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3,421,181

SPINNERET PLATE

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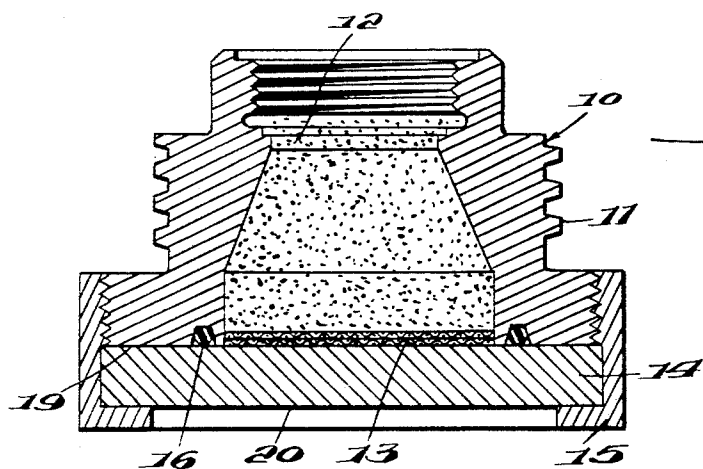


Fig. 1.

Fig. 4.

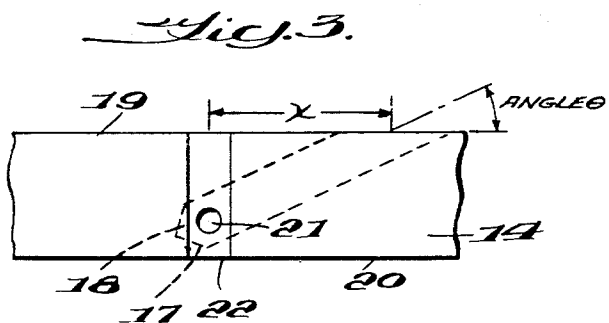
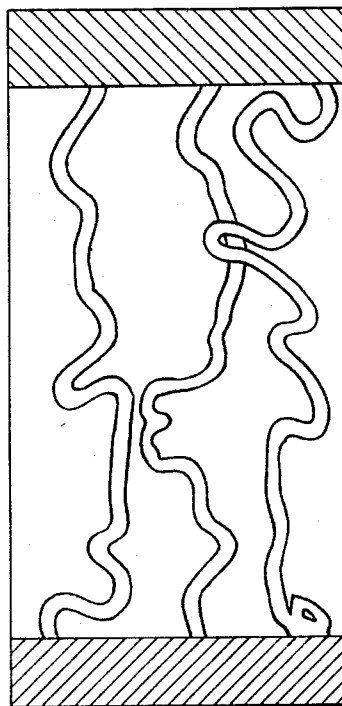
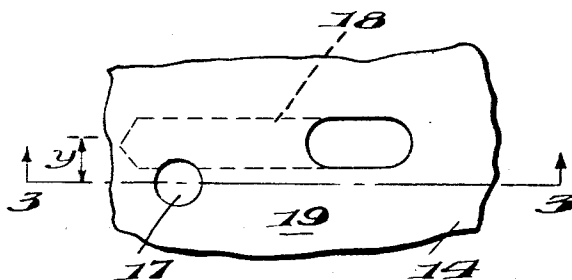


Fig. 3.

Fig. 2.



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SPINNERET PLATE

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4 Claims

ABSTRACT OF THE DISCLOSURE

A spinneret plate for producing crimped filaments, especially crimped ultramicrocellular filaments. The plate contains two passages. The first extends through the plate; the second intercepts the first at an acute angle near one surface of the plate. The axes of the passages are offset so that the passages communicate tangentially. In operation, spinning solution passes through both passages. Crimping is apparently due to spiral motion imparted to stream at juncture of passages.

This invention relates to apparatus for making crimped filaments.

In the textile art, it has been the practice to produce crimped filaments by employing various types of mechanical devices, e.g. gear and stuffer-box crimpers, at some stage of processing subsequent to the filament-spinning operation. In an alternate technique the filamentary components are so selected that after spinning, crimp is readily developed by means of chemical or physical treatments, e.g. by heat. In accordance with the present invention, crimp development is accomplished concomitantly with the filament spinning operation by use of certain spinning apparatus.

The invention will be particularly described with reference to the production of cellular filaments of the so-called "ultramicrocellular" variety as described in Blades et al. U.S. Patent 3,227,664, the disclosure of which is specifically incorporated herein by reference. It will be understood, however, that the novel spinning apparatus of the present invention may likewise be used in the production of other forms of filamentary products, e.g. non-cellular filaments or other types of cellular filaments.

The invention will be described with reference to the drawings wherein:

FIGURE 1 shows the general form of a typical spinneret assembly of the kind used in the production of synthetic filaments.

FIGURE 2 is a partial top view of one form of spinneret plate for use with such a spinneret assembly in the practice of the invention.

FIGURE 3 is a partial cross-sectional view taken along the line 3—3 of FIGURE 2.

FIGURE 4 shows typical forms of crimped ultramicrocellular filaments produced in accordance with the invention.

In accordance with the apparatus embodiment of the invention, there is provided a spinneret pack assembly comprising a filter block and a spinneret plate in stacked relationship, said plate having upstream and downstream surfaces and containing at least one filament-producing orifice in its downstream surface, a first passage extending from said upstream surface fully through said plate and terminating at said orifice, and a second passage in said plate extending from said upstream surface and tangentially communicating with said first passage near said downstream surface but terminating short of said downstream surface, the axis of said second passage forming an acute angle with said upstream surface.

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With reference to FIGURE 1, a spinneret pack assembly, shown generally as 10, comprises a threaded generally tubular spinneret pack retainer 11; a body of finely divided inert filtering material 12, e.g. sand, therein; filtering screens 13 in the path of polymer flow; spinneret plate 14 having one or more orifices, not shown; internally threaded spinneret holder 15; and annular gasket 16 insuring a tight joint between retainer 11 and the spinneret plate. The upstream and downstream surfaces of the spinneret plate 14 are indicated generally by reference numerals 19 and 20, respectively.

Details of the filament-producing portion of spinneret plate 14 are shown in FIGURES 2 and 3. A first passage 17 completely penetrates spinneret plate 14 and has an axis which is substantially perpendicular with respect to the upstream surface 19. A second passage 18 does not completely penetrate the spinneret plate and has an axis which forms an acute angle, θ , with respect to the upstream surface 19. The tangential communication of the two passages 17 and 18 defines a common opening or juncture 21 which is located near but short of downstream surface 20 of the spinneret plate 14.

The openings of passages 17 and 18 in upstream surface 19 of spinneret plate 14 are separated by a center-to-center distance designated by X. The axes of passages 17 and 18 do not lie in a common plane and do not intersect, but rather the axes are separated by a distance Y. Thus passage 18 tangentially communicates with passage 17 and opening 21 is smaller than the diameter of passages 17 and 18.

In operation, polymer in the form of a solution, melt, or other fluid form is passed to the spinneret pack assembly 10 in any convenient way and then is suitably filtered therein for delivery to the spinneret plate 14. Polymer then enters both passages 17 and 18 and the separate streams combine at opening 21 to exit from the single orifice 22 in the downstream surface 20 of spinneret plate 14. Filaments of the polymer thus produced are crimped, apparently the crimping being due to a spiral motion imparted to the polymer stream at the juncture 21 as the flow moving along passage 18 tangentially intercepts that moving along passage 17.

For the production of ultramicrocellular structures the diameter of passages 17 and 18 is desirably between 0.006 and 0.04 inch (0.015 and 0.1 cm.), preferred values being 0.015 inch (0.038 cm.) for the passage 17 and 0.02 inch (0.05 cm.) for passage 18. The ratio of the diameter of passage 18 to that of passage 17 is 1.33:1 in the preferred embodiment, but in practice this value may range from 0.5:1 to 2:1 without adversely affecting the spinning operation.

If the passage 18 is somewhat larger in diameter than passage 17, as is preferred, then this results in slightly different speeds of the converging streams prior to intersection, and this further serves to accentuate crimping of the filament produced.

The center-to-center distance, X, between passages 17 and 18 in the upstream surface 19 of the spinneret plate 14 should preferably be as great or greater than the diameter of the larger passage. The axes of passages 17 and 18 do not intersect, but are separated by a distance (Y) for which values in the range between 0.3–0.85 times $(R_1 + R_2)$ are particularly useful, where R_1 and R_2 represent the radii of passages 17 and 18, respectively. This value is 0.7 $(R_1 + R_2)$ in a preferred embodiment. The distance (Y) is measured along the line perpendicular to the axes of both passages. The preferred value for the angle θ is 45° but somewhat larger or smaller angles can also be used.

The distance from the center of orifice 21 to the downstream surface 20 should not exceed the diameter of pas-

sage 17. A greater distance would tend to diminish the swirling motion of the combined streams of polymer at exit orifice 22 due to increased frictional loss along the wall of the passage 17. The degree of crimp imparted to the emerging filament would accordingly be reduced.

As above indicated, the invention is particularly applicable to the production of the ultramicrocellular filaments described in Blades et al. U.S. Patent 3,227,664, filed Jan. 31, 1962. These filaments are formed of a crystalline organic polymer and contain at least 10^3 cells/cc., and the average transverse dimension of individual cells is ordinarily less than about 1000 microns in the expanded state. Substantially all of the polymer in these filaments is present as film-like cell-walls less than 2 microns thick, and preferably less than 0.5 micron thick. The thickness of a cell-wall, bounded by intersections with other walls, does not ordinarily vary by more than +30%; and adjacent walls commonly are of nearly equal thicknesses, usually within a factor of 3. Moreover, the polymer in the cell walls exhibits uniplanar orientation and a uniform texture, as fully defined in the aforementioned patent. Ultramicrocellular materials, when fully inflated, have densities in the range from 0.005 to 0.05 gm./cc.

In accordance with one embodiment of the invention, such an ultramicrocellular filament is produced in the form of a novel crimped filament. The crimp is defined by a random, three-dimensional, curvilinear configuration having an extended to free length ratio in excess of 1.2, preferably in excess of 1.5. FIGURE 4 shows the crimped configuration of several such filaments produced in accordance with the invention.

The crimped ultramicrocellular filaments have the advantage that more uniform batts or webs thereof, e.g. for cushioning or packaging applications, can be fabricated than would be the case with straight, essentially uncrimped ultramicrocellular filaments. Particularly unique is the fact that crimping thereof is accomplished concomitantly with spinning.

The extended to free length ratio, or Le/Lf ratio, for the crimped ultramicrocellular filaments is determined as follows. An ultramicrocellular filament is put under just enough tension to straighten it out and five segments are cut therefrom, the length, Le , of each being 20 times the filament diameter. Next, the end-to-end length of each segment is measured in its free, i.e. no tension, configuration, Lf . The ratio of Le/Lf for each of the several segments is calculated and then averaged.

Process elements leading to the above-described ultramicrocellular filaments are more fully described in Blades et al. U.S. Patent 3,227,784, issued Jan. 4, 1966, the disclosure of which is also incorporated herein by reference. According thereto there is first formed a solution containing a high molecular weight, synthetic, crystallizable polymer, and an activating liquid. Optionally, there may be included an impermeant inflatable such as perfluorocyclobutane so as to increase the pneumatic properties of the resultant filament. The solution, maintained at a temperature above the boiling point of the activating liquid and at a pressure substantially above atmospheric pressure, is extruded through a filament-forming orifice into a region of lower pressure and temperature, normally room temperature at about one atmosphere. Immediately upon extrusion into the low pressure and temperature region, substantially all of the activating liquid evaporates adiabatically. As a result, a large number of tiny vapor bubbles, usually at least about 10^5 bubble nuclei per cc., are created in the solution and sufficient heat is absorbed to lower the temperature of the confining polymer below the polymer melting point. This step occurs very rapidly, usually in less than 10^{-2} seconds, and therefore effectively freezes-in the molecular orientation generated in the polymer cell walls during the bubble expansion. In some cases, a bubble "nucleation assistant" is desirably included in the polymer solution to increase the number of bubbles and the number

of resulting cells by increasing the internal pressure and lowering the surface tension of the solution.

In accordance with this invention, the above-described spinning process is operated in such a way that there are formed first and second streams of the polymer solution, the streams converging then just prior to issuing into the low temperature and pressure region. At the point of convergence the second stream tangentially intercepts the first stream to thereby impart a spiral motion to the solution just as the filament is formed.

The invention will be further described by the following example.

EXAMPLE

A polymer solution is prepared by mixing equal weights of molten stereo-regular polypropylene (Hercules "Profax 6823" melt flow of about 0.4, determined according to ASTM-D-1238-62T, condition L) and a liquid composed of 80% methylene chloride and 20% by weight of perfluorocyclobutane. There is also included in the mix 0.3% by weight of finely divided silica aerogel, based on polymer weight, as a bubble nucleating agent. The mixing is carried out continuously in a torpedo mixer of 2" diameter and 35" length with the total flow of mixture amounting to 40 lb./hr. with the torpedo rotating at 80 r.p.m. and the mixture at 150° C. A portion of the solution is fed into a spinneret assembly of the general type shown in FIGURES 1 to 3 where it first passes through a sand filter of 2.0" depth and 5.2 cu. in. volume. The sand is of a size that would pass through a 40-mesh screen but not through a 60-mesh screen. The filtered spinning solution is supplied to the face of the spinneret plate at a constant pressure of 1100 p.s.i.

Using the same polymer solution, a comparison is made between the product extruded from a conventional spinneret plate having a single, square-edged cylindrical passage of diameter 0.015", length 0.060" and the product from a similar spinneret plate that is modified in accordance with this invention. In the modified spinneret plate, a second passage of 0.020" diameter is drilled at a 45° angle so as to tangentially intersect the vertical .015" x .060" passage, but it does not reach the downstream face of the spinneret plate. The axes of the two passages are separated a distance of .012" at their nearest approach and the center of the hole or juncture formed by their intersection is 0.015" from the downstream face of the spinneret plate.

The products formed when the polymer mix is extruded into the atmosphere from the two different spinneret plates are in each case smooth-surfaced, continuous ultramicrocellular filaments of circular cross-section and about 0.10" in diameter. The filament from the unmodified spinneret plate is straight and stiff, so that when collected as a batt on a moving table, small sections of it tend to lie parallel in an array that presents an uneven appearance. It thus accumulates with a bulk density of approximately 0.34 lb./cu. ft. The product from the modified spinneret plate emerges in a 3-dimensional crimped configuration, averaging about 150 degrees of curvature per inch and has an Le/Lf ratio of 1.82. This curvature is in randomly varying directions, so that the product piles up with a bulk density of only about 0.15 lb./cu. ft. when collected in the same manner as above and it has a much more uniform appearance than the product from the unmodified spinneret plate.

Thus, the modification greatly improves the utility of the ultramicrocellular filament for cushioning and packaging applications.

What is claimed is:

1. A spinneret plate for producing crimped filamentary material, said plate having upstream and downstream surfaces and containing at least one filament-producing orifice in its downstream surface, a first passage extending from said upstream surface fully through said plate and terminating at said orifice, and a second passage in said plate extending from said upstream surface

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and tangentially communicating with said first passage near said downstream surface but terminating short of said downstream surface, the distance between axes of said passages being in the range of about $0.3 (R_1 + R_2)$ and $0.85 (R_1 + R_2)$, wherein R_1 is the radius of the first passage and R_2 is the radius of the second passage, the axis of said second passage forming an acute angle with said upstream surface.

2. A spinneret plate according to claim 1 wherein R_2 is greater than R_1 .

3. A spinneret plate according to claim 1 wherein said angle is about 45° and the ratio of R_2 to R_1 is about 1.33 to 1.

4. A spinneret pack assembly comprising a filter block and a spinneret plate in stacked relationship, said plate having upstream and downstream surfaces and containing at least one filament-producing orifice in its downstream surface, a first passage extending from said upstream surface fully through said plate and terminating at said orifice, and a second passage in said plate extend-

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ing from said upstream surface and tangentially communicating with said first passage near said downstream surface but terminating short of said downstream surface, the distance between axes of said passages being in the range of about $0.3 (R_1 + R_2)$ and $0.85 (R_1 + R_2)$, wherein R_1 is the radius of the first passage and R_2 is the radius of the second passage, the axis of said second passage forming an acute angle with said upstream surface.

References Cited

UNITED STATES PATENTS

3,014,237	12/1961	Breen	18—8
3,117,906	1/1964	Tanner	18—8
3,244,785	4/1966	Hollandsworth	18—8
3,262,153	7/1966	Mercer et al.	18—8

FOREIGN PATENTS

29,467	1964	Germany.
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