April 15, 1969 D. J. ATTFIELD ET AL 3,438,087

SPINNERETS

Filed June 15, 1965

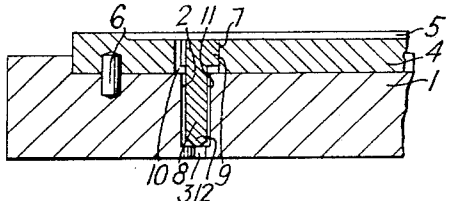


Fig. 1.

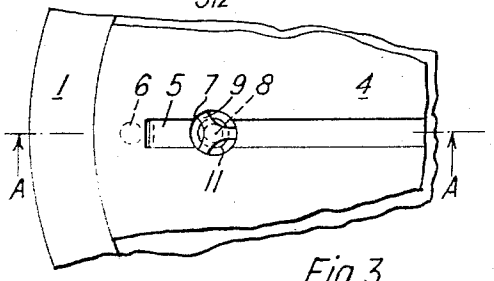


Fig. 2.

Fig. 3.

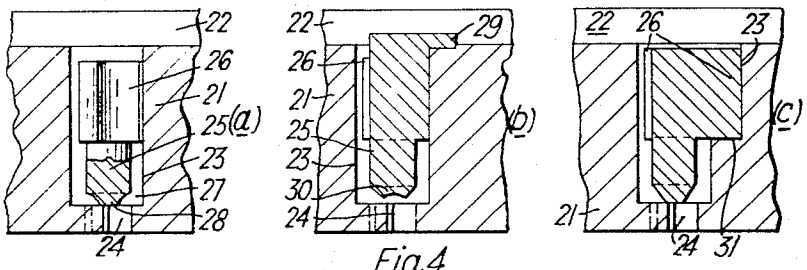
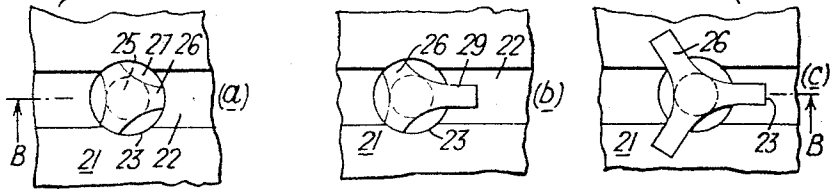


Fig. 4.



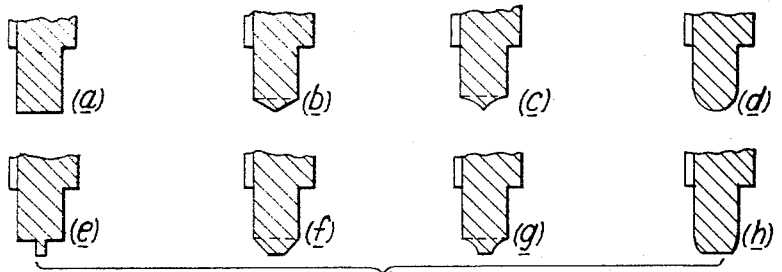


Fig. 5.

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SPINNERETS

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ABSTRACT OF THE DISCLOSURE

This invention relates to a spinneret for the manufacture of synthetic filaments having a non-circular cross-section by the melt spinning of a polymer, comprising a spinneret plate having an upper and lower face provided with a counterbore in the upper face thereof in the bottom of which is located an extrusion orifice, consisting of a body portion and at least two extended tip portions, and an insert having a tip portion which extends into the counterbore for a predetermined distance to control the flow of polymer across the extrusion orifice.

This invention relates to improvements in spinnerets used in the manufacture of filaments having a non-circular cross-section and is particularly directed to spinnerets employed in the manufacture of filaments having a multilobal cross-section.

Spinnerets for the manufacture of filaments having a non-circular cross-section contain orifices which frequently take the form of at least one arm and more usually three or more such arms, each of the said arms interconnecting with at least one other arm. As examples of such orifices we have those which take the form of thin rectangular slots for the production of elliptical cross-section filaments, Y-shaped orifices for the production of trilobular and the like cross-section filaments, cruciform-shaped orifices for the production of tetralobular and the like cross-section filaments and orifices in the form of a hollow E for the production of essentially crescent-shaped filaments. A feature common to the aforementioned and related types of orifices is that they all have a body portion and at least one extended tip portion, i.e. a tip portion which is relatively remote from the body portion of the orifice.

In the spinning of artificial fibres through orifices comprising, for example, a plurality of equi-length arms interconnecting at a single point, i.e. the centre point of the orifice, there is a marked tendency for the filaments, which initially appear having substantially the same shape as the spinneret orifice, to assume a circular cross-section. This is especially true of melt spun polymers.

To reduce this tendency it has been proposed to change the shape of the tip portions of the orifices to allow more polymer to flow therethrough. Examples of such changes in shape are given in U.S. patent specification No. 2,945,739 in which the arms of the orifice have abruptly expanded cross-sections at the tips and in U.S. patent specification No. 3,109,195 in which the tips of the arms are traversed by intersecting slots. It has been further proposed to provide bores, having diameters greater than the width of the orifice arms, at the tip portions of the said orifice arms to supply an increased volume of spinning material to those portions.

We have now discovered that the effect achieved by above proposals, viz. the supplying of relatively large volumes of spinning material to the tip portions of slot-like orifices, can be simply obtained by controlling the feed to the slot-like orifices using flow control inserts adapted to protrude into the orifice counter bore and

extending to touch or nearly touch the bottom thereof. The inserts may be contained in a distributor plate or they may be fitted into individual orifice counter-bores.

According to one aspect of the present invention therefore, there is provided a spinneret for spinning synthetic filaments having a non-circular cross-section by melt spinning processes, comprising a spinneret plate provided with a counter bore in the bottom of which is located an extrusion orifice consisting of a body portion and at least two extended tip portions, and an insert extending into the said counter bore for a predetermined distance to control the flow of polymer across the orifice.

According to another aspect of the present invention, there is provided a process for spinning synthetic filaments having a non-circular cross-section wherein molten polymer is forwarded to a spinneret as herein before described and extruded through the orifice contained therein, the relative volumes of polymer supplied to the tip and body portions of the said orifice being controlled by the dimensions of the insert and/or the depth to which it extends into the counter bore.

Normally in the cases of symmetrical slot-shaped orifices the insert will be circular in cross-section and will be located centrally of the counter-bore. In the case of non-symmetrical slot-shaped orifices, e.g. T-shaped, however, the insert may be located eccentrically of the counter-bore or it may be of a more oval cross-section.

The application of this invention is not limited to slot-like orifices but may also, if required, be used with, for example triangular or crescent-shaped orifices, it being limited only in its application to orifices containing at least one extended tip portion.

The invention will now be more fully described with reference to the accompanying drawings which illustrate but which do not limit the invention. In the drawings:

FIGURE 1 is a cross-section of one embodiment of the invention through a fragment of a spinneret plate containing an orifice.

FIGURE 2 is a plan view of the fragment of FIGURE 1.

FIGURES 3*a*, *b* and *c*, are cross-sections of fragments of other embodiments of the invention.

FIGURES 4*a*, *b* and *c* are plan views of the fragments of FIGURE 3.

FIGURES 5*a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h* show alternative shapes for inserts which may be employed in the invention.

In referring to FIGURES 1 and 2 a spinneret plate **1** containing a counter-bore **2** through the base of which extends a symmetrical Y-shaped extrusion orifice **3** has a distributor plate **4**, having a channel **5**, located in a recess in the upper face of the spinneret face by locating dowel **6**. A bore **7** concentric with, but having a greater diameter than, the counter-bore **2**, extends through the distributor plate **4** and a flow control insert **8** extending into the said counterbore is firmly fixed therein by locating lugs **9** to provide annular spaces **10** and **11**. The tip **12** of the flow control insert **8** extends within the counter-bore **2** to a point level with the base thereof.

In use in spinning filaments having a substantially Y-shaped cross-section from molten polyhexamethylene adipamide polymer, for example, using the above-described spinneret, the polymer after filtration in the normal manner, passes into channel **5** of the distributor plate **4** and thence into the annular space **10** via bore **7**. The molten polymer passes from the annular space **10** into the annular space **11** formed between the counter-bore **2** and the flow control insert and is extruded through the Y-shaped orifice **3**. The effect of the flow control insert is to direct a relatively greater volume of the polymer to the tip portions of the arms of the extrusion orifice than

to the centre portion of the orifice. As a result more polymer is extruded through these tip portions of the arms of the orifice and the extruded filament tends to retain its shape during cooling, since the tendency for the surface tension effects of the semi-molten polymer to pull in the tip portions of the filament and cause it to become more circular in cross-section is, to some extent at least, counteracted by the relatively large amounts of polymer present at the said tip portions.

FIGURES 3 and 4 are cross-sections and plan views respectively of other embodiments of the present invention in which the flow control inserts are press fits into the spinneret counter-bores.

In FIGURES 3*a* and 4*a* there is shown a fragment of a spinneret plate **21** containing in the upper face thereof a channel **22** at the base of which is drilled a counter-bore **23** terminating in a Y-shaped extrusion orifice **24**. A flow control insert **25** is contained wholly within the counter-bore and is located in position by lugs **26**. The diameter of the insert is made smaller than that of the counter-bore to provide an annular space **27** above the extrusion orifice. The end portion **28** of the insert is shaped to control the rate of polymer flow across the extrusion orifice and is in contact with the bottom of the counter-bore.

In FIGURES 3*b* and 4*b* the flow control insert **25** is seen to be longer than the counter-bore **23** and in addition to lugs **26** which locate the insert radially within the counter-bore, the said insert also contains an additional lug **29** which controls the degree of penetration of the insert into the counter-bore, in this embodiment the end portion **30** of the insert is shown to be a small distance above the base of the counter-bore.

In FIGURES 3*c* and 4*c* there is shown yet a further embodiment of the invention. In this instance the lugs **26** of the previous embodiment are extended to the same length as the lug **29** and are located on shoulders **31** formed by milling out the top of the counter-bore thus also controlling the degree of penetration of the insert into the counter-bore. As in the embodiment described in FIGURES 3*a* and 4*a*, the insert is contained wholly in the counter-bore and thus does not present any restriction to polymer flow along the channel **22**.

FIGURES 5*a*–5*h* show some of the possible shapes of the end portions of inserts which may be used to control the flow of polymer across the top of the extrusion orifice.

The following example illustrates the invention but is intended to be in no way limitative thereof.

Example

A spinneret containing 6 extrusion orifices of the type described hereinbefore with reference to FIGURES 3*a* and 4*a* and containing an insert of the type shown in 5*a* was used in the spinning of filaments having an essentially trilobal cross-section from polyhexamethylene adipamide polymer. The orifices comprised three arms each 0.020" long and 0.004" wide and at an angle of 120° to each other which were formed in the front face of the spinneret plate and extended towards the back face thereof to communicate with a counter bore having a diameter of 0.125". The insert fitted into the counter bore and its tip portion made contact with the base thereof, the said tip portion having a diameter of 0.020" so that polymer was fed to the tip portions of the orifice arms only. The polymer had a relative viscosity of 40 and was spun into a 9 denier per filament yarn at spinning temperature of 270° C. at which temperature the melt viscosity of the polymer was 2500 poises measured at a sheer rate of 4 sec.$^{-1}$, and wound up at a speed of 3930 ft./min.

The yarn was compared with that yarn which was obtained when the same polymer was spun under the same conditions but using a spinneret in which there were no inserts in the counter bores.

Comparison between the undrawn yarns so produced was made by measuring the modification ratios of the filaments, the modification ratio being the ratio of the radius of the circumscribing circle to the ratio of the inscribed circle. The modification ratios of the filaments of the two yarns are given in the table below:

Orifice:	Modification ratio
Standard	2.2
Standard and insert	2.3

The filaments spun through the orifices of the present invention had a more well defined trilobal shape than those spun through standard orifices. The invention is not limited to use with polyhexamethylene adipamide, any melt spinnable synthetic polymer may be employed where appropriate. As example of such polymers there may be mentioned polyamides in general including polyepsilon caprolactam, copolyamides; polyesters such as polyethylene terephthalate, copolyesters; polyesteramides; polyolefins such as high density polyethylene and crystalline polypropylene; polyurethanes and polycarbonates.

In order to obtain maximum benefit from the use of flow control inserts the polymers being spun should preferably have a minimum melt viscosity of about 1500 poises measured at 290° C. at a sheer rate of 4 sec.$^{-1}$ in an Eppricht viscometer.

The present invention allows different polymer flow characteristics across the extrusion orifices to be obtained merely by changing the inserts in the counter-bores. Previous proposals have required the manufacture of new spinnerets to achieve the same end. The invention has the additional merit of enabling the flow control inserts to be removed for cleaning.

What we claim is:

1. A spinneret for the manufacture of synthetic filaments having a non-circular cross-section by the melt spinning of a polymer, comprising a spinneret plate having an upper and lower face provided with a counter-bore in the upper face thereof in the bottom of which is located an extrusion orifice, consisting of a body portion and at least two extended tip portions, and an insert having a tip portion which extends into the counter-bore for a predetermined distance to control the flow of polymer across the extrusion orifice.

2. A spinneret according to claim **1** wherein the insert is contained in a distributor plate located on the upper face of the spinneret plate.

3. A spinneret according to claim **1** wherein the insert is contained within the counter-bore and located therein by lugs which are a press fit into the said counter-bore.

4. A spinneret according to claim **3** wherein the counter-bore is located in the bottom of a channel formed across the upper face of the spinneret plate.

5. A spinneret according to claim **3** wherein at least one lug is located on a shoulder formed as an extension to the counter-bore, which lug determines the degree of penetration of the insert into the counter-bore.

6. A spinneret according to claim **1** wherein the tip portion of the insert is in contact with the bottom of the counter-bore.

7. A spinneret according to claim **1** wherein the extrusion orifice consists of at least three equispaced slot like arms radiating from a central body portion.

8. A spinneret according to claim **7** wherein the insert is circular in cross-section and is located centrally of the counter-bore.

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