified therein while drawing and further drawn in boiling water and then dried to obtain filaments Y₁₈ of 180 d./60 f. (These filaments had been drawn 8.25 times their original length before wound up.)

On the other hand, said PAN solution and said PAN/PVAc solution were separately fed by gear pumps in a feeding ratio of 1/1 and layer-multiplied by means of the spinneret as shown in FIG. 17 (the number of the stage *n*:8) and extruded through orifices having a diameter of 0.12 mm. and then treated in the same manner as described in production of the filaments Y₁₈ to obtain filaments Y₁₉.

The filaments Y₁₈ had a tensile strength of 3.2 g./d. and an elongation of 17.4%, while the filaments Y₁₉ had a tensile strength of 3.5 g./d. and an elongation of 22.6%. Both of the filaments were better in dye receptivity than the filament obtained only from PAN.

EXAMPLE 7

Polyhexamethylene isophthalamide (hereinafter abridged as nylon-6I) having an intrinsic viscosity of 1.05 in m-cresol at 25° C. and nylon-6 having an intrinsic viscosity of 1.02 were melted and spun through the spinneret shown in FIG. 77 to obtain multilayer filaments having an eccentric and non-uniform structure.

Thus, nylon-6 was fed by a gear pump to a reservoir R_{11} of the spinneret shown in FIG. 77 in a feed rate of 1 and nylon-6I was fed by a gear pump to a reservoir R_{12} in a feed rate of 1, while nylon-6 was fed by a gear pump to a passage 300 in a feed rate of 2. The thus obtained filaments had a cross-section as shown in FIG. 65. The spinneret temperature was 275° C. and the diameter of the orifices 105 was 0.25 mm. The extruded filaments were quenched in air and wound up on a bobbin at a take-up velocity of 800 m./min. after oiling. The up-drawn filaments thus formed were drawn 3.4 times their original length on a draw pin at 60° C. to obtain drawn filaments Y_{19} of 45 d./8 f. When the drawn filaments Y_{19} were treated in boiling water under no load for 10 minutes and dried, the number of developed crimps was 14 per 1 cm.

A mixture obtained by mixing nylon-6I and nylon-6 by means of a conventional mechanical stirring process and nylon-6 can be spun through a common orifice simultaneously into a unitary filament, but in said mechanical stirring process it is necessary to effect an additional mixing step and further it is difficult to obtain a uniform mixture and in order to obtain a uniform mixture by the mechanical stirring, a considerably long time is required in which an amide exchange reaction occurs and a copolymer of both the components is formed, whereby the mechanical and chemical properties are deteriorated and further the softening point, melting point, etc. are lowered. On the contrary, in the filaments of the present invention, both components can be mixed into multilayers in the spinneret and this mixing is uniform and no special step is necessary and further a contact time of both components is shorter than that in the chemical stirring, so that the formation of the copolymer of both components is extremely little. Furthermore, in the filaments of the present invention each layer constituting the multi-layer structure continues along the axis of the filament and in this point, said filaments are fundamentally different from the mixed filaments obtained by the mechanical stirring process. Therefore, the mixture according to the present invention is entirely different from a conventional granular or microfibrillar mixture and further the filament obtained according to the present invention is high in strength. Such embodiments will be explained in the followings:

Said nylon-6I and nylon-6 were mixed in a mixing ratio of 1:1, melted at 280° C., mixed mechanically by a propeller in an autoclave for 30 minutes, extruded into water, quenched and cut into pellets, which were washed with water and dried. The thus obtained mixed chips (an intrinsic viscosity of 1.10) and nylon-6 were spun simultaneously through a common orifice in a side-by-side relation in a conjugate ratio of 1/1 according to a conventional melt spinning process and thereafter treated in the same manner as described in production of the drawn filament Y_{19} to obtain a drawn filament Y_{20} . Tensile strength, elongation and softening temperature of the drawn filaments Y_{19} and Y_{20} are shown in Table 6.

TABLE 6

Sample	Tensile strength (g./d.)	Elongation (percent)	Softening temperature (° C.)
Drawn filament Y_{19} -----	4.35	38.0	160
Drawn filament Y_{20} -----	3.77	30.2	133

As another mixing process, there is a method in which two pellets are mixed by means of a pellet blender and the resulting blend is melted.

However, this process has the following defects. Namely, a non-uniformity occurs in transportation of the pellets, because both the pellets are different in a density, coefficient of friction and property of electrification and further another non-uniformity occurs in melter based on a difference of melting properties (melting point and melt viscosity). Furthermore, it is impossible to avoid non-

uniformity resulting from the reason that the materials to be mixed themselves are pellets. Further, it is impossible to avoid an occurrence of an amide exchange reaction in the melter or the transporting tube of the melts.

EXAMPLE 8

Polyethylene terephthalate having an intrinsic viscosity of 0.65 in o-chlorophenol at 30° C. (hereinafter abridged as PET) and nylon-6 having an intrinsic viscosity of 1.02 were melted separately and then spun by the spinneret as shown in FIG. 77 to obtain an eccentric multilayer filament. However, in this case, distributing plate D_{50} and spinneret plate 100 in the spinneret were partially varied so that a spinning material in a reservoir R_{101} formed a core portion and a spinning material in a reservoir R_{102} formed a sheath portion (A structure of a spinneret for obtaining such an eccentric core and sheath type composite filament has been disclosed, for example, in U.S. Pat. No. 3,038,236).

Thus, nylon-6 was fed by a gear pump to a reservoir R_{12} in a feed rate of 1 and PET was fed by a gear pump to a reservoir R_{11} in a feed rate of 1 and further nylon-6 was fed by a gear pump to a passage 300 in a feed rate of 1. The cross-section of the filament obtained was similar to that shown in FIG. 67 (wherein the core portion was constituted from two components and the sheath portion was constituted from one component).

The filaments were spun through said spinneret at 280° C., quenched and wound up on a bobbin at a take-up velocity of 600 m./min. after oiling. Then the undrawn filaments thus formed were drawn 3.8 times their original length on a draw pin at 80° C. and wound up while contacting with a heated plate at 120° C. for 0.1 second to obtain drawn filaments Y_{21} of 30 d./8 f. When the drawn filaments Y_{21} were treated in boiling water under no load for 10 minutes and dried, the number of crimps developed was 7 per 1 cm.

On the other hand, 1 part by weight of nylon-6 powder and 1 part by weight of PET powder were melted and mixed by means of a screw extruder to obtain mixed polymer. Said mixed polymer and nylon-6 were spun through a conventional spinneret for conjugate spinning in an eccentric core and sheath relation, and thereafter treated in the same manner as described in production of the drawn filaments Y_{21} to obtain drawn filaments Y_{22} . Tensile strength and elongation of the drawn filaments Y_{21} and Y_{22} are shown in Table 7.

TABLE 7

Sample	Tensile strength (g./d.)	Elongation (percent)
Drawn filament Y_{21} -----	4.26	29.0
Drawn filament Y_{22} -----	3.97	27.0

Both of the drawn filaments were boiled in water under no load for 10 minutes to develop crimps and dried and thereafter crimp stability was measured. A sample was applied to a load of 0.2 g./d. (in this case the crimps of said sample have almost disappeared) and then said sample was further elongated 20% and in such a state the sample was left to stand for 24 hours and then crimps of the sample were caused to be recovered under no load for 10 minutes and the crimp stability was calculated by the following formula.

$$\text{Crimp stability} = \frac{m}{m_0} \times 100$$

m_0 : the number of the original crimps.

m : the number of crimps after the abovescribed treatment.

The crimp stability of the drawn filaments Y_{21} and Y_{22} are shown in Table 8.

TABLE 8

Sample	Number of original crimps	Number of recovered crimps	Crimp stability
Drawn filament Y ₂₁ -----	7.0	4.1	58.5
Drawn filament Y ₂₂ -----	7.4	3.9	52.7

Generally, it is known that when polyester and polyamide are kept in a melt state while mixing and stirring, both components are mutually reacted to deteriorate the quality. Furthermore, polyesters cause an ester exchange reaction and the quality is varied (copolymerize). As described in Example 7, different polyamides cause an amide exchange reaction.

As mentioned above, the filaments of the present invention can be spun, even if the contact time of components is very short, if required, so that it is possible to minimize such a reaction between components.

EXAMPLE 9

As a spinning material A, use was made of nylon-6 having an intrinsic viscosity of 1.15 in m-cresol at 25° C. and containing 0.5% by weight of titanium oxide as a delustrant. As a spinning material B, use was made of nylon-6 having an intrinsic viscosity of 1.10 and containing no delustrant. As a spinning material C, use was made of polyhexamethylene isophthalamide having an intrinsic viscosity of 0.85 and containing no delustrant. A spinneret as shown in FIG. 81, in which the number of the stage for joining-separation in a layer-multiplying mixer was 6, was used. The spinning material B was fed to a supplying portion R₁₁, the spinning material A was fed to supplying portions R₁₂ and R₁₃ and the spinning material C was fed to a supplying portion R₁₄ by gear pumps in the same amount respectively, and these spinning materials were layer-multiplied and bonded and then extruded through orifices 105 into air and the thus spun filaments were wound up on a bobbin after quenching and drawn 3.9 times their original length at room temperature to obtain multilayer filaments Y₂₃. The thus obtained filament Y₂₃ had a crosssection as shown in FIG. 69. Said filament Y₂₃ had a latent crimpability and developed crimps by heating in boiling water.

The number of crimps was 8 per 1 cm. The spinning materials B and C did not contain any delustrant. Nevertheless the resulting filament was moderately delustered, because the spinning material A containing the delustrant was completely layer-multiplied.

EXAMPLE 10

Polyethylene terephthalate (PET) having an intrinsic viscosity of 0.65 in o-chlorophenol and nylon-6 having an intrinsic viscosity of 1.10 in m-cresol were melted and mix-spun. Namely, both of the polymers were melted separately and spun through a spinneret shown in FIG. 87. PET was fed to a reservoir R₁₁ in a feed rate of 1, and nylon-6 was fed to a reservoir R₁₂ in a feed rate of 1 and to a passage 300 in a feed rate of 2 respectively by a metering pump. The temperature of the spinneret was 280° C. and the diameter of orifice 105 was 0.25 mm. Filaments extruded from the orifice were quenched in air and wound up on a bobbin at a take-up velocity of 600 m./min. after oiling to obtain undrawn filaments Y₂₄ (monofilament: about 60 deniers). The undrawn filaments Y₂₄ were cut by means of a microtome, dyed with an acid dye (only nylon-6 was dyed) and the dyed filaments were observed by a microscope. The cross-section of said filaments was an archipelagic and substantially uniform structure.

On the other hand, by a substantially same spinneret as that shown in FIG. 87, except that the distributing plates D₅₀ and D₆₀ were the same to a distributing plate (D₂₀), PET was fed to a reservoir R₁₁ in a feed rate of 1 and nylon-6 was fed to a reservoir R₁₂ in a feed rate of 3 and thereafter treated in the same manner as described in

production of the undrawn filaments Y₂₄. When a structure of a cross-section of the undrawn filaments Y₂₅ was observed in the same manner as described above, said structure was fairly non-uniform.

The undrawn filaments Y₂₄ and Y₂₅ were drawn 3.7 times their original length on a draw pin at 80° C. to obtain drawn filaments Y₂₄ and Y₂₅ respectively. Tensile strength, elongation and initial modulus of the drawn filaments Y₂₄ and Y₂₅ are shown in Table 9.

TABLE 9

Sample	Tensile strength (g./d.)	Elongation (percent)	Initial modulus (g./d.)
Drawn filament Y ₂₄ -----	4.72	31.0	63.3
Drawn filament Y ₂₅ -----	4.61	28.5	62.3

EXAMPLE 11

One part by weight of magnesium lauryl phosphate (hereinafter abridged as LPM) was dissolved in 10 parts by weight of ε-caprolactam and then nylon-6 was mixed therewith to obtain a filament having a low property of electrification. Namely, both the components were layer-multiplied by a spinning apparatus of a system as shown in FIG. 86. In FIG. 86, spinning materials A₁, B₁, B₂, B₃ and B₄ were nylon-6 and a spinning material A₂ was a solution of LPM in lactam. The mixers M₁, M₂, M₃, M₄ and M were substantially the same as that in the spinneret shown in FIG. 87 and the number of the stage for joining-separation in each mixer was 5. A feed rate was 1 in A₁ and A₂, 2 in B₁, 4 in B₂, 8 in B₃, and 16 in B₄. In this manner, about 0.3% by weight based on nylon-6 of LPM was mixed in nylon-6. Filaments extruded from orifices were quenched, oiled and wound up on a bobbin at a take-up velocity of 600 m./min. and drawn 3.6 times their original length at room temperature to obtain drawn filaments Y₂₆ of 70 d./18 f. When the filament Y₂₆ was run at a velocity of 200 m./min. in air at 25° C. and under 65% RH while being contacted with an alumina porcelain having a diameter of 1 cm., by winding the filament around said porcelain one time, the generated static electricity was no more than 114 volts. On the other hand, a static electricity generated in a drawn filament of nylon-6 containing no LPM was 490 volts.

EXAMPLE 12

Polyoxyethylene having a molecular weight of about 10,000 (hereinafter abridged as POE) was mixed with nylon to improve hydrophilic property of nylon. Thus, 20 parts (by weight) of nylon-6 and 3 parts (by weight) of POE were melted and stirred in an autoclave equipped with a propeller stirrer at 260° C. for 2 hours, but both of the components were not substantially mixed. For the similar purpose, although both of the components were mixed by means of a screw extruder, they were not substantially mixed also in this case. Furthermore, although they were mixed and spun through a spinneret provided with only a layer-multiplying mixer as shown in FIG. 87 in which the number of the stage *n* was 7, in a mixing ratio of 7/1 (by volume), the mixing was incomplete and non-uniform.

Accordingly, the two components were mixed in a layer-multiplying mixer having the number of stages of 7 in a mixing ratio of 1/1 and the resulting mixed flow was introduced into a screw extruder and milled therein and then fed to a reservoir R₁₂ in a spinneret shown in FIG. 87 in a feed rate of 1, while nylon-6 was fed to a reservoir R₁₁ in a feed rate of 1 and nylon-6 was fed to a passage 300 in a feed rate of 2. The spun filaments had excellent uniformity and satisfactory hydrophilic property.

What is claimed is:

1. A spinneret for producing multilayer filament, which comprises

(1) means for supplying a plurality of spinning materials, a spinneret plate provided with at least one spinning orifice, and at least one layer-multiplying

mixer interposed between said supply means and said spinneret plate,

(2) said mixer consisting of a plurality of superposed distributing plates,

(3) each distributing plate comprising a plurality of pairs of reservoirs on the upper surface; a plurality of channels for connecting a pair of the adjacent reservoirs on substantially the same plane with that of the reservoirs; a plurality of distributing channels on the lower surface, one end of which opens alternately to a pair of adjacent reservoirs of the distributing plate of the next stage; and ducts, each of which connects the connecting channel with the other end of the distributing channel, and

(4) said distributing plates being superposed so as to layer-multiply the spinning materials by separating flows of the spinning materials in a pair of the reservoirs, supplying the separated flows into a plurality of the connecting channels, joining the flows in the connecting channels on substantially the same plane with that of the separation and in a phase different from that of the separation, and alternately distributing the joined flows into a pair of the adjacent reservoirs of the next stage distributing plate through the ducts and the distributing channels.

2. A spinneret for producing multilayer filament, which comprises

(1) means for supplying a plurality of spinning materials, a spinneret plate provided with at least one spinning orifice, and at least one layer-multiplying mixer interposed between said supply means and said spinneret plate,

(2) said mixer consisting of a plurality of superposed distributing plates,

(3) each distributing plate comprising a plurality of pairs of reservoirs on the upper surface and on the lower surface, respectively; a plurality of channels for connecting a pair of the upper adjacent reservoirs on substantially the same plane with that of the upper reservoirs; a plurality of distributing channels on the lower surface, one end of which opens alternately to a pair of the lower adjacent reservoirs; ducts each of which connects the connecting channel with the other end of the distributing channel, and

(4) said distributing plates being superposed so as to layer-multiplying the spinning materials by separating flows of the spinning materials in a pair of the upper reservoirs, supplying the separated flows into a plurality of the connecting channels, joining the flows in the connecting channels on substantially the same plane with that of the separation and in a phase different from that of the separation, and alternately distributing the joined flows into a pair of the lower reservoirs through the ducts and the distributing channels.

3. The spinneret of claim 1, wherein a plurality of said distributing plates are superposed so that the distributing channel is arranged on the upper surface of the plate and the connecting channel is arranged on the lower surface of the plate, whereby flows of the spinning materials in the reservoir are joined at the inlet of the distributing channel and the joined flow is separated in the connecting channel in a phase different from that of the joining.

4. The spinneret of claim 1, wherein the horizontal cross-section of said spinneret is substantially circular, said layer-multiplying mixer is arranged in a circumferential portion thereof and a separate passage is disposed in the center portion, whereby the spinning materials flowing from said mixer and flowing from said passage are bonded and then spun simultaneously from said orifices.

5. The spinneret of claim 1, which comprises a plurality of layer-multiplying mixers arranged in parallel, whereby a flow of layer-multiplied spinning materials and another flow of layer-multiplied spinning materials, at least one of which is different from the former spinning materials, are bonded and then spun simultaneously from said orifices.

6. The spinneret of claim 1, which comprises at least one additional mixer above said layer-multiplying mixer, whereby a mixed flow of at least two spinning materials and another flow are layer-multiplied by said layer-multiplying mixer and then spun simultaneously from said orifices.

7. The spinneret of claim 1, which comprises said layer-multiplying mixer provided with at least one additional layer-multiplying mixer thereabove.

References Cited

UNITED STATES PATENTS

2,815,532	12/1957	Braunlich	18—8 SC
3,217,734	11/1965	Fitzgerald	264—171 X
3,406,427	10/1968	Tsuji	18—8 SC
2,639,275	5/1953	Vickers et al.	259—4 X
2,890,868	6/1959	Potchen	259—4
3,344,472	10/1967	Kitajima et al.	18—8 SC
3,404,869	10/1968	Harder	259—4
3,424,437	1/1969	Shearer	259—4
3,480,996	12/1969	Matsui	264—171 UX
3,559,237	2/1971	Van Den Biggelaar et al.	18—8 SC
3,565,985	2/1971	Schrenk et al.	264—171

J. SPENCER OVERHOLSER, Primary Examiner

MICHAEL O. SUTTON, Assistant Examiner

U.S. Cl. X.R.

264—171; 425—198, 382