July 22, 1969 W. G. PARR ET AL 3,457,342

METHOD AND APPARATUS FOR SPINNING HETEROFILAMENTS

Filed Dec. 5, 1966 2 Sheets-Sheet 1

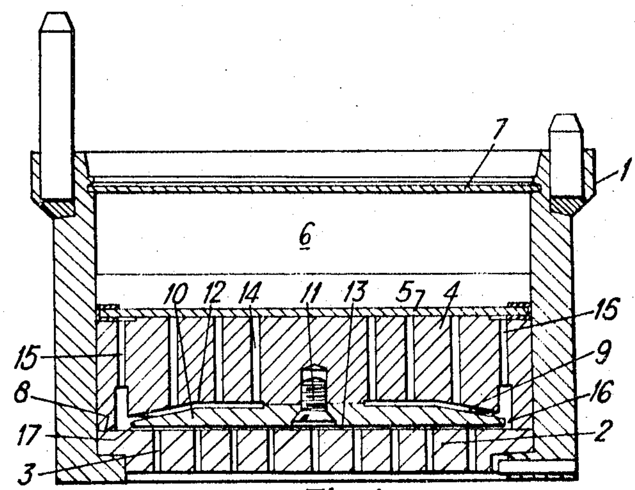

Fig. 1.

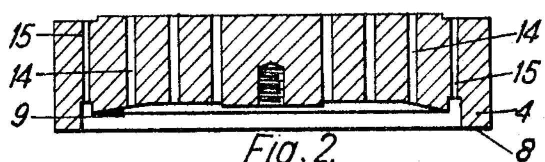

Fig. 2.

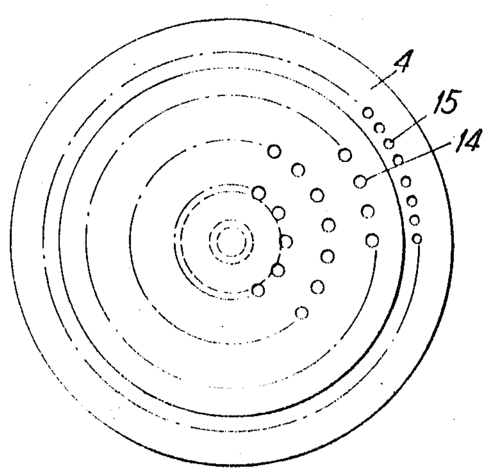

Fig. 3.

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METHOD AND APPARATUS FOR SPINNING HETEROFILAMENTS

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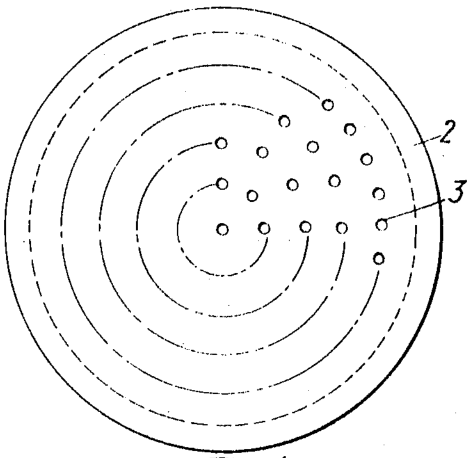

Fig.4.

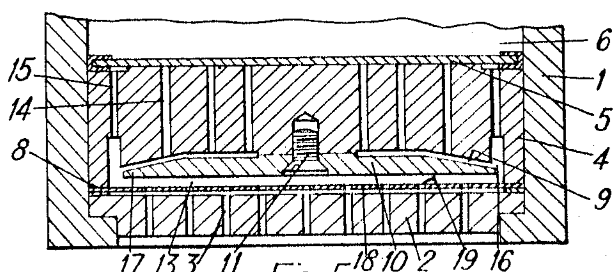

Fig.5.

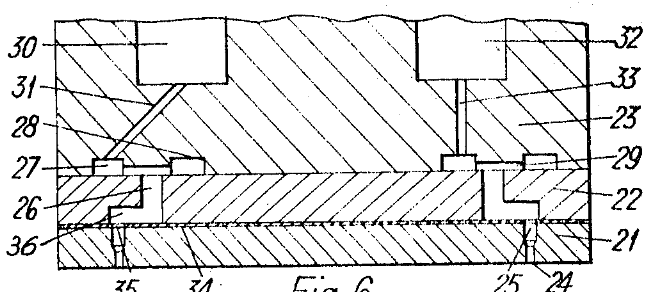

Fig.6.

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3,457,342

Patented July 22, 1969

1

3,457,342

METHOD AND APPARATUS FOR SPINNING HETEROFILAMENTS

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Filed Dec. 5, 1966, Ser. No. 599,084
Claims priority, application Great Britain, Dec. 16, 1965, 53,395/65
Int. Cl. B29 3/10; B32b 31/30
U.S. Cl. 264—171 33 Claims

The present invention relates to methods and apparatus for the manufacture of conjugate filaments containing at least two components, and is especially concerned with the manufacture of such filaments by melt-spinning techniques.

By the term conjugate filaments we mean filaments formed from at least two different substances, at least one of which is fibre-forming for example synthetic polymeric substances, existing in distinct continuous phases along the filament length, said substances differing in respect of some chemical and/or physical property. The continuous phases may be in a sheath/core or side-by-side arrangement.

Conjugate filaments formed from synthetic polymeric substances are of special interest because of their self-crimping and the novel bonding and dyeing effects which can be obtained when the component substances differ in an appropriate physical and/or chemical respect.

There exists a substantial body of published patent literature relating to methods and apparatus for the manufacture of conjugate filaments of interest in the field of sheath/core conjugate filaments is British patent specification No. 830,441. In the method described therein the sheath-forming material in viscous liquid state is caused to flow to extrusion orifices radially from all directions by the provision of a region of high impedance around the said orifices. The core-forming material is then injected as a jet centrally of the sheath-forming material.

The present invention also relates especially to the manufacture of sheath/core conjugate filaments although forms of side-by-side conjugate filaments may also be produced. The method is attractive for its simplicity involving the novel concept of introducing the substances to form the components of the conjugate filament as superposed layers in a confined space above the spinneret plate nad then extruding them through at least one extrusion orifice contained in the spinneret plate in the form of, for example, sheath/core filaments in which the upper of the superposed layers is the core component.

Glass may be used as a fibre-forming substance as well as synthetic polymeric substances such a, for example, polyamides, polyesters, polyolefins, polyurethanes, polyethers and other melt spinnable polymers and also solution spinnable polymers such as polyacrylonitrile.

The fibre-forming substances may include, where appropriate, the normal additives, antioxidants, pigments, delustering agents, extractable material and so on as required.

Accordingly therefore from one aspect the present invention provides a process for the manufacture of conjugate filaments from at least two substances at least one of which is fibre-forming and which differ in respect of some physical and/or chemical property comprising supplying the fibre-forming substances as viscous melts or solutions to a confined region bounded on one side by the back face of a spinneret assembly to form shallow superposed layers lying adjacent to the spinneret in said confined region and extruding the said substances through at least one extrusion orifice contained in a spinneret plate as composite streams to form conjugate filaments which are subsequently collected.

2

The confined region may, for example, cover substantially the total area of the spinneret plate or it may be in the form of a narrow band parallel to, or around, the periphery thereof. The substances may be supplied to a periphery of the confined region as a band-like composite stream e.g. as annular concentric streams, by feeding them jointly in a sheath/core arrangement to a common filtering medium, for example, mounted above the spinneret assembly. Alternatively the substances may be fed individually to the spinneret assembly, through separate filtering media if required, and subsequently combined either immediately at the periphery of the confined space or at some point upstream therefrom, into a band-like composite stream. In such band-like composite streams the substances, when a cross section of the stream is considered, are in side-by-side relationship.

The method of the invention can be made to yield sheath/core conjugate filaments by suitably impeding the viscous liquid flow towards the extrusion orifices to ensure that a sheath component which forms the lower layer flows towards the orifice entrance from all sides and down the outer portion of the orifice while the core material forming the upper layer flows down through the inner portion of the orifice.

This effect may be achieved by providing a protuberance on the spinneret plate surrounding the entrance to the extrusion orifice or on the confining means above the entrance to produce a relatively narrow gap between the spinneret assembly and the confining means in the region surrounding the hole.

Alternatively, if the confined space above the orifice is sufficiently shallow, the necessary convergent flow may be induced by narrowing the orifice entrance. This may be conveniently achieved by locating an "orifice" plate immediately above the spinneret plate with its narrow orifices aligned with the extrusion orifices.

Highly eccentric sheath/core filaments, in which the core component may protrude through the sheath to form part of the surface thereof yielding, effectively, a side-by-side conjugate filament, may be produced by modifying the flow of fibre-forming substances towards the extrusion orifice, e.g. by restricting the said flow around a portion of the periphery of the said orifice. If the flow is restricted at a number of points around the periphery of the extrusion orifices then a conjugate filament having a core of non-circular cross-sectional shape may be produced in which the core portion may protrude through the sheath at one or more points to form part of the surface of the filament, thus forming a form of side-by-side conjugate filament.

According to another aspect the present invention also provides apparatus for the manufacture of conjugate filaments comprising a spinneret assembly holder, a spinneret assembly containing a spinneret plate having at least one extrusion orifice, means positioned behind the spinneret assembly to form a confined region between the said means and the spinneret assembly and means communicating with a periphery of the confined space for supplying viscous melts or solutions of at least two substances thereto in the form of a band-like composite stream.

The means positioned behind the spinneret assembly to define the confined region may be a baffle plate of substantially the same shape as the spinneret plate, which defines a region between itself and the wall of the spinneret assembly holder to permit flow of the substances therebetween to the confined space between the baffle plate and the spinneret assembly as a band-like e.g. annular, composite stream. The orifice in the spinneret plate should lie within the area covered by the baffle plate. The baffle plate may be mounted on a protuberance standing proud of, but not necessarily integral with, the spinneret plate. The baffle plate may support the centre portion of a filter pack located thereabove, the outer portions of pack being supported on projections standing out from the wall of the spinneret assembly holder, a space being provided between the said projections and the upper surface of the baffle plate. The baffle plate may also be located on the underside of a distributor plate mounted above the spinneret assembly, the distributor plate containing an inner and outer series of orifices to permit flow of the substances therethrough; the said orifices communicating with the space between the distributor and baffle plates and the wall of the spinneret assembly holder. Alternatively the means postioned behind the spinneret assembly may comprise a back plate having a continuous band-like recess in the underside thereof to define the confined space and containing a plurality of orifices or a continuous slot parallel to the periphery of the said plate communicating with one side of the recess and the back of the plate to permit the introduction of the substances into the said recess. A distributor plate containing channels in the underside thereof arranged to lie on either side of and in communication with the said annulus may be positioned above and in contact with the aforementioned back plate, each channel communicating with a separate substance supply.

The flow of fibre-forming substances to the extrusion orifices, to affect the shape and position of the core portion of a sheath/core conjugate filament relative to the sheath, may be modified by modifying the shape of the inlet or counterbore of the orifices, e.g. by making it of a non-axisymmetric shape, or by providing a barrier at one or more parts around the periphery of the extrusion orifices extending between the spinneret plate and the plate positioned therebehind.

The process and apparatus of the present invention will now be more fully described by reference to the accompanying drawings.

In the drawings:

FIGURE 1 is a cross-section of one spinneret and filter assembly employed in the melt spinning of conjugate filaments.

FIGURE 2 and FIGURE 3 are cross-section and plan views of the distributor plate used in the assembly depicted in FIGURE 1.

FIGURE 4 is a plan view of the spinneret plate used in the assembly depicted in FIGURE 1.

FIGURE 5 is a cross-section of a spinneret assembly employing an orifice plate above the spinneret plate.

FIGURE 6 is a cross-section of another spinneret assembly employed in the melt spinning of conjugate filaments.

Referring to FIGURES 1, 2 and 3, a pack holder **1** contains a spinneret assembly comprising a spinneret plate **2**, containing extrusion orifices **3**, a distributor plate **4** mounted on the spinneret plate, a bottom screen **5** resting on the top of the distributor plate, filter pack **6** and an upper screen **7**. The distributor plate **4** has its lower face **8** cut away to provide a recess **9** into which a baffle plate **10** is secured by a countersunk screw **11**. An annular space **12** is provided between the recess **9** and the upper face of the baffle plate which shaped to conform with the contour of the lower face of the baffle plate. The depth of the baffle is arranged such that a confined space **13** is defined by the underside thereof and the top face of the spinneret plate **2**. Inner feed orifices **14** provide communication between the bottom of the filter pack **6** and the annular space **12** and outer feed orifices **15** provide communication between the bottom of the filter pack and the annular region **16** defined by the outer wall of the spinneret assembly and the outermost portion **17** of the baffle plate including the annular slit in the distributor plate with which the orifices **15** communicate.

The above described apparatus is particularly suitable for melt spinning sheath/core conjugate filaments from two molten fibre-forming substances, or polymers, which are introduced into the top of the filter pack **6** through screen **7** in the form of two annular streams, the innermost stream forming a cone. The polymers are forced through the filter pack and the bottom screen **5** without any significant degree of mixing at the liquid interface. The polymers are required to be introduced into the pack such that when they arrive at the top of the distributor plate **4** the innermost stream (core) polymer only passes through the inner feed holes **14** into the annular space **12** down which it flows into the annular region **16**. The outermost feed orifice **15** introduce the second polymer into the annular region **16** where it forms a liquid interface with the first mentioned polymer to reform two annular concentric streams. The streams pass around the outermost portion **17** of the baffle plate into the confined space **13** where they form two superposed layers, the inner stream forming the upper layer. The two layers approach the narrow extrusion orifices **3** from all sides and turn downwards to form coaxial streams, the upper layer forming the inner stream, and are extruded as sheath/core conjugate filaments which are then solidified by cooling and collected.

Uniformity of the sheath/core conjugate filaments produced by this method can be improved by causing the superposed streams of polymer in the confined space **13** to pass through restricted regions immediately around the extrusion orifices **3**, the restricted regions providing areas of relatively high impedance to polymer flow. The effect may be achieved by forming protuberances on the spinneret plate through which the said orifice pass, or by forming the protruberances on the baffle plate immediately over the orifices in each case to provide a narrower constriction in the area immediately around the extrusion orifices. The beneficial effects of such protuberances are described in British patent specification No. 830,441.

The desired increase in impedance in the areas surrounding the spinneret orifices may also be obtained by the use of an orifice plate placed between the baffle plate and the spinneret plate and resting on the latter. The orifice plate contains orifice formed immediately over each extension orifice. An arrangement employing such a plate is shown in FIGURE 5 in which the reference numerals have the same significance as in FIGURE 1. The orifice plate is designated **18** and containing orifices **19** and is seen to be placed in the confined region **13** between the baffle plate **10** and the spinneret plate **2**, and resting on the latter.

If desired the baffle plate shown in FIGURE 1 need not be attached to a distributor plate but may be supported on a stem resting on the spinneret plate to form a "mushroom" above the said spinneret plate. In this arrangement the centre portion of the spinneret plate cannot contain extrusion orifices, it being covered by the aforementioned stem. The filter pack and distributor plate may be discarded and pre-filtered polymers introduced directly onto the upper face of the baffle plate in a sheath/core arrangement, the polymers then flowing round the baffle plate to form annular concentric streams to form superposed layers in the confined space.

Although the above arrangements have been described with specific reference to melt spinning, it is clear that the spinneret assembly may be employed in the production of conjugate filaments from viscous solutions of substances at least one of which must be fibre forming.

Another embodiment of the present invention is shown in FIGURE 6, which embodiment will also be described by reference to melt spinning conjugate filaments.

In this embodiment the apparatus consists of a spinneret plate **21** containing an annular arrangement of extrusion orifices **24** located in the base of counterbores **25**. A back plate **22** is positioned behind the spinneret plate and consists of inner and outer concentric portions separated by an annular gap **26**. The outer portion of the back plate has an annular recess **36** formed on its lower inner peripheral surface which forms a confined space between the back plate and a drilled plate **34** containing orifices **35** which rests on the spinneret plate. Orifices **35** in the drilled plate **34** are positioned so as to be in line with the spinneret orifices. Behind the back plate is a distributor block **23** containing in the lower face thereof channels **27** and **28** which lie on either side of the annulus **26** in the back plate. The channels are joined by a shallow annular recess. **29**. Polymer cavities **30** and **32** are joined with channels **27** and **28** by polymer feed ports **31** and **33** respectively.

Molten polymers flow from cavities **30** and **32** from whence they flow via feed ports **31** and **33** into channels **27** and **28** respectively. The polymers flow from the channels into recess **29** where they meet to form a liquid interface and then proceed as two concentric annular streams down the annulus **26** into the confined space **36** where they form the superposed layers. The superposed polymer layers approach the orifice **35** in the drilled plate **34** from all directions and passes therethrough in a coaxial arrangement into the counterbore **24** in the spinneret plate **21** and are extruded in the same form through extrusion orifice **24** to form sheath/core conjugate filaments.

The following examples illustrate the process of the present invention but are not intended to be limiting.

Example 1

In this example the apparatus described with reference to FIGS. 1, 2 and 3 was used. In this apparatus the spinneret contained 69 x 0.0025 inch full depth holes, within a pitch circle diameter of 2.34 inches, the baffle plate was 2.76 inches diameter and the distributor plate contained 60 x 0.0625 inch outer holes and 62 x 0.0625 inch inner holes. The filtering medium consisted of alumina and the confined space between the baffle plate and the spinneret was 0.030 inch deep. The polymers employed were 66 nylon and an 80/20/66/6 nylon copolymer.

The above polymers were received from their respective melters and individually metered through the top screen of the pack in a sheath/core arrangement the copolymer forming the sheath component, the polymers were supplied to the filter pack at a temperature of approximately 289° C. The ratio of the metering speeds was approximately 3:1 core to sheath.

The polymers were forced through the filter pack, through the bottom screen and on to the top of the distributor plate. The core polymer passed through the inner holes in the distributor plate whence it flowed to the periphery of the baffle plate to be joined by the stream of sheath polymer. The combined streams of polymers passed round the periphery of the baffle plate and entered the confined space between the baffle plate and the spinneret where they formed superposed layers with the core component above the sheath. The polymers, were then extruded through the extrusion orifices into filaments, cooled by a traverse blast of air to solidify the filaments, passed over a finish roll and all which applied 0.3% of oil to the filaments and then wound up at 1068 f.p.m. The sheath/core filaments so produced contained about 75% of the core component (66 nylon) surrounded by a sheath of 6.6/6 nylon copolymer. The filaments were drawn at a draw ratio of 3.8 to yield 12 d.p.f. filaments.

The above apparatus can be employed to produce sheath/core conjugate filaments containing up to about 50% of the sheath component.

Example 2

For this experiment the apparatus described with reference to FIG. 6 was used. The spinneret plate **21** contained 36 orifices 0.020 inch long and 0.015 inch diameter formed in the base of an 0.0625 inch diameter counterbore and the drilled plate **34** was 0.020 inch thick and contained orifices 0.009 inch diameter. The annulus **26** in the back plate was 0.0625 inch wide and 0.187 inch thick, and the confined spore **36** was 0.1 inch wide and 0.030 inch deep. The assembly was maintained at a temperature of 295–300° C. Polypropylene polymer was introduced into cavity **32**, whence it flowed via feed pipes **33** into channel **28**, and polyethylene terephthalate polymer introduced into the cavity **30** whence it flowed via feed pipes **31** into channel **27**. The feed rates of the polymers into their respective cavity were in the approximate ratio of 1:2. The polymer streams formed an interface in the recess **29** and superposed layers in the confined space **25** with the polyethylene terephthalate as the upper layer. The polymers were extruded through orifices **24** via the drilled plate orifices **35** to yield sheath/core conjugate filaments and were wound up after solidification at a speed of 2500 f.p.m. The yarn, consisting of filaments each having a sheath of polypropylene constituting approximately ⅓ of the filament, had a spun denier of 680 and was drawn in a steam atmosphere at a draw ratio of 3.6 to yield a yarn of approximately 5.6 d.p.f.

Example 3

The previous example was repeated using the same apparatus but the feed rates of the polymers changed to yield sheath/core conjugate filaments in which the polypropylene sheath formed approximately 50% of each filament. After drawing in steam the filaments had a denier of about 5.6.

Using the apparatus described with reference to FIG. 6 the relative proportions of sheath and core components in sheath/core conjugate filaments can be varied merely by adjusting the relative feed rates of the components. Eccentric sheath/core filaments may be obtained by removing the drilled plate and suitably modifying the flow of the polymer components to the extrusion orifices, e.g. by forming a barrier at one or more points around the periphery of the orifices to restrict the flow of polymer at these points.

What we claim is:

1. A process for the manufacture of a conjugate filament from at least two different substances at least one of which is fibre-forming comprising supplying the substances as viscous melts or solutions to a confined region to form therein shallow superposed layers lying above and adjacent a spinneret assembly containing a spinneret plate, and extruding the said substances through at least one extrusion orifice as composite streams to form sheath-core filaments which are subsequently collected, the upper layer forming the core of said filaments.

2. A process according to claim **1** wherein the confined region covers substantially the total area of the spinneret plate.

3. A process according to claim **1** wherein the confined region covers a continuous narrow band parallel to the periphery of the spinneret assembly.

4. A process according to claim **3** wherein the confined region is in the form of a narrow band around the periphery of the spinneret assembly.

5. A process according to claim **1** wherein the substances are forwarded to a periphery of the confined region from separate sources of supply thereof.

6. A process according to claim **5** wherein the process is a melt spinning process, the substances are forwarded to a periphery of the confined region as a band-like composite stream to form superposed layers therein and the extruded filaments solidified before being collected.

7. A process according to claim **6** wherein the conjugate filament obtained consists of the substances in a sheath/core arrangement, the core forming substance being the upper of the superposed layers formed in the confined region.

8. A process according to claim **1** wherein the process is a melt spinning process and the substances, in a molten state are introduced into a filter pack in a sheath/core arrangement, forced therethrough maintaining their individual identities and forwarded as a band-like composite stream to a periphery of the confined region to form superposed layers therein and the extruded filaments solidified before being collected.

9. A process according to claim **8**, wherein the conjugate filament obtained consists of the substances in a sheath/core arrangement, the core forming substance being the upper of the superposed layers formed in the confined region.

10. A process according to claim **1** wherein the flow of substances in the confined region towards the extrusion orifice is modified to yield an eccentric conjugate filament.

11. A process according to claim **10** wherein the flow of substances is modified by restricting the said flow around a portion of the periphery of the orifice.

12. A process according to claim **11** wherein the restriction to flow forces the core-forming substance to appear as a portion of the surface of the conjugate filament.

13. A process according to claim **10** wherein the flow is modified at a number of points around the periphery of the orifice to yield a conjugate filament in which the core portion has a non-circular cross-section and may form part of the surface of the filament at one or more points across a cross-section thereof.

14. Apparatus for the manufacture of a conjugate filament comprising a spinneret assembly holder, a spinneret assembly containing a spinneret plate having an extrusion orifice, means positioned behind the spinneret assembly to form a confined region between the said means and the spinneret assembly and means communicating with a periphery of the confined space for supplying at least two spinnable substances thereto in the form of a band-like composite stream.

15. Apparatus according to claim **14** wherein the means positioned behind the spinneret assembly comprises a baffle plate having substantially the same shape as the spinneret plate and defining a region between the baffle plate and the wall of the spinneret assembly holder, the orifice in the spinneret plate lying within the area covered by the baffle plate.

16. Apparatus according to claim **15** wherein the baffle plate is mounted on a protruberance standing proud of the spinneret plate.

17. Apparatus according to claim **16** wherein the baffle plate supports the centre of a filter pack positioned thereabove, the outer portion of which is supported on projections from the wall of the spinneret assembly holder, a space being provided between the said projections and the baffle plate.

18. Apparatus according to claim **15** wherein a distributor plate having upper and lower surfaces is mounted above the spinneret assembly and the baffle plate mounted on the lower surface thereof defining a space therebetween, said distributor plate containing an inner and outer series of orifices extending therethrough communicating with the space between the baffle plate and the distributor plate and the wall of the spinneret assembly holder.

19. Apparatus according to claim **18** wherein there is provided above the distributor plate a filter pack assembly containing an inert filtering medium and means for introducing streams of substances in a sheath/core arrangement into said filter pack assembly, and the inner series of orifices in the distributor plate being positioned to receive the core forming substance only.

20. Apparatus according to claim **18** wherein at least one channel is provided in the lower surface of the distributor plate, which channel communicates with at least some of the outer series of orifices in the distributor plate.

21. Apparatus according to claim **15** including means forming a region of high impedance to liquid flow in the area of the extrusion orifice.

22. Apparatus according to claim **21** wherein the means forming the region of high impedance includes a protuberance located on the baffle plate immediately above the spinneret orifice to form a restricted gap in the area surrounding the orifice.

23. Apparatus according to claim **21** wherein the means forming the region of high impedance includes a protuberance located around the extrusion orifice to form a restricted gap in the area surrounding the orifice.

24. Apparatus according to claim **21** wherein the means forming the region of high impedance includes a plate positioned above and in contact with the spinneret plate, said plate containing an orifice of smaller diameter than the extrusion orifice located directly above and in line with the said extrusion orifice.

25. Apparatus according to claim **14** wherein the means positioned behind the spinneret assembly comprises a back plate having upper and lower surfaces and having a continuous band-like recess in the lower surface thereof to provide a confined space between the back plate and the spinneret assembly, said back plate containing at least one opening communicating with one side of the recess, the extrusion orifice being located under the area of recess not containing the said opening.

26. Apparatus according to claim **25** wherein an assembly having a lower face is positioned above and in contact with the back plate, said assembly being provided with two channels in the lower face thereof which channels are arranged to belie either side of and in communication with the opening in the back plate, each channel communicating with a separate substance supply.

27. Apparatus according to claim **25** wherein a region of high impedance to liquid flow is provided in the area of the extrusion orifice.

28. Apparatus according to claim **27** wherein the region of high impedance is provided by a protuberance located around the extrusion orifice to form a restricted gap in the area surrounding the orifice.

29. Apparatus according to claim **27** wherein the region of high impedance is provided by a plate positioned above and in contact with the spinneret plate, said plate containing an orifice of smaller diameter than the extrusion orifice located directly above and in line with the said extrusion orifice.

30. Apparatus according to claim **24** wherein the approaches to the extrusion orifice are modified to change the pattern of flow of the substances into the said orifices.

31. Apparatus according to claim **30** wherein the modification consists in providing the extrusion orifice with a counter-bore having a non-axisymmetric shaped lead in portion.

32. Apparatus according to claim **30** wherein the modification is achieved by the provision of a barrier at least one point around the periphery of the extrusion orifice extending between the spinneret plate and the means defining the confined region behind the spinneret assembly.

33. Apparatus according to claim **32** wherein the barrier extends to the means defining the confined region behind the spinneret assembly.

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U.S. Cl. X.R.

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