Sept. 3, 1957 R. E. WILFONG 2,804,645

SPINNERET PLATE FOR MELT SPINNING

Filed May 12, 1953

Fig. 1.

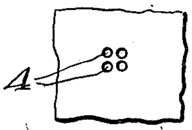


Fig. 2.

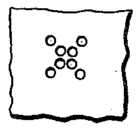


Fig. 3.

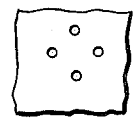
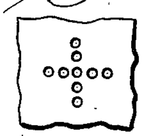


Fig. 4



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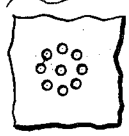

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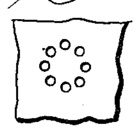

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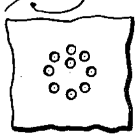


Fig. 8.

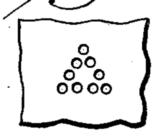


Fig. 9

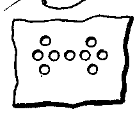


Fig. 10.

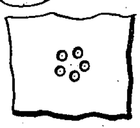


Fig. 11.

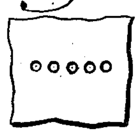


Fig. 12.

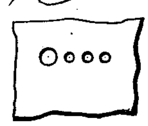


Fig. 13.

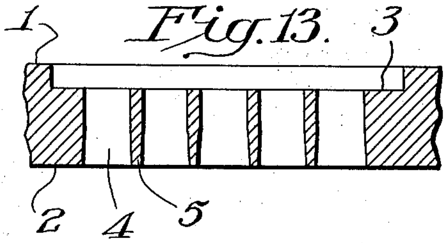
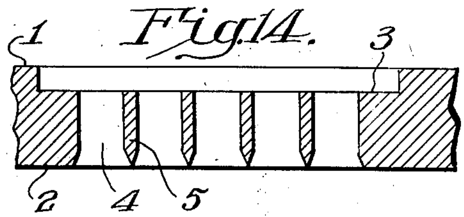


Fig. 14.



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SPINNERET PLATE FOR MELT SPINNING

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4 Claims. (Cl. 18—8)

The present invention relates to apparatus for the spinning of a synthetic funicular body. More particularly, it relates to a spinneret which is particularly useful in the formation of a longitudinally-channeled funicular body of a melt-spun, fiber-forming synthetic linear polymer. By the term "funicular body" is meant a filament, fiber, staple, yarn, tow, cord or the like which is suitable for textile and other uses.

It is an object of the present invention to provide a novel spinnert useful in the art of melt-spinning.

Another object is to provide a novel spinnert useful in the production of a longitudinally-channeled funicular body.

These and other objects will become apparent in the course of the following specification and claims.

In accordance with an invention described in copending United States Patent application, Serial No. 334,457, filed February 2, 1953, longitudinally-channeled funicular bodies are produced from a fiber-forming synthetic polymer by melt-spinning through a spinneret containing single or multiple, suitably patterened arrangements of holes of such proximity and size that as the filaments emerge, coalescence occurs among the strands of each patterned arrangement. Thereafter, the extrusions are subjected to rapid quenching to arrest plastic flow. Further deviation from a circular cross-section is obtained by drawing the extruded filaments. It has been observed that the completeness with which the individual strands are coalesced to a composite filament may be improved by modifying the spinneret plate so as to reduce the web thickness (i. e., the closest distance between the circumference of adjacent holes) within the patterned arrangement. However, any such decrease in web thickness will obviously be accompanied by a corresponding loss of strength in the spinneret plate.

In accordance with the present invention, it has been found that coalescence among individual strands in the melt-spinning of a longitudinally-channeled filament as described in the aforementioned copending application can be improved by modifying the individual orifices on the spinneret plate so that they flare outwardly toward the extrusion face.

The invention will be more readily understood by reference to the figures.

Figures 1 through 12 inclusive, are plan views of fragmentary sections of spinneret plates showing various typical individual patterned arrangements which may be employed in accordance with the present invention.

Figure 13 is a magnified fragmentary cross-sectional view of a spinneret plate in which the individual orifices of the patterned design have been gradually flared.

Figure 14 is a magnified fragmentary cross-sectional view of a spinneret plate in which the individual orifices of the patterned design have been flared by countersinking.

The following examples are cited to illustrate the invention. They are not intended to limit it in any manner. By the term "relative viscosity" as used herein is meant the quotient of the efflux time in a capillary viscometer at 25° C. of solution of 11 grams of polymer in 100 ml. of solvent divided by the efflux time of the solvent under the same conditions. This figure gives a relative indication of the degree of polymerization. The reference solvent employed in the examples for hexamethylene adipamide is a 90% aqueous solution of formic acid. The reference solvent for polyethylene terephthalate is a solution of 7 parts by weight of trichlorophenol and 10 parts by weight of phenol.

Example I

A spinneret plate having a thickness of 0.312 inch and containing 360 holes, consisting of 40 of the 9-holed patterned arrangements as shown in Figure 4, is drilled. The holes have diameters of 0.007 inch. Within each patterned arrangement, they are spaced 0.009 inch from center to center. Prior to drilling of the holes, a countersink 0.300 inch on a 1/16 inch diameter is made on the polymer melt face for each patterned arrangement. The patterned arrangements are laid out on concentric circles. The spinneret plate is locked in conventional melt-spinning equipment similar to that disclosed in U. S. Pat. No. 2,266,368.

Polyhexamethylene adipamide prepared in accordance with the procedure described in U. S. Pat. No. 2,130,948, having a relative viscosity of 46, is spun through this equipment to obtain an 840-denier, 40-filament yarn. The yarn is spun at a rate of 500 yards per minute into a cross-flow cooling chimney which extends 12 inches below the spinneret. Such an arrangement is shown in U. S. Pat. No. 2,273,105. Air flow is maintained in the chimney at 234 cubic ft. per minute. The air at the influx is approximately at room temperature. The spinneret filter pack is maintained at approximately 270° C.

A series of observations is made by cutting across each yarn in several places and counting the number of filaments, the strands of which are not completely coalesced. The yarn spun as described above is found to average 8.5 filaments having strands which are not completely coalesced.

The spinneret plate described above is then modified by flaring out the orifices on a 1/8 inch radius so as to reduce the web thickness at the extrusion face to 0.001 inch. A magnified, fragmentary, cross-sectional view of a spinneret plate in which the individual orifices of the patterned design have been so flared is illustrated in Figure 13. With reference to the figure, the flare is obtained by gently expanding the individual orifices **4** from the polymer melt face **1** toward the extrusion face **2**, producing a web **5** of varying cross-section. Surface **3** is produced by the countersink on the polymer melt face. The web thickness at the polymer melt face at the bottom of the countersink is 0.002 inch. The thickness of the spinneret plate in the countersink region is 0.012 inch. The polymer described above is extruded under the conditions stipulated. The resulting yarn ends average only 1.0 incompletely coalesced strand.

Example II

The original spinneret plate of Example I is modified by countersinking the holes at the extrusion face with a 50 degree cutter. The resulting design is illustrated in Figure 14 where the reference numerals correspond with those identified above. In this figure, it will be noted that the cross-section of the individual web is uniform except near the extrusion face. The web thickness at the extrusion face is 0.0005 inch. The polymer of Example I is extruded under the conditions of that example. No incompletely coalesced strands are observed in the resulting yarn ends.

Example III

A spinneret plate having a thickness of 0.312 inch and containing 306 holes consisting of 34 of the 9-holed patterned arrangement as shown in Figure 9 is drilled. The diameters of the holes and their spacings are the same as described in the plate of Example I. The plate is locked in conventional, melt-spinning equipment.

Polyethylene terephthalate prepared in accordance with the procedure described in U. S. Pat. No. 2,465,319, having a relative viscosity of 35, is spun through this equipment to obtain a 306-denier, 34-filament yarn. The yarn is spun at a rate of 980 yards per minute into a crossflow chimney as described in Example I. The air flow in the chimney is maintained at 78 cubic ft. per minute. The air at the influx is approximately at room temperature. The spinneret filter pack is maintained at approximately 285° C.

Observation for filaments having incompletely coalesced strands in the yarn, spun as described above, disclosed an average of 10 such filaments. The spinneret is then modified by flaring out each orifice toward the extrusion face on a ⅛ inch radius so as to reduce the web thickness at the extrusion face to 0.001 inch. A fragmentary, cross-sectional view illustrating such a spinneret plate is shown in Figure 13. The web thickness at the polymer melt face at the bottom of the countersink remains 0.002 inch. No split filaments are observed.

The nature and viscosity of the polymer to be extruded, the particular patterned arrangement employed and the size and spacing of the individual holes within each patterned arrangement are variables, the combined effect of which determines optimum operating conditions. In general, it is desirable to extrude at as low a temperature as possible to avoid unnecessary plastic flow in the extruded mass. The individual holes within each patterned arrangement must be maintained small to present a structure having a relatively large surface area to cross-section which is easily quenched. These individual holes must be close enough together within each patterned arrangement that coalescence of the individual strands within each arrangement occurs.

In general, it may be stated that optimum temperature for the melt-spinning of any particular polymer will be slightly lower when practicing the present invention than is usually employed in the conventional melt-spinning of the same polymer. A pack temperature of from about 255° C. to about 290° C. is recommended for the spinning of polyethylene terephthalate having a relative viscosity of from 25 to 35 when following the teachings of the present invention. Polyhexamethylene adipamide, having a relative viscosity within the range of 25 to 45, is best spun at a pack temperature of from 245° C. to 270° C. when proceeding in accordance with the present invention.

Rapid quenching of the extruded filament assists in the arrest of its plastic flow. It is promoted by maintaining the diameter of the extruded individual strand as low as practicable in order to assist heat transfer after extrusion. In general, a hole diameter of from about 0.004 to about 0.030 inch has been found suitable for the melt-spinning of polyesters and polyamides. A relatively high-velocity, low-temperature air stream is also beneficial in obtaining this result. Concurrent or countercurrent flow at the spinneret face may be advantageously employed. In any of these techniques, care must be taken to avoid fouling the extruded filaments, one with the other. Beside quenching in air, quenching in any inert cooling fluid may be employed.

The thickness of the spinneret plate is not critical. It should be maintained as thin as practicable in order to avoid temperature changes of the polymer melt between its polymer melt surface and the extrusion surface. Furthermore, a thick plate introduces friction losses. The matter of strength of the plate must be considered and this will depend not only on its thickness but on its material of construction. For a chromium steel plate (such as illustrated in U. S. Pat. No. 2,341,555) a plate thickness of from about 0.2 to about 0.4 inch is sufficient. It is possible to decrease the thickness at each extrusion point by countersinking on the polymer melt face over each patterned arrangement. In this manner, it is possible to have as low an effective thickness at the point of extrusion as about 0.01 inch when using a plate of the metal described above. The thickness of the web at the extrusion face of the spinneret plate should be kept as low as practical. The maximum permissible thickness will be primarily related to the size of the extrusion orifices. However, the nature of the extruded polymer will also affect it to a certain degree. Where the orifice diameter is between the limits of about 0.004 to about 0.030 inch and the polymer is a member of the group consisting of polyesters and polyamides, the web thickness at the extrusion face is advantageously maintained at less than 0.002 inch and is preferably maintained between the limits of about 0.0015 and about 0.003 inch.

This invention is applicable broadly in the production of all types of fiber-forming synthetic linear polymers which are capable of being melt spun. Illustrative of polyamides and copolyamides which can be spun employing the apparatus of this invention are those described in any of the U. S. Patents No. 2,071,250; 2,071,253; 2,130,523; 2,130,948; 2,190,770; 2,252,555; 2,252,557 and 2,374,137. Examples of polyesters and copolyesters are shown in U. S. Patents No. 2,071,250; 2,071,251; 2,465,150 and 2,465,319.

Many other modifications within the scope of the disclosed invention, without a departure therefrom, will be apparent to those skilled in the art.

What is claimed is:

1. A spinneret plate for melt-spinning which comprises a thin plate containing at least one group of outwardly flared holes so spaced that coalescence occurs among the adjacent extruded strands of each group; with the diameter of the flare of the said holes increasing towards the extrusion face so as to provide a web thickness at the extrusion face of less than about 0.002 inch; and with each group of said outwardly flared holes having a countersink region on the polymer melt face of the said plate.

2. The structure of claim 1 wherein the web thickness at the extrusion face is between about 0.0015 and about 0.0003 inch.

3. A spinneret plate for melt-spinning which comprises a thin plate containing at least one group of outwardly flared holes having diameters of from about 0.004 to about 0.030 inch on the polymer melt face and being so spaced that coalescence occurs among the adjacent extruded strands of each group; with the diameter of the flare of the said holes increasing towards the extrusion face so as to provide a web thickness at the extrusion face of less than about 0.002 inch; and with each group of said outwardly flared holes having a countersink region on the polymer melt face of the said plate.

4. The structure of claim 3 wherein the web thickness at the extrusion face is between about 0.0015 and about 0.0003 inch.

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