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[54] PACK FOR SPINNING HETEROFILAMENT FIBERS

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[52] **U.S. Cl.** ....**425/198,** 264/176 F, 425/463
[51] **Int. Cl.** **D01d 3/00,** D01d 1/10
[58] **Field of Search**......425/462, 463, 131, 132, 133, 425/198, 199, 382 S; 264/176 F

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[57] **ABSTRACT**

A spin pack is provided for producing heterofilaments from two polymer streams. Each stream is subdivided and the subdivisions filtered and delivered to a common header. The two headers are parallel and are defined between the upper face of a spinnerette and the adjacent members. Off each header and extending toward the other are a plurality of grooves, the grooves of one header alternating with those of the other and constituting pairs or couplets. Between each pair of grooves there are a plurality of channels of precise dimensions, e.g. length of at least about 0.075 inch, width of at least about 0.016 inch and depth of from about 0.005 to 0.030 inch, and a spinning orifice is located centrally of each channel. In this fashion each orifice gets the same amount of each polymer.

9 Claims, 9 Drawing Figures

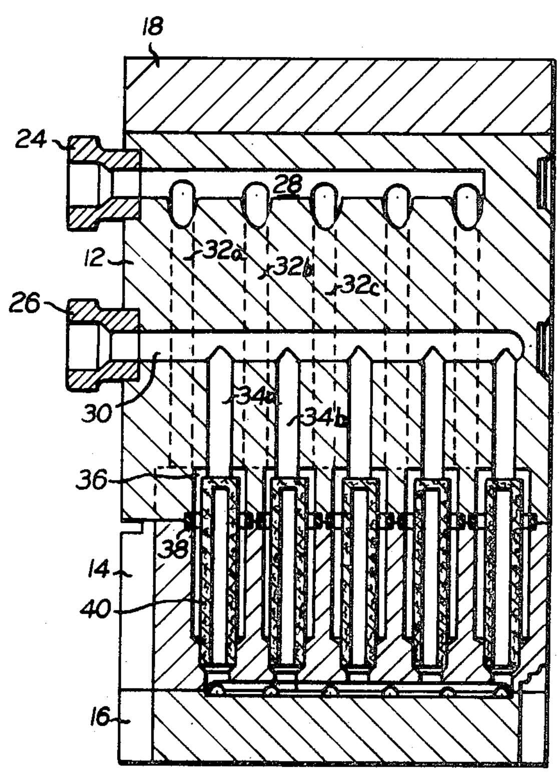


FIG. 1.

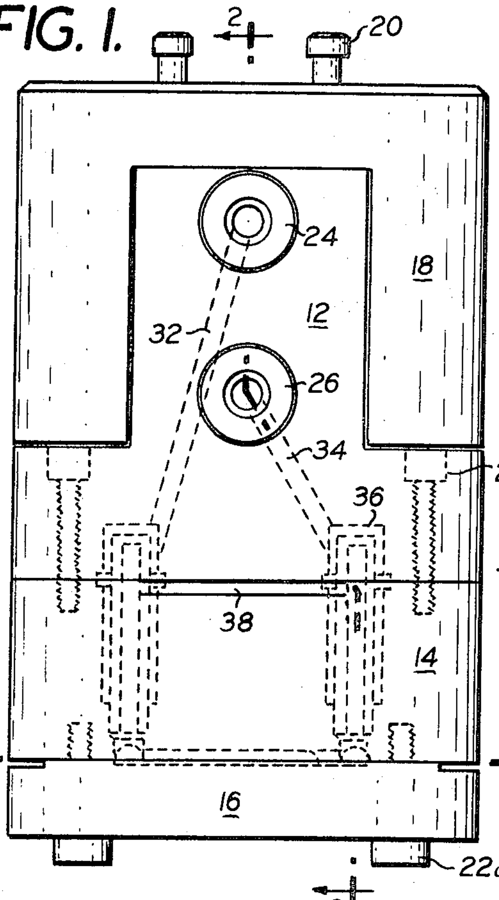


FIG. 2.

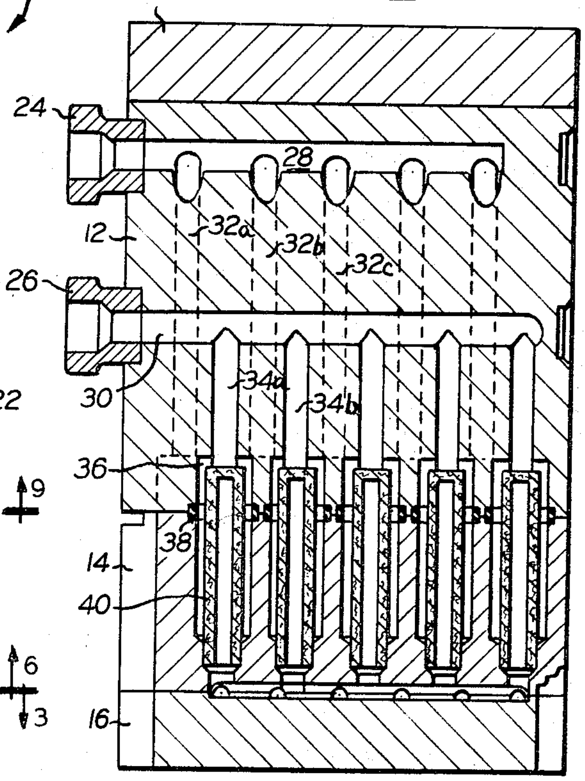


FIG. 3.

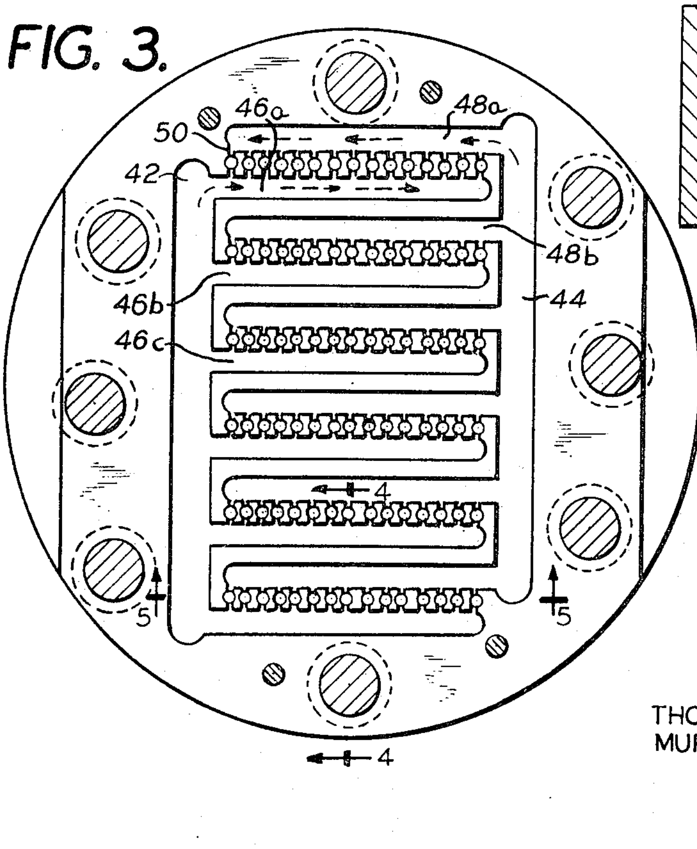


FIG. 4.

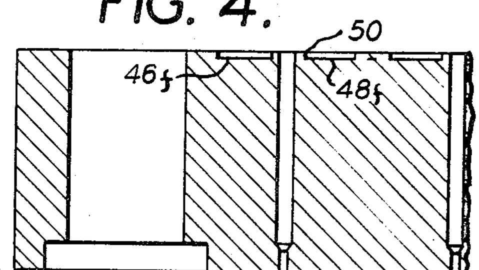
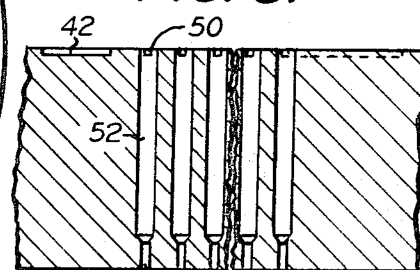


FIG. 5.



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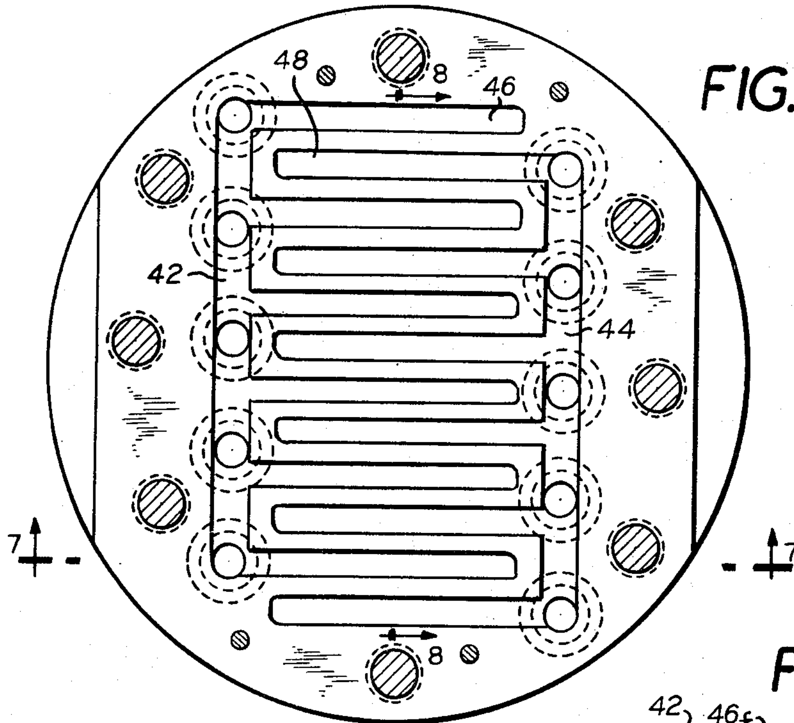


FIG. 6.

FIG. 7.

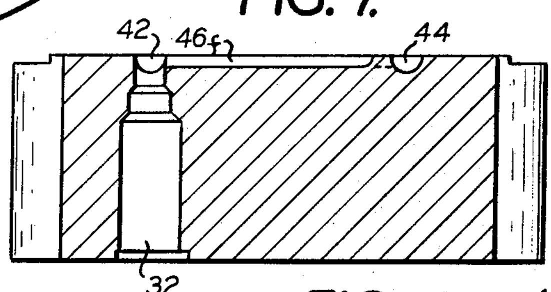


FIG. 8.

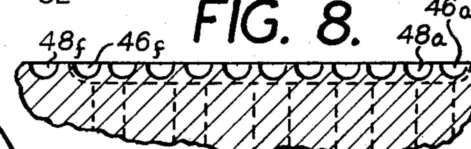
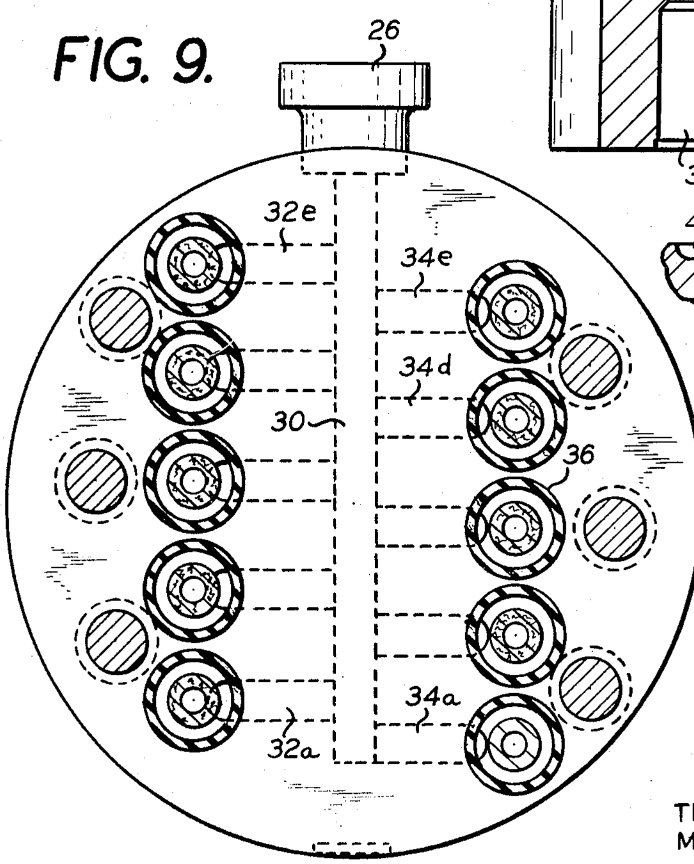


FIG. 9.



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PACK FOR SPINNING HETEROFILAMENT FIBERS

The present invention relates to an apparatus for the production of large numbers of uniform heterofilaments.

In the production of synthetic fibers it has proven desirable to produce filaments which are not homogeneous in cross-section. Rather, filaments having zones of different composition in cross-section have proven desirable for certain purposes. Thus, the zones may differ in color, in chemical composition, or the like. If the components are sufficiently different in physical properties, for example, they will frequently shrink non-uniformly during the post-treatment and the resulting filament will no longer be straight. Alternatively, the different composition may result in some zones becoming tacky at elevated temperatures at which the other zones are unaffected so that the filaments can be bonded to one another or a substrate without complete loss of tenacity. In still another possibility, one zone may accept a dye while the other does not.

The different zones are generally more or less well-defined and while there may be some irregularity along the interface they generally fall into the two major categories side-by-side and sheath core. In side-by-side heterofilaments each component is partially on the outside of each filament while in sheath core one component surrounds the other. Side-by-side heterofilaments are produced by bringing the two fiber-forming streams together at some point upstream of the spinnerette orifice and allowing them to issue together. Sheath-core heterofilaments can be produced by surrounding one stream by the other and directing the compound-stream to the spinnerette orifice. Alternatively, it is sometimes possible to produce sheath-core heterofilaments by side-by-side extrusion if the temperature and viscosity conditions are such that upon issuing under the influence of surface tension the less viscous material flows and surrounds the more viscous component.

In such side-by-side extrusion, whether the ultimate filaments are side-by-side or sheath-core, it has not proven too difficult to spin more than one filament, using a plurality of orifices arranged in a circle and supplied with polymers from sources equidistant from all the orifices. If such distances are not equal, the distribution of each polymer to the several orifices will vary, e.g., while the overall composition of polymers A and B may be 50—50, some filaments may be 100%A, 80%A, 40%A or 0%A. For most purposes such variation is undesirable.

If the arrangement of spinning orifices is rectilinear rather than circular, the problem of uniformity of distribution is especially pronounced. Those orifices most remote from a feed duct will have the lowest pressure and they are found to produce filaments which differ markedly from the average in denier as well as in composition.

When it is desired to spin large numbers of filaments the foregoing problems are aggravated since there is a limit to the number of orifices which can be provided in a circular locus and the problems of non-uniform pressure drop in rectilinearly arranged orifices is especially pronounced as the number of orifices increases.

The problems are further aggravated when the proportions of the polymers are far from equal, i.e., when one is present in two or three times the amount of the other.

It is accordingly an object of the present invention to provide an apparatus for producing heterofilaments of interfilament uniformity.

It is a further object of the invention to provide an apparatus for extrusion of a plurality of two component side-by-side fiber-forming streams.

A further object is to provide a simple apparatus of such type wherein the number of filaments can be varied easily and inexpensively.

Still another object is to provide a process for simultaneously producing many heterofilaments of interfilament uniformity even at relatively high ratios of one of the components to the other.

These and other objects and advantages are realized in accordance with the present invention wherein there is provided a novel spin pack and especially a novel spinnerette.

The novel spin pack comprises a pack body for distribution of polymer streams, a filtration section, a further distribution system and a spinnerette for extrusion. The body is provided with a pair of inlets for receiving two fluid streams. The inlets each lead to a bore from which a plurality of passages branch off. Each branch passage includes a special filter of high capacity such as a sintered metal hollow body through whose wall polymer must flow, the effective surface area and pore size being selected to give a predetermined pressure drop and degree of filtration. The individual filters are removable and, following cleaning, may be reused.

The pack body filtration selection are joined in such fashion that they can readily be separated for access to and removal of the filters. Advantageously, a gasket is provided to improve the seal about each passage.

From the multiple passages associated with each bore, the multiple streams enter a header bounded by and defined between the filtration section and spinnerette. The header can be gouged out of either or partially out of both the filtration section and the upper face of the spinnerette. Its cross-sectional area is not critical so long as it is relatively uniform and several fold greater than that of subsequent passages through which the polymer streams must later flow.

From the header a plurality of grooves extend, also defined between the filtration section and spinnerette and gouged in whole or in part out of either. The groove cross-section is also not critical. The number of grooves off each header will generally be equal to the number of bundles into which it may be desired to group the filaments ultimately obtained, e.g., if six bundles of filaments are desired there could be six, 12, etc., grooves. The number of passages leading to each header is independent of the number of grooves leading away from each header. The number of grooves off both headers are equal, each groove off one header forming a pair or couplet with a corresponding groove off the other, i.e., the grooves off one header extend toward, but terminate short of, the other like a ladder whose rungs are incomplete alternately at each end.

Between each pair of grooves a plurality of channels extend and their dimensions are the most important feature of the invention. These channels are also defined between spinnerette and filtration section and they are equal in number to the number of filaments to be produced. For this reason they are preferably gouged out of the upper face of the spinnerette, i.e., if it is desired to change the number of filaments being spun, it is necessary to change only the spinnerette without disassembling more of the spin pack. The channels should be arranged substantially uniformly along each groove except that the dead end of each groove desirably extends somewhat past its last channel to ensure that the last channel is not accidently of different length from the others.

The channels should be at least about 0.075 inch long and preferably at least about 0.150 inch long. Their depth into the spinnerette face should be at least about 0.005 inch and preferably at least about 0.010 inch up to about 0.030 inch while their width should be at least about 0.016 inch and preferably at least about 0.032 inch up to about 0.060 inch; the cross-sectional area is advantageously about 0.000080 to 0.000960 square inch and preferably about 0.000160 to 0.000480 square inch. If this cross-sectional area is less than about 3 percent that of the grooves and headers, the extrusion will be relatively insensitive to minor variations in pressure along the grooves. Advantageously, the total cross-sectional area of the channels off a groove, i.e., the product of individual channel cross-sectional area multiplied by the number of channels per groove, is less than about 50 percent and preferably less than about 20 percent of the cross-sectional area of each groove to minimize the pressure drop along the groove from the beginning to the end of the groove. As indicated, the channels are preferably rectangular in cross-section but this is merely for ease of formation and they could be polygonal, elliptical, semi-circular, or the like.

Centrally of each channel an orifice of varying diameter so as to include at least one countersink and a capillary is drilled through the spinnerette from top to bottom. The upper section of each spinnerette is, in effect, a countersink of enlarged cross-sectional area leading into a reduced area portion (capillary) of the shape and dimension needed for the filaments. Generally the area of the orifice at the channel (i.e., the upper part of the countersink portion) will be from about 0.00125 to 0.00385 and preferably from about 0.00238 to 0.00332 square inch. These may be noncircular but are preferably circular, for ease of formation, and thus are wider than the channel at their intercept. Advantageously, the length of each channel beyond the countersink in both directions, i.e., half the channel length minus the countersink radius, is at least about 0.0075 inch and preferably at least about 0.045 inch. The length of the countersink is not significant; it should be so long relative to the thickness of the spinnerette that the portion of reduced diameter is of the length desired in view of known requirements of spinnerette orifices.

Preferably the headers are parallel to one another, the grooves are parallel, the feed channels are parallel and the orifices are parallel, said headers, grooves, channels and orifices being successively perpendicular to one another.

Advantageously, the spin pack is made of metal inert to the materials with which is comes into contact. Individual bolts may pass through all component parts to

unite them into the spin pack or individual parts may be separately fastened so that complete disassembly is not necessary to remove or replace only some of the parts.

The polymeric fiber-forming material supplied to the spin pack may be a solution or melt and the technique for forming fibers may include melt spinning, which is preferred, as well as wet or dry spinning. The fiber-forming material may include polyesters, polyamides, polyolefins, polyhaloolefins, cellulose esters, viscose, acrylics, and the like, e.g., homopolymers and/or copolymers of terephthalic acid, isophthalic acid, adipic acid, sebacic acid, ethylene glycol, diethylene glycol, butylene glycol, hexamethylene diamine, ethylene, propylene, butylene, acrylonitrile, methyl acrylate, vinyl acetate, vinylidene cyanide, vinyl chloride, vinylidene chloride, caprolactam, aminoundecanoic acid, and the like. Representative polymers include polyethylene terephthalate, polybutylene terephthalate, nylon 66, nylon 6, nylon 66-nylon 6 copolymers, polyethylene, polypropylene, polybutylene, poly-vinyl chloride-vinylidene chloride, cellulose acetate including triacetate, cellulose propionate, acrylonitrile-methyl acrylate copolymer, and the like.

The two polymer streams may differ from one another in polymer or merely in molecular weight, in pigmentation, or in any other fashion. Upon extrusion through an apparatus as described herein, the bi-component filaments will all have approximately the same composition rather than some being high in one component with others high in the second component. Thus, over a range of 3:1 to 1:1 for the two components, it has been found that at least about 90 percent of the filaments will vary by less than about 10 percent and preferably less than about 5 percent from the overall composition (i.e. if the overall composition is 50 percent Component A, then at least about 90 percent of the filaments will have from 40 to 60 percent Component A).

The resulting filaments as extruded can range in denier from as little as 3 or less to as much as 60 or more, depending upon intended use and post treatment. Generally the filaments will be drawn from about two- to 10-fold to develop their potential physical properties. The filaments may be collected as yarn or may be converted into staple fiber and spun into yarn which can be used to make fabrics and end products which may then be treated, as by immersion in hot water, to produce differential shrinkage and bulking.

The number of filaments collected into a bundle will of course depend upon the desired ultimate denier. The novel arrangement permits the filaments issuing along each groove to be grouped independently of the groups or bundles from other grooves, in contrast with generally unsuccessful attempts to subdivide the array of filaments into smaller bundles when using apparatus wherein the spinning orifices are arranged in a circle. In this fashion a single spin pack and spinnerette can be used to form a plurality of independent yarn bundles.

The novel arrangement is especially suited for use in producing spun-bond non-woven products where a relatively small number of undrawn filaments are passed through an aspirating jet wherein a fast-moving stream of fluid such as air draws the filaments down at the same time as it propels them toward a moving support. Since there is a practical upper limit to the size of the aspirating jet if the air consumption is not to be too great, this places a corresponding limit on the number of filaments which can be handled, e.g., fewer than about 40 and generally fewer than about 20. Instead of providing a spinnerette and spin pack for each aspirator, the present invention permits multiple aspirators to be supplied from a single common source. The resulting non-woven structure can then be treated in known fashion, e.g., by spot heating to activate the lower-melting polymer while leaving the other polymer substantially unaffected.

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

FIG. 1 is a lateral elevation of a spin pack in accordance with the invention;

FIG. 2 is a section taken along line 2—2 of FIG. 1;

FIG. 3 is a section taken along line 3—3 of FIG. 1, looking down;

FIG. 4 is an enlarged section taken along line 4—4 of FIG. 3;

FIG. 5 is an enlarged section taken along line 5—5 of FIG. 3;

FIG. 6 is a section taken along line 6—6 of FIG. 1, looking up;

FIG. 7 is an enlarged section taken along line 7—7 of FIG. 6;

FIG. 8 is an enlarged fragmentary section taken along line 8—8 of FIG. 6; and

FIG. 9 is a section taken along line 9—9 of FIG. 1.

Referring now more particularly to the drawings, in FIG. 1 there is shown a spinpack **10** comprising a polymer receiving section **12**, a polymer filtration section **14**, a spinnerette **16** and a cap **18**. The bolts **20** serve to secure the cap **18** to the polymer receiving section **12** and the bolts **22** serve to unite the polymer receiving section **12** to the filtration section **14**, bolts **22*a*** unite the spinnerette **16** and the filtration section **14**.

As seen in FIG. 2 one polymer stream enters the pack **10** through a coupling **24** and a second stream enters through coupling **26**. Polymer flows from the couplings **24, 26** to their respective distribution bores **28,30** and from each bore to a plurality of passages **32*a*, *b*, *c***, etc. and **34*a*, *b*, *c***, etc., all of which are identical so only one need be further described. Each passage **32** or **34** includes an enlarged chamber **36** defined by matching holes in the polymer receiving section **12** and filtration section **14** between which a gasket **38** is positioned to effect a tight seal. Preferably, there is one gasket fro each passage which gaskets may be made of materials such as Teflon or aluminum.

A hollow sintered stainless steel needle filter **40**, open at its lower end is positioned in each chamber so that liquid entering the chamber from a passage **32** or **34** must pass from outside the filter through it to be inside. From inside the bank of filters associated with each group of passages **32** or **34**, the polymer flows through the continuation of the passages into a header **42** or **44**. As can be seen in FIG. 7, these headers are parallel to one another and as can be seen in FIG. 1 they are approximately semi-circular in cross-section with their flat facing downward, being defined partially by removal of metal from the filtration section **14** and from the upper face of spinnerette **16**. The passages **32*a*, *b***, etc., and **34*a*, *b***, etc., communicate with their respective headers approximately at equal distances therealong.

As can best be seen in FIG. 3, the headers **42** and **44** have a plurality of grooves, **46*a*, *b***, etc., and **48*a*, *b***, etc., respectively. In this embodiment, the grooves are six in number and are spaced substantially uniformly along their header. The grooves **46*a***, **48*a*** form a pair between which there extend a plurality of feed channels **50**, in this case 15 between each pair of grooves for a total of 90 channels. Centrally of each channel **50** and perpendicular thereto there is drilled a spinning orifice comprising an enlarged countersink **52** at its lower end terminating in a section **54** of reduced diameter which is of such length and dimension as is necessary for producing suitable filament-forming streams of polymer.

The feed channels **50** are each at least about 0.075 inch and preferably at least about 0.150 inch long, i.e., in the vertical direction as viewed in FIG. 3. The channel width, which is the horizontal dimension in FIGS. 3 and 5, is from about 0.0010 to 0.064 inch and preferably from about 0.016 to 0.032 inch. The depth of the channels, i.e., the vertical dimension in FIGS. 4 and 5, is from about 0.005 to 0.030 inch and preferably from about 0.01 to 0.02 inch.

These channel dimensions are essential for producing the desired result, which is insensitivity to minor pressure fluctuations, or minor variations in the dimensions of the different channels. The configuration of the grooves **46** and **48** is such that thy minimize any pressure drop therealong, i.e., polymer is delivered to each channel at approximately the same pressure. Since some channels are closer to one header than to the other, it might have been expected that the relative proportions of the two polymer streams would vary from orifice to orifice along each channel but actual measurements show this does not occur. Rather, the novel configuration permits uniform delivery of each polymer to each orifice so that the filament issuing from each hole will have approximately the same proportion of each component as the overall filament bundle, i.e., ±10 percent from the overall composition.

To this end the channel dimensions must be substantially uniform so that the pressure drops will be equal. Thus, the dead ends of the grooves extend slightly past the last channel to ensure such equality of channel length.

The sintered metal needle filters provide more filtration area than could be obtained in an equivalent volume of conventional sand filter. The porosity of the filter can be selected as desired to provide the desired pressure drop and degree of filtration. Moreover, following disassembly the needle filters can be steam and/or hot air cleaned and reused.

The novel spinnerette and spin pack permit production of large numbers of uniform streams comprising two different polymers meeting along an interface. This is especially suited for making bilateral filaments such as of two different molten polymer streams. The novel configuration readily allows grouping of the filamentary streams from the orifices along each channel to form a bundle separate and distinct from the bundles of filaments from other respective channels. As noted hereinbefore, the polymer streams may differ in the chemical composition of their polymers, or both could have the same polymers but of different molecular weights, or the streams could be differently pigmented, or the like.

The invention will now be further described in the following illustrative examples.

EXAMPLE 1

A spin pack as shown in the drawings was assembled using stainless steel sintered needle filters of 10 micron porosity, the headers **42** and **44** having a cross-sectional area of about 0.0520 square inches. The grooves **46**, **48** have cross-sectional areas of about 0.0277 square inches. The feed channels **50** are about 0.175 inch lone 0.032 inch wide and 0.010 inch deep, the countersinks **52** being about 0.060 inch in diameter and 0.660 inch long, the overall spinnerette thickness being about 0.750 inch having spinnerette holes of about 0.030 inch diameter and a capillary length of about 0.090 inch. The spin pack was used to spin ninety heterofilaments of an overall composition of equal weights of a 40 relative viscosity (measured in 8 percent formic acid at 25° centigrade) nylon 66 polymer and a 35 relative viscosity copolymer comprising 35 mole percent of units of hexamethylenediamine, 35 mole percent of adipic acid units and 30 mole percent of united of epsilon-caprolactam, i.e. epsilon-aminocaproic acid. The spinning block was heated to 280° centigrade. The spinning pack fits in the block, as in a Dowtherm box, the pack being heated by heat transfer from block and from polymer. The molten polymers were fed to the pack from separate melt extruders and metering pumps. Each polymer was supplied at the rate of 3.37 pounds per hour. The filaments which issued were grouped into six bundles of 15, one bundle from each group of feed channels, and each bundle was passed through an aspirating jet having an inlet bore diameter of about 0.040 inch. The jets were positioned 12 feet below the spinnerette, thereby drawing down the filaments about 35 times to a final denier of about 6.0 each and expelling them at a linear velocity of about 2,800 feet per minute. The expelled filaments were projected toward a moving screen, depositing in the form of a non-woven web which could be collected, bonded or processed in known manner.

The individual filaments making up the web were examined in cross-section under the microscope. In 100 samples, 91 had filaments wherein neither component was present in more than about 60 percent, i.e., 50 ± 10 percent, as determined by cross-section, The individual filament tenacity in 10 samples ranged from about 1.75 to 2.50 grams per denier and averaged 2.0 grams per denier. The individual elongations in such samples ranged from about 135 to 275 percent and averaged about 200 percent.

With the particular group of aspirating jets employed, it was not possible to accommodate more than about 15 filaments and still achieve the minimum level of physical properties desired and needed in superior products.

In parallel runs with the relative proportions of the polymers at 3:1 and 1:3 by weight, cross-sectional photomicrographs showed that in each run the proportion of the major component in more than 90 percent of the filaments was 75 ± 10 percent.

EXAMPLE 2

Heterofils were spun using 1.8 pounds per hour of each of polyethylene terephthalate of 0.61 intrinsic viscosity measured in orthochlorophenol at 25°centigrade and a terephthalate of a 75–25 (by moles) mixture of ethylene glycol-diethylene glycol having an intrinsic viscosity of about 0.60. The spin pack contained a 38 micron stainless steel filter and differed from that of Example 1 in that a different spinnerette was used; the spinnerette holes were 0.015 inch diameter and 0.045 inch length. Each pair of grooves were connected by only five channels so that only 30 filaments are extruded. The header area was 0.2705 square inch; the groove area was 0.0214 square inch and the feed channel length was 0.114 inch. The spin pack temperature was 285° centigrade. The issuing filaments were passed over a finish roll and collected at 1,000 feet per minute as an undrawn yarn of 775 denier. The yarn was drawn at a ratio of 4.5 in a hot finish spray at 92° centigrade and the resulting 7.5 denier filaments had a tenacity of 3.0 grams per denier and an elongation of 45 percent. Photomicrographs showed 95 percent of the filaments to have each component present to the extent of 50 ± 10 percent.

EXAMPLE 3

A spinning pack with 90 spinnerette holes of 0.015 inch diameter by 0.045 inch length was used to spin side-by-side heterofilament fibers from a 0.61 intrinsic viscosity polyester and a copolymer of tetramethylene terephthalate with ethylene terephthalate. The copolymer was composed of 32 mole per cent tetramethylene terephthalate units and had an intrinsic viscosity of 0.60 when measured in o-chlorophenol at 25° centigrade. The pack employed contained **38** micron porosity sintered stainless steel filters, feed channels of 0.175 inch in length, 0.032 inch in width and 0.010 inch depth. The countersinks to the individual spinnerette holes were 0.060 inch in diameter and 0.705 inch in length. The spinning pack temperature was maintained at a temperature of 280° centigrade by an electrically heated block. A total throughput of 8.30 pounds per hour split equally between the two polymers was used. The fiber was cooled by a crossflow of air and wound-up at 2,000 feet per minute to yield 927 denier.

The fiber was plied together to form a heavy tow and drawn on a staple fiber drawframe. A draw ratio of 4.05 was used and hot liquid finish at 92° centigrade was sprayed onto the tow immediately after it left the feed rollers to localize the drawpoint. After crimping in a stuffer box crimper and heat-setting at 112° centigrade for 18 minutes, the fiber was cut to 1¼inch staple. The staple had a denier per filament of 3.2, a tenacity of 3.2 grams per denier and a elongation to break of 34.5 percent.

It will be appreciated that the instant specification and examples are set forth by way of illustration and not limitation, and that various modifications and changes may be made without departing from the spirit and scope of the present invention.

What is claimed is:

1. A spinnerette provided in its upstream face with
   a. a pair of independent polymer distribution headers;

b. each header being provided with a plurality of grooves, the grooves from each header being grouped into parallel pairs;

c. a plurality of feed channels extending between the grooves making up each pair, said feed channels having a length of at least about 0.075 inch, a width of about 0.016 to 0.050 inch and a depth of about 0.005 to 0.30 inch; and

d. a plurality of orifices extending through said spinnerette to the downstream face, said orifices being located centrally of said feed channels;

whereby upon supplying a different polymer stream to each of said headers, each polymer stream flows to its respective grooves and then along each channel to meet the other polymer stream midway of the channel, the streams exiting from each orifice in side-by-side relationship.

2. A spinnerette according to claim 1, wherein said feed channels have a length of about 0.150 inch, a width of about 0.032 inch and a depth of about 0.01 to 0.02 inch.

3. A spinnerette according to claim 1, wherein the orifices are circular and have a diameter of about 0.040 to 0.070 inch.

4. A spinnerette according to claim 2, wherein the headers are parallel, the grooves are parallel, the feed channels are parallel, and the orifices are parallel, the orifices being circular and having a diameter of about 0.055 to 0.065 inch, said headers, grooves, channels and orifices being successively perpendicular to one another.

5. A spin pack comprising a pack body, a plurality of filter means and a spinnerette, said pack body being provided with a pair of bores for introduction of polymer, a pair of multiple elongated passages, the passages of each of the pairs communicating at one of their ends with a respective one of the bores and at the other of their ends with said spinnerette, the filter means being separately associated with the passages making up each of the pairs so that two liquids each respectively flowing through one of the pair of passages will be filtered separately, said spinnerette being provided with a pair of independent distribution headers each to receive liquid from a respective one of the pair of multiple passages, a plurality of orifices extending through the spinnerette, and means for delivering the liquid from each of said headers to each orifice through which said two liquids issue in side-by-side relationship.

6. A spin pack according to claim 5, wherein said spinnerette is additionally provided with a plurality of grooves, the grooves communicating at one end with one header, the grooves from each header being grouped into parallel pairs, and a plurality of feed channels extending between the grooves making up each pair, said feed channels having a length of at least about 0.075 inch, a width of about 0.016 inch to 0.048 inch and a depth of about 0.005 to 0.030 inch, said orifices being located centrally of said feed channels.

7. A spin pack according to claim 6, wherein said feed channels have a length of about 0.150 inch, a width of about 0.032 inch and a depth of about 0.01 to 0.02 inch.

8. A spin pack according to claim 5, wherein said filter means comprise a sintered metal filter associated with each passage.

9. A spin pack according to claim 7, wherein said filter means comprise a sintered metal filter associated with each passage, and wherein the headers are parallel, the grooves are parallel, the feed channels are parallel, and the orifices are parallel, the orifices being circular and having a diameter of about 0.040 to 0.070 inch, said headers, grooves, channels and orifices being successively perpendicular to one another.

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