Nov. 3, 1970 P. D. HANN 3,538,206

METHOD FOR FORMING FILAMENTS AND PRODUCED THEREBY

Filed June 27, 1966 2 Sheets-Sheet 1

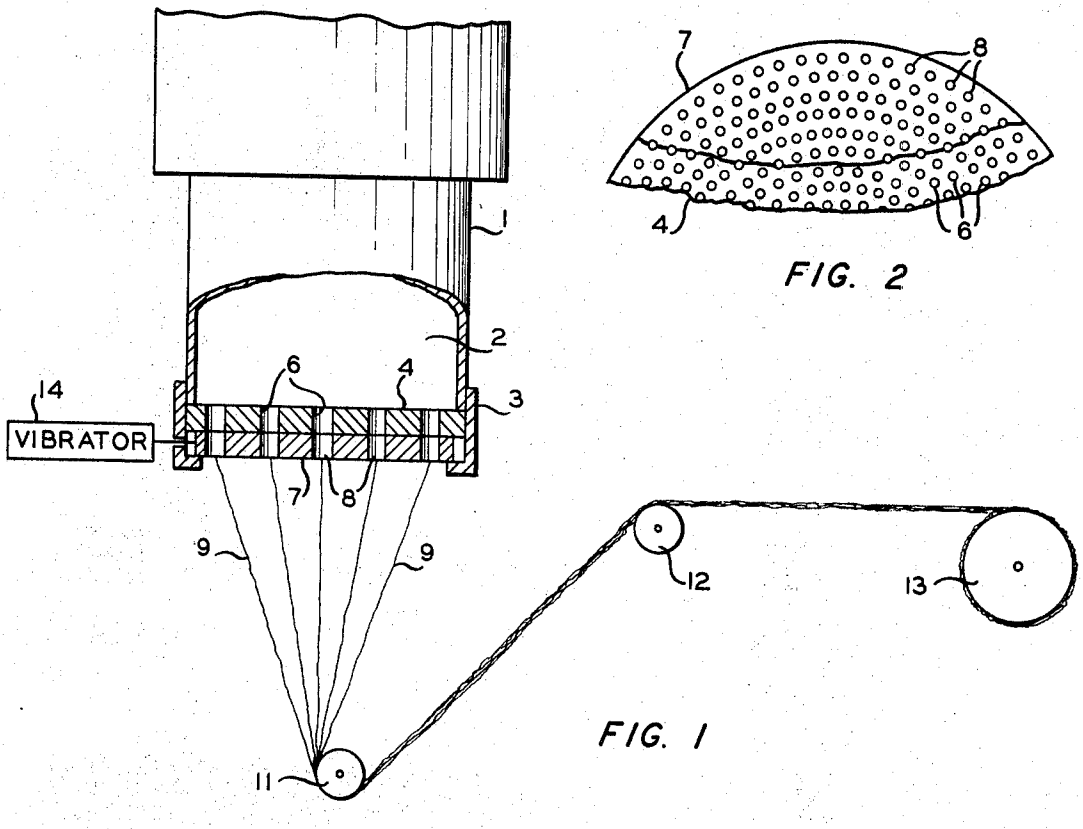


FIG. 1

FIG. 2

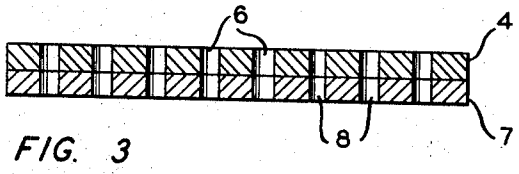


FIG. 3



FIG. 3a

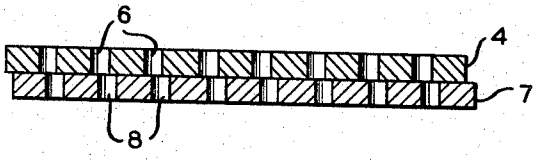


FIG. 4

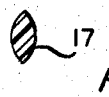


FIG. 4a

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METHOD FOR FORMING FILAMENTS AND PRODUCED THEREBY

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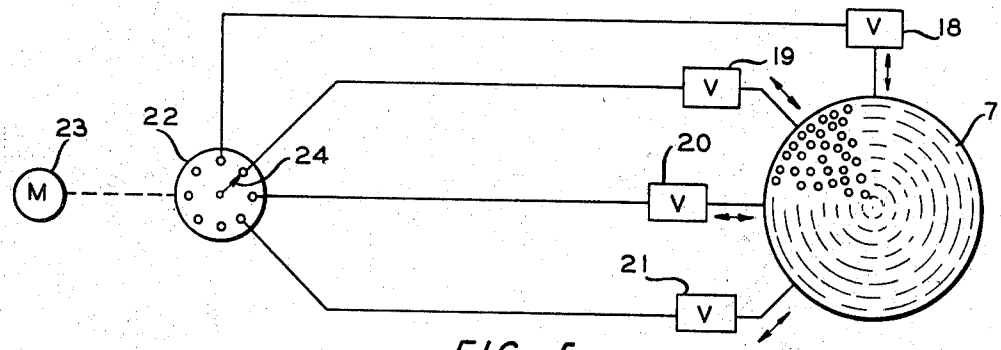


FIG. 5

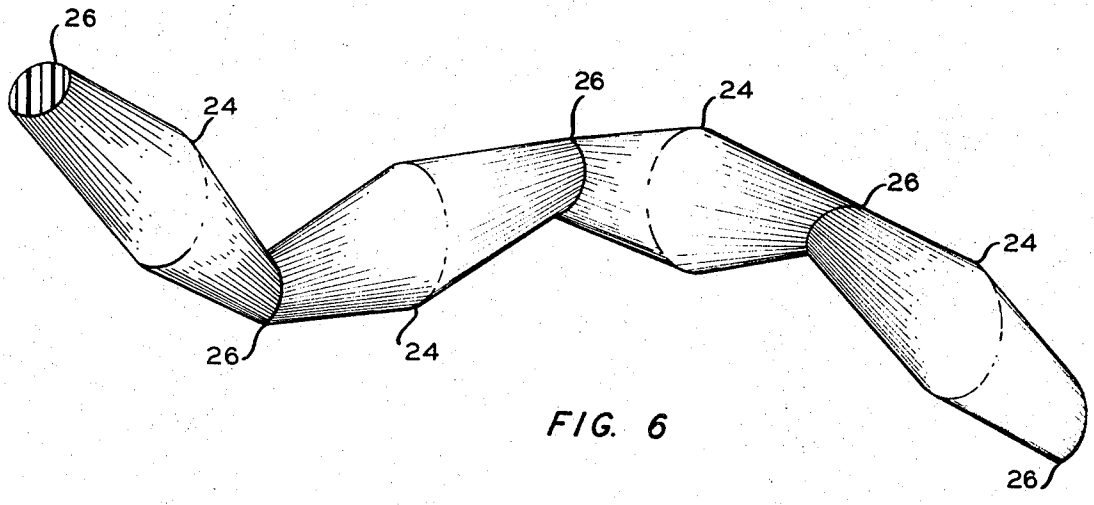


FIG. 6

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3,538,206

METHOD FOR FORMING FILAMENTS AND PRODUCT PRODUCED THEREBY

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Int. Cl. D01d 5/20, 5/22
U.S. Cl. 264—70 4 Claims

ABSTRACT OF THE DISCLOSURE

The invention pertains to a method of producing filaments of varying cross-sectional area. The filaments are produced by extruding material through a spinnerette comprising a plurality of plates, at least one of which is vibrated.

This invention relates to methods and apparatus for producing filaments. In one aspect, this invention relates to methods and apparatus for producing filaments of particular cross-section. In another aspect, this invention relates to filaments of varying cross-sectional configuration, and to yarns formed therefrom.

In the formation of filaments by extruding a molten material through a spinneret, it is known to impart vibrations to the spinneret for the purpose of establishing sinuous stresses in the individual filaments. It is stated that the sinuous stresses cause the filaments to contract and thus become crimped. While these stresses are apparently effective for this purpose, the cross-sectional configuration of the filaments cannot be controlled and thus remains substantially unchanged throughout the length of the filaments.

According to this invention, filaments having a varying cross-sectional area are produced by extruding a filament-forming material through an extrusion head in the form of a spinneret which includes a first plate having a plurality of orifices and a second plate in register with the first plate and having a plurality of orifices in register with the orifices in the first plate. The orifices in the first and second plates serve as passageways through which the material is extruded to form the filaments. A vibration means connected to one of the plates is actuated to impart movement to the plate to vary the cross sectional area of the passageways during extrusion of the organic material. This causes the passageway to change in cross-sectional area from circular to marquise or navette in an alternate manner. While it is within the spirit and scope of the invention to impart the vibrations from a single direction only, it is preferred to vibrate one of the plates successively and repeatedly from a first direction for a first period of time, from a second direction offset from said first direction about 45 degrees for a second period of time, from a third direction offset from said first direction about 90 degrees for a third period of time, and from a fourth direction offset from said first direction about 135 degrees for a fourth period of time. This technique for imparting the vibrations to the plate produces filaments having alternate zones of circular and marquise cross section wherein the major axis of the marquise in the several zones of marquise cross section lie in different planes. When the vibrations are imparted to the plate from the directions described above, the major axes of the marquise in the several zones will be offset by about 45 degrees between adjacent zones. If desired, the plate can be vibrated from different directions varying by amounts other than 45 degrees or from different directions at random. This produces filaments wherein the plane of the major axes of the marquise in the zones of marquise cross section are offset by different angular amounts of randomly. It is also within the spirit and scope of the invention to vibrate both plates at the same time from different directions and to vary the direction of vibration of either plate in measured amounts or at random.

The filaments formed in accordance with this invention tend to bend along the major axis of the smallest marquise in the zones of marquise cross section. This phenomena results in a curled filament which has a high degree of crimp or bulk. When the individual filaments from the spinneret are bunched to form a tow and eventually a yarn, the random and highly crimped or curled configuration of the filaments prevents packing and results in a highly bulked yarn.

Accordingly, it is an object of this invention to produce filaments having a varying cross-sectional area. Another object of this invention is to provide a method for producing filaments. A further object of this invention is to produce a highly crimped or curled filament. These and other objects of the invention will become apparent to one skilled in the art after studying the following detailed description, the appended claims, and the accompanying drawings wherein:

FIG. 1 illustrates an apparatus partly schematic and partly in cross section according to the invention;

FIG. 2 is a partially broken plan view of a spinneret constructed in accordance with the invention;

FIG. 3 is a cross section of a spinneret of the invention with the passageways aligned to produce a filament having a circular cross section;

FIG. 3*a* is a cross section of a filament formed by passing through the spinneret with the passageways in the position illustrated by FIG. 3;

FIG. 4 is a cross section of the spinneret with one plate offset for producing a filament of marquise cross section;

FIG. 4*a* is a cross section of a filament formed by passing through the spinneret with the passageways in the position shown by FIG. 4;

FIG. 5 is a plan view of one plate of the spinneret with a schematic illustration of a vibration means including a switch means for controlling the vibration means in a predetermined manner; and

FIG. 6 is a schematic illustration of the structural characteristics of a single filament formed in accordance with the invention.

Referring now to the drawings, wherein like reference numerals are used to denote like elements, the invention will be described in more detail. Many motors, valves, controls, switches, etc., not necessary in explaining the invention to one skilled in the art, have been omitted from the drawings for the sake of clarity.

In FIG. 1, a chamber 1 contains a filament-forming material in the form of a melt 2. An extrusion head 3 attached to chamber 1 includes a first plate 4 having a plurality of orifices 6 and a second plate 7 having a plurality of orifices 8. A plurality of filaments 9 formed by extruding the melt through the passageways formed by the orifices 6 and 8 is solidified and passed over directional rolls 11 and 12 to a take-up reel 13. A vibrator 14 is positively connected to plate 7 in a manner which will cause the plate to move in response to the vibrations from the vibrator 14. If desired, the vibrator can be attached to plate 4 and the extrusion head 3 modified slightly to allow plate 4 to be moved relative to plate 7 in response to the vibrator. Any vibrator such as an electrically energized coil or an electrical transducer such as a piezoelectric member or laminated nickel plate can be used in the practice of the invention.

FIGS. 2, 3 and 4 illustrate the two plates 4 and 7 of the extrusion head in more detail. FIG. 3*a* illustrates a filament 16 of circular cross section which is formed by extruding the melt 2 through the passageways formed by

orifices 6 and 8 when they are in the position illustrated by FIG. 3. FIG. 4*a* illustrates a filament 17 having a marquise or navette cross section which is formed by extruding the melt 2 through the passageways formed by orifices 6 and 8 when they are in the position illustrated by FIG. 4. As plate 7 alternates between the positions illustrated by FIGS. 3 and 4 in response to the vibratory energy applied thereto, the filaments formed by extrusions through the passageways will have alternate zones of circular and marquise cross section.

In FIG. 5, each of a plurality of vibrators 18, 19, 20 and 21 is connected to plate 7 in a manner which will allow the plate 7 to be vibrated from several different directions. A multipoint stepping switch 22 driven as desired by motor 23 will transmit electrical current from a suitable source (not shown) to each of the vibrators as contact arm 24 rotates and engages each of the contact points of the stepping switch. When contact arm 24 is positioned for transmitting electrical current to vibrator 18, plate 7 will vibrate in a vertical plane as viewed in FIG. 5. As the contact arm 24 is rotated clockwise in response to motor 23, the vibrations will be imparted to plate 7 successively and repeatedly from a second direction by vibrator 19 which is offset from the vibrations obtained from vibrator 18 by about 45 degrees, from a third direction by means of vibrator 20 which is offset from the vibrations of vibrator 18 by about 90 degrees, and from a fourth direction by means of vibrator 21 which is offset from the direction of the vibrations from vibrator 18 by about 135 degrees. By regulating the speed of rotation of the contact arm 24, the duration of the vibrations from each of the directions can be controlled as desired.

In all cases, the major axis of the marquise which defines the cross section of the filaments is substantially perpendicular to the direction at which the plate is vibrated. Thus, by imparting the vibrations to the plate from the several different directions successively and repeatedly in the manner described, the major axis of the marquise in the zones of marquise cross section will lie in different planes. When the vibrators 18, 19, 20, and 21 are operated at random rather than in a predetermined sequence as described, the planes of the major axes of the several zones of marquise cross section will be at random.

In FIG. 6, a filament produced in accordance with this invention has a cross section with alternate zones of circular cross section 24 separated by zones of marquise cross section 26. The major axes of each of the marquise cross sections 26 are offset with respect to each other by about 45 degrees. This structural characteristic of the filament is accomplished by vibrating plate 7 from the different directions of vibrators 18, 19, 20, and 21. When a single vibrator is employed and the plate vibrated in one direction only, the cross-sectional configuration of the filament will alternate between circular and marquise with the major axes of the marquise occupying the same plane.

The cross-section of a synthetic filament produced in accordance with this invention alternates between circular and marquise. In a preferred form of filament structure, obtained by vibrating the plate from different directions at random, the major axis of each of the several marquises lies in randomly different planes. The area of the smallest marquise cross section is preferably at least about one-half or more of the area of the circular cross section.

The area of the zones of circular cross section of a synthetic filament produced in accordance with this invention can be represented by the equation

$$\pi r^2$$

where r is the radius of the circle defining the filament. The area of the zones of marquise cross section can be represented by the equation

$$\pi r_1^2 - 2\left(y\sqrt{r_1^2 - y^2} + r_1^2 \arccos \frac{y}{r_1}\right)$$

where r_1 is the radius of the arc of the marquise defining the filament, y is one-half the major axis of the marquise, and the radius r of the circle is the same as the radius r_1 of the marquise.

Any suitable filament-forming material can be extruded to produce the novel filament structure of this invention. Exemplary materials include polyamides, cellulose esters, polyesters, polyalkylenes, polyvinyls, and the like.

In practicing the method of this invention, the filament forming material is extruded in molten form through passageways formed by a first plate having a plurality of orifices in register with the orifices in the first plate. Vibrations are imparted to the second plate during the extrusion of the filament-forming material to vary the cross-sectional area of the passageways formed by the orifices and thus produce filaments having the varying cross-sectional configuration. The filaments are solidified as for example by cooling to a temperature below their melt temperature just as they leave the orifices in the lower plate so that the filaments will retain the produced variable cross-sectional areas. While the vibrations can be imparted at any suitable frequency, it is preferred that the vibrations be within the range of about 100 to about 15,000 cycles per second. It is likewise preferred to impart the vibrations to the plate from several different directions successively to produce a filament with a high degree of crimp or curl.

While the rate of extrusion and frequency of vibration can be coordinated and controlled to provide a high number of changes in the cross section between circular and marquise per unit length, it is desirable to coordinate these variables so as to provide an occurrence of change of at least about 10 per inch.

While any suitable denier filament can be formed by the technique of this invention, it is preferred to practice the method with filaments having a denier within the range of about 2 to about 2000.

The following example illustrates the invention. It is to be understood that the invention is not to be limited thereby.

EXAMPLE

Poly(hexamethylene adipamide) having a relative viscosity of 40 is extruded at 280° C. through the spinneret of the invention having 20 orifices of 0.020 inch diameter spaced 0.2 inch or ten diameters apart on their centers. The lower orifice plate is moved or vibrated randomly at the rate of 500 times a second to cause the filaments to issue with cross sections varying from circular to marquise. The major axis of the smallest marquise between two circular cross sections is 0.019 inch. The greatest distance between the centers of aligned orifices of the two plates is about 0.0062 inch during a vibration cycle. The filaments issue at a rate of about 250 yards per minute and are quenched with a relatively cold gas to about 100° C. The final bundle of filaments is recovered in a bulked condition, each filament being curled at the locus of the navette or marquise cross-sectional areas.

Although the invention has been described in considerable detail, it must be understood that such detail is for the purpose of illustration only and that many variations and modifications can be made by one skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. A method of producing filaments each having a varying cross-sectional area comprising extruding a filament-forming material through a plurality of passageways formed by a first plate having a plurality of orifices and a second plate, said first plate and said second plate being superimposed in the direction of flow therethrough, said second plate having a plurality of orifices in register with the orifices in the first plate to define the passageways, and imparting vibrations to the second plate during extrusion of the organic filament-forming material to vary the cross-sectional shape of the passageways while maintaining registry of at least a portion of the cross section of said

orifices at all times to produce undivided continuous filaments having a varying cross-sectional configuration.

2. A method according to claim 1 wherein the vibrations are within the range of about 100 to about 15,000 cycles per second.

3. A method according to claim 1 wherein the second plate has the vibrations imparted thereto from a plurality of directions successively.

4. A method according to claim 3 wherein the vibrations are imparted successively and repeatedly from a first direction for a first period of time, from a second direction offset from said first direction about 45° for a second period of time, from a third direction offset from said first direction about 90° for a third period of time, and from a fourth direction offset from said first direction about 135° for a fourth period of time.

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U.S. Cl. X.R.

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