APPARATUS AND PROCESS FOR PRODUCTION OF FILAMENTS

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FIG. 1.

FIG. 3.

FIG. 2.

FIG. 2a.

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APPARATUS AND PROCESS FOR PRODUCTION OF FILAMENTS

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ABSTRACT OF THE DISCLOSURE

Filament-spinning apparatus and process including a substantially coplanar row of spinning orifices adapted to spin a multitude of filaments therethrough and means on each side of the row of orifices for filaments for impinging a fluid, preferably air, onto the filaments as spun, whereby to draw the filaments wherein the impinging air emerges from slits. Means are provided for rendering the air emerging from the slits, both non-turbulent and substantially uniform in velocity from one end of the slit to the other. These means preferably include two successive channels connected to each other through conduit means with one of the channels being connected to each slit with the air being introduced into the channel furthest from the slit in order to permit the air to pass through both channels, the conduit means therebetween and the conduit means between one channel and the slit discharge opening in such manner as to emerge substantially non-turbulent and with substantially uniform velocity.

The present invention relates to the production of filaments. More particularly, the invention is concerned with the production of filaments from a melt of the material composing the filaments. In the usual manner of producing textile products, the filaments are formed in, for example, a spinning process and are collected on spools. The textile product is formed by the working of filaments withdrawn from the spools. Several attempts have been made to provide a procedure wherein the textile products are formed concurrently with the production of the filaments, so that the step of collecting the fibers on spools is eliminated. In particular, attempts have been made to produce non-woven fabrics in this manner. Thus, polymer melts have been sprayed from a spray gun onto a form provided for the production of a fabric. The resulting products are in general not satisfactory since the filaments are of low strength. Such filaments do not have a molecular orientation as is desired for the fibers. It has also been proposed to subject filament forms issuing from various discharge devices to the influence of electrical forces so that the filaments are changed to cobweb-like structures. The cobweb is then collected on a suitable form. These products do not have as high a strength as is desired.

In the previous attempts to form fabrics directly from a melt, described above, the melt outlet openings have been of the type in which is customary in customary processes. It has also been proposed to utilize smaller outlet openings and to direct air currents along the path of the melt streams issuing from the outlet openings. Electrical forces can also be utilized. The filaments are then collected on a suitable form for the desired fabric. In these prior art attempts, difficulty is encountered in the respect that as the width of the fabric is increased, the distribution and structure of the fabric tend to become non-uniform. The number of discharge devices is increased in order to increase the width and the various forces existing during production of the fleeces interact so that non-uniformity results in the product. These fabrics have the further disadvantage that the filaments thereof do not have desired molecular orientation.

Still another procedure for the production of non-woven fabrics direct from a melt is the subject of U.S. application Ser. No. 341,489, filed Jan. 27, 1964 and assigned to the assignee of the present application. In the process of that application, a spinning head is used which has a plurality of melt outlet openings disposed at spaced intervals along a straight line of any suitable length, for example a length equal to the desired width of the fabric being produced. Melt is discharged from the melt outlet openings, and simultaneously air streams generally parallel to the plane along which the melt streams move, are directed into impinging relation with the melt streams. The air streams and the melt streams enter a guide passageway which is a channel open at both ends and serves to define the path of travel of the filaments from the discharge point from the spinneret head to the form on which they are collected. The gas stream also passes through the guide passageway.

The melt streams are drawn by the gas stream into filaments and the gas stream then serves to cool the filaments to the desired extent, prior to collection thereof as a fleece. This procedure provides the desired molecular orientation, and, further, is suitable for production of fleeces of substantial width. This procedure, however, as practiced hitherto involves difficulty due to turbulence of the gas streams which results in a measure of non-uniformity. This is particularly significant in respect to the production of thin fleeces. The turbulence is due, at least in part, to the structure of the spinning devices used. The conditions of temperature and pressure require supporting members for the spinning devices which are in the path of the gas streams, and thus cause turbulence.

It is the principal object of the instant invention to obviate the disadvantages mentioned for the spinning devices just described.

The manner in which this and other objects are attained, will be best understood by reference to the following description, taken in reference to the accompanying drawings, wherein:

FIG. 1 is a cross-sectional view of the back member of the spinneret head shown in FIG. 2;
FIG. 2 is a cross-sectional view of a spinneret head according to the invention;
FIG. 2a is an enlarged view of a portion of the spinneret head shown in FIG. 2; and
FIG. 3 is a perspective view of a spinneret head according to the invention and a guide passageway, and also indicates the path of melt streams from the spinneret head.

According to the invention, the spinning device is suitable for spinning a plurality of filaments from a melt by discharging a like number of filaments from the spinneret head, drawing the streams into the filaments with a fluid, preferably a gas and commonly air or steam or air and steam. The head includes means defining a plurality of melt outlet openings for discharging the streams from the melt, and includes two slot discharge openings disposed opposite each other across the spinneret head, whereby the gas to impinging relation with the melt streams to draw the streams into the filaments. The invention is characterized in that the gas is delivered to the melt streams in a manner that low turbulence exists. The spinneret head is provided with means for delivering the gas to the slot discharge openings, and reducing the turbulence of the gas. Thus, the head can include an elongated distribution chamber for each slot discharge, which extends over the length of the slot discharge and is adapted for receiving the air for delivery to the slot discharge openings, and a passageway which communicates each of the distribution chambers.
with its slot discharge opening. The passageways have means for reducing turbulence of the fluid passed there-through to the slot discharge openings. Desirably, the passageways include directional changes and changes in cross-section. In one construction for the spinneret head, found well suited for the purposes of the invention, each of the passageways includes a length adjacent its discharge opening and terminating therefrom, which diverges towards its slot discharge opening, and each of the passageway 1.0-3.0 mm. restriction therein, the distri-

bution chamber side of the diverging length thereof, for reducing pressure of the fluid flowing through the passageway. The head is constructed such that the flow paths through the two distribution chambers and the passageways is the same. Further, the device of the invention includes an elongated filament guide passageway for receiving the filament material issuing from the melt outlet openings and guiding it on to the form on which the textile product is produced. The guide passageway is open at both ends and is disposed in spaced relation with respect to the melt outlet openings. It receives the melt streams and also has a gas brought into impinging relation with the melt streams. Referring to the drawings, as is shown in FIG. 2, a spinneret head includes a back member a, and a front member a'. The back member is shown disassembled from the spinneret head in FIG. 1.

The member a can be milled from a steel plate and includes a cone-shaped nozzle b which extends over the length of the head (see FIG. 3), and is provided along the apex thereof, at spaced intervals, with melt outlet openings m. The angle of the cone-shaped nozzle can be about 10-45°, and the apex of the cone can be cut away about 40-45°, from the apex, to provide a total discharge edge p of about 1.4-2.2 mm. height. The melt outlet openings m can be spaced 1.0-10 mm., center to center, and preferably they are spaced about 2 mm. The diameter of the melt outlet openings m can be 0.1-0.6 mm., and the melt openings are disposed along a straight line. The openings are disposed midway along the height of the edge p. The back member has a bore q leading to the melt discharge openings m. Further, the back member is milled to provide the channels e and d, as to which more will be said shortly.

The front member a' is formed of two like elements r and s, positioned one on either side of the cone-shaped nozzle b. The rear side of element r and element s of the front member a' is each milled to provide a channel z, which, when the front member and the back member are assembled, opens into one of the channels e of the back member. That is, the front member is formed to a distribution channel for receiving the gas and distributing it over the length of the slot discharge openings shortly to be described. Further, the front members r and s are provided with recesses r which, when the members are assembled, communicate the distribution chambers e, z with the channels d in the back plate, and the end portions f of the front member elements r and s are positioned and formed so that the ends f define with the cone-shaped nozzle b of the back plate two passageways disposed one on either side of the cone-shaped nozzle b, each terminating in an elongated slot g which extends over the length of the line of melt outlet openings m in the cone-shaped nozzle b. Thus, a passageway is provided from each of the distribution chambers e, z to the slot discharge openings g. Also, the ends f of the front member elements form with the cone-shaped nozzle b a length of passageway adjacent each of the slot discharge openings, terminating at the slot discharge openings, which lengths diverge towards the slot discharge openings.

The inserts j are fixedly secured in the front member elements r and s and serve as baffles to direct gas flow from the distribution chambers e, z into the channels d. Thus, the spinning head is constructed so that there are directional changes along the flow path from the distribution chambers to the slot discharge openings. Fur-

ther, the cross-section, i.e. the cross-sectional flow area, of the path from the distribution chambers e, z to the slot discharge openings g, changes. These construction features serve to reduce turbulence of the gas stream issuing from the slots g.

Also, on the distribution chamber side of the diverging length u, restrictions are disposed in the path of the gas. Thus, the lip h in each of the front member elements provides a restriction or orifice in the flow path of the gases, and, further, the distribution chamber side of the length u such that restriction h is provided. This construction causes the turbulence of gas issued from the melt outlet openings g to be low.

The number of melt outlet openings can be 160-300; more or less can also be used. The distribution channels can extend into the front and back members a distance of about 7-35 mm., and the width of the channel c can be about 10 mm. The distribution chambers are disposed parallel to the slot discharge openings g, and the flow path from one distribution chamber e, z to its slot discharge opening g is the same as the flow path from the other distribution chamber e, z to its discharge slot g, so that flow conditions along the two paths from the distribution chambers will be substantially the same.

The width of the slot discharge openings g can be 0.3 mm.

As is indicated in FIG. 3, the distribution chambers have been provided to gas inlet conduits d. A gas inlet conduit is connected to each end of one of the distribution chambers. Desirably these inlet conduits are connected to a common source of gas.

Due to the manner in which the spinning head is constructed, gas is discharged from the slot discharge openings g which is of low turbulence to the extent that improved results are realized in respect to the production of fleeces. In the passage of the gas from the distribution chambers to the slot discharge openings, a continuous change in flow velocity occurs, and a pressure drop occurs, for example a pressure drop of from 0.14 atmospheres gauge to 0.11 atmospheres gauge. This is a pressure drop of about 20% and a pressure drop in the amount of about 15-30% is desirable. In the lengths u of the passageways, the conditions of the gas are substantially the same, and, accordingly, the gases are delivered from the slot discharge openings in about the same conditions so that improved operation is realized.

As the melt streams issue from the melt outlet openings m, they are engaged by the gas streams, and over a distance of about 5 mm. from the outlet openings for the melt, the gas streams greatly extend the filaments. For example, for an outlet opening size of 400 microns, the melt streams can be drawn into filaments of 1 micron diameter and this extension takes place substantially within the distance of 5 mm. This great elongation effects a desired molecular orientation for the filaments, and is done without substantial breakage of the filaments.

The invention further provides a guide passageway s' (see FIG. 3) for the filaments. The guide passageway is open at both ends and is disposed in spaced relation with respect to the melt outlet openings m. It receives the filaments from the outlet openings and also receives the gas from the slot discharge openings g. The passageway guides the filaments on their way to the form (not shown) on which they are collected for the making of the fabric. The guide passageway can be spaced 3-8 cm., preferably about 5 cm., from the melt outlet openings m. For a length of 220 mm. for the cone-shaped nozzle b, the length of the slot discharge openings g can be about 340 mm., and the length of the inlet opening of the guide passageway s' can be about 360 mm. Preferably these elements are related in this manner, i.e. the length of the cone-shaped nozzle b is less than the length of the gas slot discharge openings, and the corresponding dimension of the guide passageway is greater than the length of the slots. The width of the inlet opening to the guide channel s' can be about 3 cm. The length of...
the guide channel is such that the elongation of the filaments is complete before the filaments leave the guide passage. As a result, far by the time a part of the expansion occurs immediately following issuance of the melt streams from the melt outlet openings, but some further elongation occurs. The filaments become set during the course of travel through the guide passage. For example, for polycaprolactam, the length of the guide passage is 50 cm. As is indicated by the arrows, some gas is aspirated from the vicinity of the spinning head into the guide passage, by reason of the movement of the gas streams from the slot discharge openings. Due to the fact that these gas streams are at the same conditions, uniform aspiration occurs, so that the aspiration effect does not cause harmful turbulence.

The amount of gas which is aspirated into the inlet opening of the guide passage will depend on the conditions, and particularly on the condition of the gas streams issuing from the slot discharge openings. For example, the gas which is called secondary air, can exceed in amount the gas streams from the slot discharge openings. For example, the secondary air can be ten times the amount of gas from the slot discharge openings. This is an important aspect of the operation of the spinning head. The secondary gas stream may contribute to the cooling of the melt streams and/or may serve to facilitate evaporation of solvent from the melt streams, whereby the solidification of the threads is effected. Further, the secondary gas streams may facilitate the obtaining of a desired water content for the fibers. Thus, the secondary stream may assist the adiabatic cooling of the gas streams from the slot discharge openings so that the desired take-up of water by the fibers is obtained. On the other hand, the secondary gas stream may be used to remove excess moisture from the fibers. Also, of course, the secondary gas streams aid in the setting of the filaments at the desired molecular orientation, and aid in the guiding of the filaments on their course through the guide passage.

It will be appreciated that the guide passage performs the important function of maintaining the individual filaments substantially out of contact with each other during the setting thereof. After leaving the guide passage the filaments are collected as a non-woven fleece on suitable forms. Substantial contacting of the different filaments does not occur until just shortly after the filaments are collected on the form. This is an important characteristic of the device of the invention, since, by reason of such operation, it is possible to obtain fibers of good uniformity.

A plurality of spinning heads according to the invention can be used together, and in such operation each spinning head is provided with its own guide channel. Further, the guide channel or channels can be rocked to provide a desired shifting of the fibers so that good intermixing of the fibers in the non-woven fleece is obtained. Where several channels are used, different melt compositions can be discharged from the various heads to produce fibers of mixed composition.

The spinning head of the invention is well suited for the spinning of polymer compositions in general. It can be used for spinning of filaments of polyamides, polyesters, polycaprolactams, polyethylene terephthalate, etc. The melt can be a solution, and the melt can contain softeners and other modifying agents. The device can also be used for production of rayon fabrics, particularly when using a collecting forming suitable for rayon, such as, for example, that illustrated in FIG. 14 or FIG. 13 of the above-mentioned co-pending application, Serial No. 341,489, filed January 27, 1964.

The spinning head is well suited for use of steam as the gas utilized to draw the filaments. Water vapor-air mixtures can also be used. The use of water vapor or steam offers the possibility of controlling the moisture content of the filaments. As is indicated above, the use of steam or water vapor-air mixture as the gas stream can be correlated with the secondary air stream which is aspirated into the guide passage in a manner as will permit close and accurate control of the moisture content of the filaments.

The spinning head of the invention provides the further advantage that the air streams supplied are substantially uniform across the entire cross-sectional flow area. Thus, the gas on each side of the filaments is at the same condition, whereas at the same time the conditions of the gas along the width of the filaments is the same.

**EXAMPLE**

Polycaprolactam (nylon 6) was spun with a spinning nozzle according to the invention, under the following conditions:

| Melt outlet openings, number | 160 |
| Melt outlet diameter, microns | 400 |
| Melt outlet spacing, center to center, mm | 2 |
| Slot discharge opening, width, mm | 340 |
| Slot discharge opening, width, mm | 0.3 |
| Nozzle temperature, °C | 225 |
| Gas mixture, air-water vapor, 10:1 | 225 |
| Gas temperature in slots, °C | 600 |
| Fiber diameter, den. | 1 |

While the invention has been described with respect to particular embodiments thereof, it will be understood that these embodiments are merely representative of the invention and do not serve to provide the limits thereof.

What is claimed is:
1. In an apparatus for spinning a plurality of filaments which apparatus comprises at least one elongated spinneret having a plurality of substantially coplanar spinning orifices therein; a pair of fluid outlet slit means on either side of said spinning orifices; means to feed polymer to said spinning orifices; and means to feed a fluid to each of said slit means; the improvement which comprises said fluid feeding means comprising a first channel means operatively connected to said slit means via conduit means; a second channel means operatively connected to said first channel means via conduit means; and means for feeding said fluid to said first channel means by fluid emitted from said slit means is at substantially the same velocity at substantially all points therealong.
2. The improved apparatus claimed in claim 1 wherein said channels are substantially parallel.
3. The improved apparatus claimed in claim 2 wherein said slit means is substantially parallel to said first channel.
4. The improved apparatus claimed in claim 1, including a multiplicity of conduit means between said first and second channels.
5. The improved apparatus claimed in claim 1, including at least one turbulence-reducing insert in said conduit means.
6. The improved apparatus claimed in claim 1, including means, at both ends of said second channel, for introducing said fluid therein.
7. In the process of producing drawn filaments which comprises issuing polymer from a row of substantially coplanar spinning orifices, impluming a fluid onto both sides of said row of filaments at a velocity higher than the filament velocity, and drawing said filaments with said fluid; the improvement which comprises passing said fluid through multiple successive channel means connected to each other through conduit means prior to impingement thereof onto said filaments which passage substantially reduces the turbulence of said fluid and makes the velocity of said fluid substantially uniform upon impingement.
8. The improved process claimed in claim 7 wherein said fluid is a gas.

9. The improved process claimed in claim 7 wherein said fluid is air.

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