

April 30, 1968

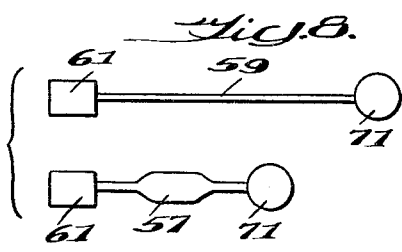
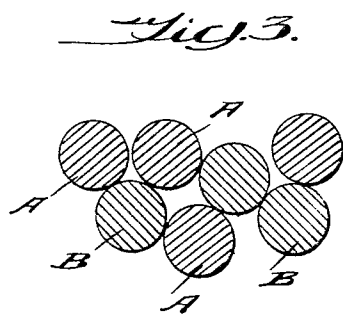
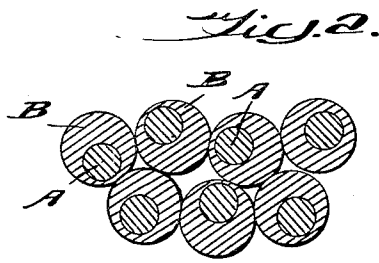
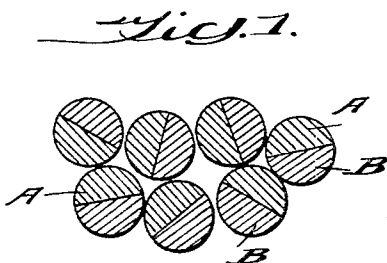
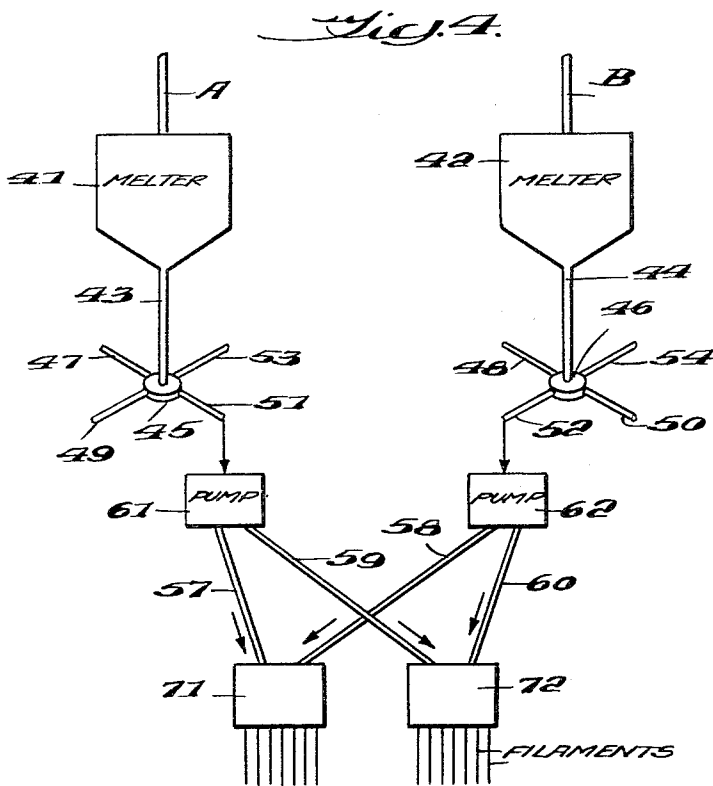
J. C. BRYAN ET AL

3,381,074

PROCESS FOR SPINNING BICOMPONENT FILAMENTS

Original Filed Nov. 4, 1963

3 Sheets-Sheet 1



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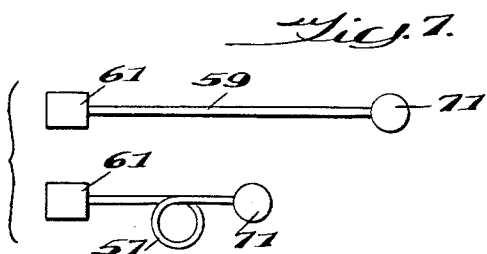
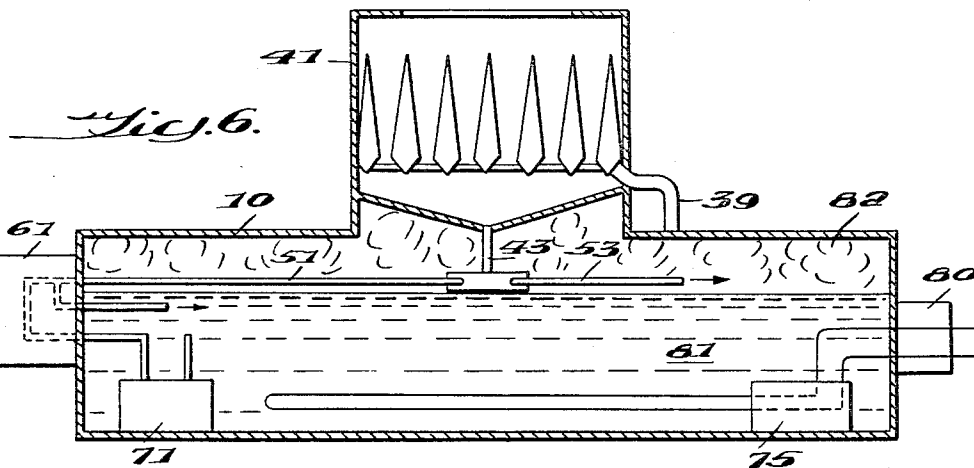
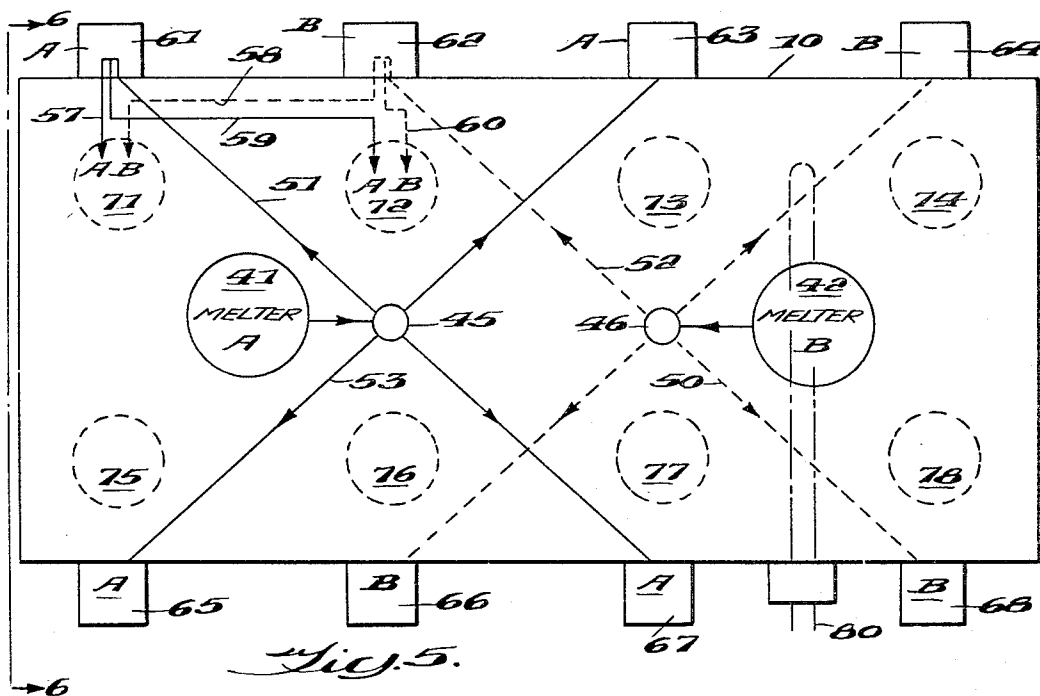
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PROCESS FOR SPINNING BICOMPONENT FILAMENTS

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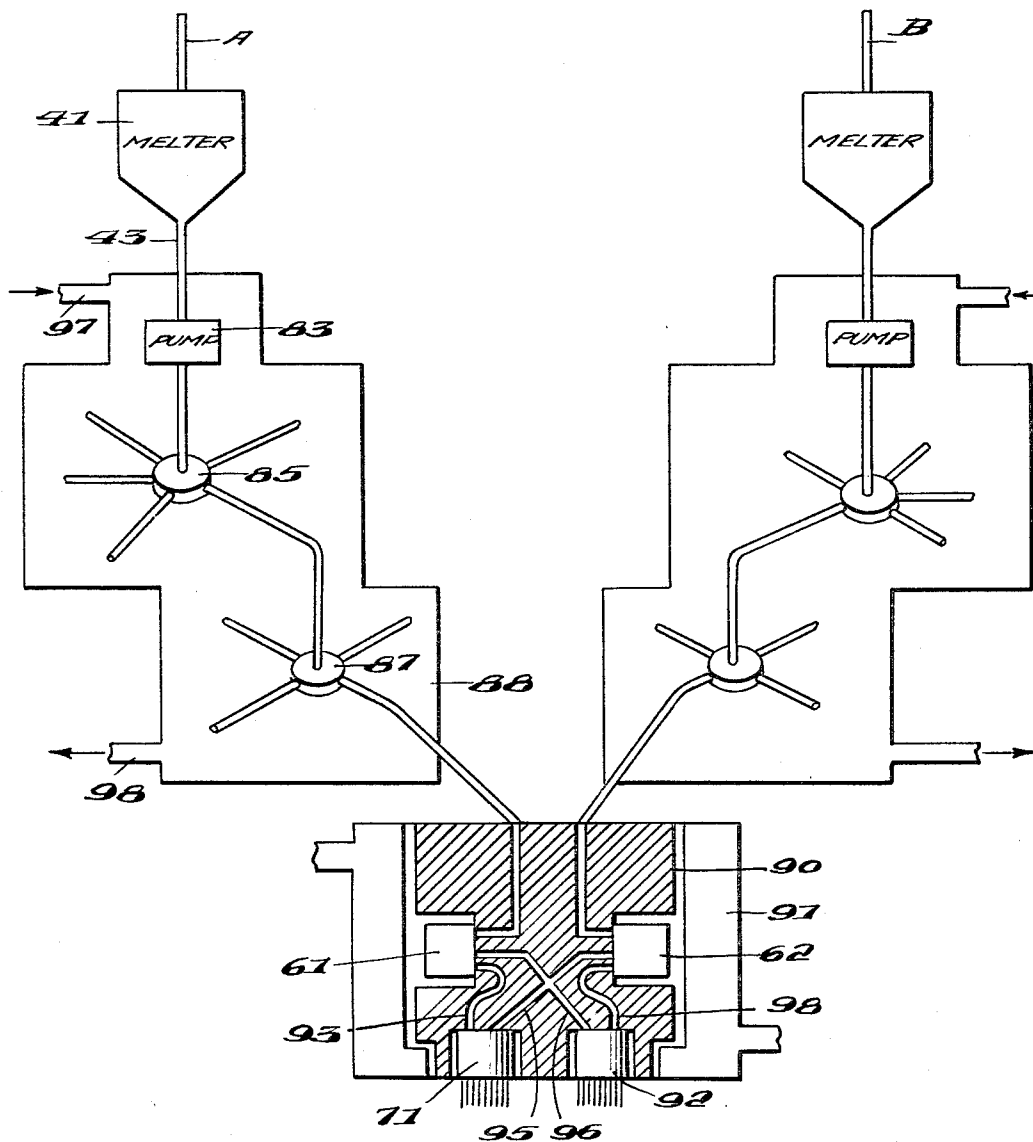
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Fig. 9.



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PROCESS FOR SPINNING BICOMPONENT FILAMENTS

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Application Nov. 4, 1963, Ser. No. 332,320, now Patent No. 3,200,440, dated Aug. 17, 1965, which is a continuation-in-part of abandoned application Ser. No. 245,195, Dec. 17, 1962. Divided and this application May 19, 1965, Ser. No. 456,922

3 Claims. (Cl. 264—171)

ABSTRACT OF THE DISCLOSURE

A method for melt-spinning composite fibers having improved quality, uniformity and the like which in general includes the steps of melting a fiber-forming polymeric material in a continuous stream, subdividing the stream, maintaining each portion under like temperature for an equal length of time, and delivering each portion to a predetermined point of entry to several melt-spinning spinneret assemblies, while simultaneously delivering at least one other fiber-forming molten polymeric material in like manner to another predetermined point of entry to each spinneret assembly.

This application is a division of our copending application Ser. No. 332,320, filed Nov. 4, 1963, and now U.S. Patent 3,200,440, which in turn is a continuation-in-part of our application Ser. No. 245,195, filed Dec. 17, 1962, and now abandoned.

This invention relates generally to the spinning of filaments and the like from liquid organic compositions, and more particularly to a method for melt spinning of fibers from two or more fiber-forming materials.

The art of melt spinning in which solid fiber forming material is melted and extruded has been developed during the past quarter century for conversion of polyamides, polyesters, and other synthetic linear polymers into filaments, films, and the like. Melt spinning has become a method widely used to economically produce strong, thermally stable filaments and films of very uniform quality. These products have generally been composed of a single homogeneous polymeric material.

Where it is desired to incorporate the separate characteristics of two individual polymers into a single yarn, it is frequently advantageous to spin the two polymers in such a way that each polymeric species remains separate and distinct within a different area of fiber cross-section. The resultant conjugate fibers and yarn products are well known. For example, a crimped fiber may be produced when polymers with widely different properties are melt spun in eccentric relationship in the fiber cross-section. Or, a polymer of great tensile strength may be sheathed with a skin of different properties. Fabrics with enhanced properties may be made with yarns in which the individual filaments are composed of different polymers, the intermingling of the filaments of different polymers is more intimate when they are spun simultaneously from a common spinneret rather than being made from separate yarns. Spinneret assemblies for extruding such filaments from separate solutions or melts have been described in U.S. 2,386,173, U.S. 3,006,028, and others. The prior art, however, does not seem to have recognized the need for or advantages of conducting the process under such conditions as to impart a uniform thermal history to all the material delivered to a plurality of spinneret assemblies from a given polymer supply. This invention is based on the observation that creation and

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maintenance of such a uniform thermal history has an unexpected beneficial effect on the quality and uniformity of the resulting composite fibers.

It is, therefore, a principal objective of this invention to provide an improved method for supplying a plurality of molten, polymeric, fiber-forming materials at constant temperature to each of several spinning nozzles.

Another objective is to provide (a) means for melting each of several molten polymers under uniform conditions to provide melts of identical thermal history, and (b) means for subdividing the melt stream of each polymer into several equal metered streamlets for extrusion under pressure, each streamlet of melt being subjected to the same thermal history during transit from the melt source to the zone of extrusion.

A further objective is to provide a portable, unitary assembly with heating means for melt spinning from a plurality of spinnerets.

These and other objectives will become apparent in the course of the description and claims which follow.

Thermal history hereinabove and in the discussion which follows refers to a quality which takes into account both the temperature to which a given sample of a melt has been subjected in passing from one specified point to another and the time of exposure of such sample to said temperature. Thus, two samples which have been held at the same temperature and have had the same transit time are samples of equal thermal history.

The foregoing objectives of this invention are accomplished in general, by melting a fiber-forming polymeric material in a continuous stream, subdividing the stream, maintaining each portion under like temperature for the same length of time, and delivering each portion to a predetermined point of entry to several melt spinning spinneret assemblies, while simultaneously delivering at least one other fiber-forming molten polymeric material in like manner to another predetermined point of entry to each spinneret assembly. This process is accomplished by a novel unitary apparatus assembly which comprises a rectangular, box-like, pressure-tight vessel surmounted by a separate melter for each polymeric component, each melter connecting to an internal manifold conduit system which leads to metering pumps mounted on the side of the vessel, and each pump, in turn, being piped to a plurality of predetermined positions in cavities in said box-like structure which connect with spinneret assemblies on the under side. Instead of being rectangular, the box-like vessel may also have a cylindrical or other geometrical shape, to conform to the spinning machinery with which it is to be used. The unitary assembly includes a suitable heat transfer medium along with a heating means and control means for regulating the latter.

The nature of the invention will be more clearly understood by reference to the accompanying drawings, in which—

FIGURES 1, 2, and 3 illustrate cross-sections of filaments which may be produced by the method of this invention.

FIGURES 4 and 9 are diagrammatic vertical arrangements of two different embodiments of this invention, in each of which, however, are present two melting units, two spinneret assemblies and intermediate distributing systems (including distributors, pumps and conduits), which transport the melts from the melting units to the level of the spinneret assemblies.

FIGURE 5 is a top view and FIG. 6 is a side view of a preferred apparatus of this invention.

FIGURES 7 and 8 are diagrammatic side views of two equivalent modifications for achieving equal transit time (or "dwell") between any of the metering pumps and the spinneret assemblies which it feeds.

Referring to FIGS. 1, 2, and 3, these are idealized cross-sections of yarn made from two different components, A and B. In the filaments of FIGS. 1 and 2, both components are present in each filament. The filament of FIG. 1 in which the components are in juxtaposition with the cross-section are the result of bringing together a molten stream of each of two polymers as they extrude together through a spinneret capillary. In the filaments of FIG. 2, polymer A is extruded as an eccentric core within polymer B. The yarn of FIG. 3 is comprised of filaments of polymer A intermingled with filaments composed of polymer B. The fiber components used in making these yarns may include any melt spinnable fiber-forming material including linear polyamides, e.g., poly(ϵ -caproamide), poly(hexamethylene adipamide) or those derived from bis(1,4-aminocyclohexyl)methane and azelaic, sebacic or dodecanedioic acid, polyesters, e.g., polyethylene terephthalate or poly(hexahydro-p-xylylene terephthalate), polyolefins, e.g., polyethylene or polypropylene, glass and others. Although shown in circular cross-section, fibers of these types may be made with other geometric cross-sections, such as oval, trilobal, or multilobal, or with completely irregular transverse sections.

Spinneret apparatus for producing composite or side-by-side fibers from separate materials, as shown in FIG. 1, are described by Kulp in U.S. 2,386,173, and by Calhoun in U.S. 3,006,028. Similarly, chambered spinneret assemblies for feeding spinning materials to spinneret orifices for simultaneous extrusion of filaments of different compositions, as in FIG. 3, are disclosed in Taylor et al. U.S. 2,398,729. With the method and apparatus of this invention, however, several such spinneret assemblies can be supplied continuously with the necessary fiber-forming materials of uniform quality and at constant temperature.

The manner of delivering two fiber-forming spinning materials to two spinnerets, according to this invention, is shown in FIG. 4. A solid, granular polymer, A, is fed to a melting device 41 such as a grid melter or screw extruder, or melt may be withdrawn directly from a polymerizer vessel. A molten polymer stream passes from the melt source through a conduit 43 to a distributor 45, where it subdivides into smaller equal streams and enters into conduits 47, 49, 51 and 53 of approximately equal internal diameter and length. The polymer stream passing through conduit 51 enters metering pump 61, where it is again subdivided and metered into passages 57 and 59 of approximately equal volume which discharge into the same relative position in the spinneret assemblies 71 and 72, respectively. A second polymer B reaches spinneret assemblies 71 and 72 by a similar route, the melt from melter 42 passing through conduit 44 to distributor 46, subdividing into smaller streams, one of which passes through conduit 52 to pump 62 from whence it is metered through interconnecting passages 58 and 60 to the spinneret assemblies. In similar fashion, the other polymer streams 47, 48, 49, 50, 53 and 54 are distributed through passages, pumps, and spinnerets which have not been shown. The entire system of the diagram of FIG. 4 would supply each of eight spinneret assemblies with metered streams of two different fiber-forming materials. The entire system from melters to spinneret assemblies is immersed in a constant temperature heat transfer medium, as shown in FIG. 6.

By this method, each of several melt spinning spinneret assemblies is supplied with a plurality of fiber-forming materials of constant and uniform temperature and quality. Each increment of material reaching the spinneret has had its origin in a common melt source, and the melt is maintained under the same temperatures during essentially the same transit time en route to the spinneret. This makes not only for more uniform chemical quality of the spun fibers, but also renders the flow properties (viscosity) of the material more uniform, which, in turn, benefits the physical extrusion of the individual filaments. Although this layout requires a relatively complex interconnecting

network of conduits, fewer pumping units and heating devices with their attendant controls are required than if individual pumps and heating elements were employed for each individual spinneret assembly.

Although FIG. 4 illustrates but two melting units and two spinnerets, it will be obvious that the principle can be extended to any number of melters and any number of spinnerets. Furthermore, the system of this invention is not confined to the production of multi-component yarns and, therefore, lends itself to flexibility in production operations. Thus, by operating only one melt supply network or by supplying the same material to each network, conventional single component yarns and fibers may be produced with the same advantages of uniformity among a plurality of spinneret assemblies.

A more detailed apparatus layout for melt spinning of two-component yarns is shown in FIG. 5 in a diagrammatic form, to simplify the rendition. The unitary assembly comprises a body shell 10 with internal network of conduits for distribution of melt, melters 41 and 42, metering pumps 61 through 68, electrical immersion heaters such as 80 inserted through suitable body openings and sealed with gaskets, with thermostatic control and regulation. The melters 41 and 42 for supply of polymers A and B are of the hollow, vapor-heated grid type of Graves U.S. 2,253,176, Flores U.S. 2,916,262, or other continuous source of molten polymer such as a screw extruder. The body shell 10 is in the form of a steel rectangular box-like structure with a suitable mounting on the upper surface for the melters, and on the sides for the pumps and immersion heaters. A metal forging is welded beneath the melter reservoir and drilled to provide main conduits and distributor passages, e.g., 43 and 44. Steel tubes, e.g., 47, 49, 51 and 53 serve as equally sized conduits between the distributor and the inlets of the metering pumps 61, 63, 65 and 67. Transfer pipes 57 and 59 conduit dual streams from each pump to a predetermined entry to the nearest spinneret assembly and to the adjacent position; for example, pump 61 delivers a metered stream of polymer A to the left side of spinneret assemblies 71 and 72. Similarly, pump 62 delivers polymer B through pipes 58 and 60 to the right side of spinneret assemblies 71 and 72. In a like fashion, both polymers are metered to spinneret assemblies 73 and 74 by pumps 63 and 64 and so on around the unitary assembly.

FIGURE 6 shows portions of the unitary assembly, viewed from the end 6—6 in the diagram of FIG. 5. The vertical path of polymer A from melter 41 to a spinneret is shown in entirety, flowing from the melt reservoir in the melter through conduits 43 and 51 to pump 61 and discharging through pipe 57 to spinneret assembly 71. The shell 10 of the unitary assembly is pressure-tight and contains an organic liquid or other heat transfer medium 81, heated by electrical immersion heater 80 and regulated by thermostatic or pressure actuated devices. In the apparatus shown, pipe 39 supplies vapor 82 of the heat-exchange liquid to the melt grid 41 to provide heat for melting the polymer. With this arrangement, the grid, the polymer ducts and spinneret assemblies are continuously immersed in a uniform, constant temperature medium. The entire assembly, except for polymer feed, power connections, and spinneret faces, is covered with thermal insulation to minimize heat losses and to assist in maintaining constant temperature within the system. The metering pumps are powered by retractable horizontal drive shafts rotating at the desired speed and the relative proportions of the polymers being extruded may be controlled by adjusting the relative speeds of the meter pumps.

The unitary assembly is portable. It may be installed in appropriate supports in a fixed spinning machine when fiber production is to be commenced and removed from the machine as required for maintenance, repair or other servicing.

It is not necessary to duplicate exactly the preferred apparatus which has been described by example to utilize

the present invention. Numerous changes and substitutions are feasible. The number and kinds of polymers may be varied. Multistream pumps of various sizes and capacities may be employed for metering polymers. The source of heat may be diphenyl diphenyl-oxide mixture, steam, p-cymene, or any other of a number of heat transfer agents. The unitary assembly may be installed in a fixed position and heat transfer medium piped to it. The number and arrangement of spinning nozzles may be elected by the user; and the polymer distribution system may be arranged accordingly. Other apparatus variations may be employed without departing from the invention.

With further reference to the term "thermal history," it will be understood that while this term implies equal time of exposure of two or more polymer streamlets to the same temperature, the latter does not necessarily have to be constant. For instance, if the temperature is allowed to vary with time, equal thermal history for a given group of streamlets can still be achieved, provided each is exposed to the same variations, and the exposure is for the same length of time at each temperature value. In other words, the history of each streamlet is represented by the same temperature-time curve.

Of course, the simplest way of achieving equal thermal history is to place all the conduits for a given group of streamlets in the same vessel, whose inside temperature, at any given instant, is maintained at the same value throughout its volume, and then to assure equal transit time (or dwell within the vessel) for all streamlets under discussion. One embodiment, for instance, for assuring equal transit time is to provide conduits of the same diameter and the same length for the plurality of streams under consideration. For instance, when the distance to be reached by two streams is unequal, the pipe for the shorter path may be coiled at one or more points, to make the transit time for both streams equal. This is illustrated in FIG. 7. An equally effective remedy is to provide the shorter pipe with a bulge (larger diameter) near its middle, as illustrated in FIG. 8. Since the rate of flow is slower across a section of larger diameter, the total dwell of the liquid within the shorter pipe may, with proper design of the bulge, be made equal to that of the liquid passing through the longer pipe.

It will be noted, incidentally, that since the conduits in FIGS. 5 and 6 are shown in diagrammatic form, no attempt has been made there to show either coils or bulges. But the subject is clearly within the skill of those engaged in the art.

The invention, however, is not limited to the above mentioned simplest way. Thus, where polymers of very much different melting points are to be combined into a single composite fiber, it may be advantageous to melt each polymer at a temperature best suited to its nature, bearing in mind that overheating of a molten polymer often tends to degrade the same. In such an event, each polymer may be conveyed successively through its own sequence of distributors, conduits, metering pumps, and further conduits whereby the melts of different polymers meet eventually in a plurality of spinneret assemblies. Said metering pumps and further conduits, however, should be so arranged that when traced backward, each spinneret assembly receives a streamlet of molten mass from each of the different polymers initially started with. As in said simplest systems above, the entire apparatus may be heated by the aid of heated vapors circulating through jackets around all units of apparatus and intervening conduits. But in the instant case, the heated vapor circulating around each path and its pressure will be selected so as to maintain around each path the temperature best suited for the respective polymer.

To clarify the point further, let us refer back to FIG. 4 and assume that two polymers are on hand of which one (say, polymer A) melts at about 220° C., while the other one (polymer B) melts at 260° C. Each molten polymer may be allowed to rise in temperature to a cer-

tain extent after melting; therefore let us assume that it is desired to maintain polymer A at 250° C. at the point where it emerges from the melter (conduit 43), while polymer B is to be maintained at 280° C. at the corresponding point 44. Then pumps 61 and 62, spinneret assemblies 71 and 72, and the intervening conduits 57 to 60 may all be enclosed in a single vessel, hereinafter referred to as the pump block. The latter, then, may be heated as in FIG. 6, by circulating through it a compressed vapor (say diphenyl diphenyl-oxide mixture) at a pressure sufficient to maintain the system at the desired spinning temperature, say 295° C. Branch B of the system (i.e. the sequence of distributor and conduits which transport molten polymer B) may then be enclosed wholly in an insulated chamber or each member thereof (conduit or distributor) may be individually jacketed for passing heating vapor around it. The heating vapor may be the same as the one which was passed around the pump block, or it may be supplied from an independent source but maintained at a temperature of, say, 285 to 290° C.

Branch A will likewise be boxed wholly or individually jacketed, but will be supplied independently with a heating vapor maintained say at 275 to 280° C. On side A, the temperature of the polymer will then gradually rise from 250 to 295° C., as the melt reaches the pump block, while on side B, it will vary only from 280 to 295° C. At each level, however, along the path of flow of molten polymer, the temperature will be the same in all the substreams or streamlets of the same branch in the apparatus layout. For instance, the temperature would be the same in all the conduits 47, 49, 51, 53 on side A, and would be the same in all conduits 48, 50, 52 and 54 on side B; but there would be a difference between the temperature in conduit 47 on side A and the corresponding conduit 48 on side B. Needless to say, the temperature would be identical in all pumps and in all spinneret assemblies.

Furthermore, instead of having the pumps act as stream dividers as shown in FIG. 4, each pump feeding two or more spinnerets, it is possible to interchange the location of pumps 61, 62 and conduits 57 to 60. For instance, pump 61 may be replaced by a distributor which will receive melt from line 51 and pass it out in two streamlets through pipes 57 and 59. Pump 62 would then likewise be replaced by a distributor which would divide substream 52 into two streamlets going down through channels 58 and 60. Metering pump 61 would then be replaced by two pumps situated immediately above block 71, to receive streamlets 57 and 58, respectively, and to pass them on directly into spinneret assembly 71, while metering pump 62 would likewise be replaced by two pumps, one receiving melt from conduit 59 and one from conduit 60, the two streamlets being then directed into spinneret assembly 72. The same system of course would be extended to all the other substreams 47 to 54 inclusive, whereby there would now be in the setup what may be called a second level of distributors (eight in number), each dividing one of the substreams 45 to 54 into a pair of streamlets like 57 and 59.

Moreover, additional levels of distributors may be inserted if desired, whereby a cascading system of distributors is obtained, each distributor acting to subdivide the stream of molten polymer it receives into a plurality of substreams or streamlets.

Nor is this invention limited to any particular number of subdivisions at each stage. For instance, instead of subdividing the stream from each melting unit first into four substreams and then into double that number (as shown in FIG. 4), a system of two distributors in series may be employed on each side of the apparatus layout (that is, following each melting unit), wherein the first distributor breaks up the melt into 5 substreams, and the second distributor subdivides each substream, say, into 4 streamlets, with the result that 20 streamlets are obtained from each melting unit, each streamlet running then to its own metering pump. If just two different poly-

mers are involved, there will be a total of 40 pumps but only 20 spinneret assemblies, and the latter will be arranged so that each shall receive the streamlets from two pumps, one being taken from each side of the system.

A system modified along the lines above discussed is shown in FIG. 9. The four-point distributor of FIG. 4 is replaced here by a two-stage distributor system which includes first a distributor 85 (in branch A) having five outlet conduits, and each of the latter is connected to a second distributor 87 which has four outlets. Accordingly, there are five distributors at the level 87, and the single stream of polymer A issuing from melter 41 becomes divided into 20 streamlets. To assure sufficient pressure for the moving melt, an auxiliary pump 83 may be inserted in pipe 43 preceding distributor 85.

Branch B, of course, also has the same type of distributor system, but each of the branches A and B is enclosed in its own insulated housing 88, and each of these is supplied with its individual stream of heating vapor which enters at 97 and flows out as condensate at 98.

Another modification shown in FIG. 9 is the inclusion of pumps 61, 62 and spinnerets 71, 72 in a single steel block 90, housed in an insulated heating jacket 91. Conduits 57, 59, 58 and 60 of FIG. 4 then become replaced here by channels 93, 95, 96 and 98, respectively, machined into block 90.

It will be clear that all the systems and modifications discussed hereinabove have the following two features in common:

I. While the molten stream for each polymer is being subdivided repeatedly as it moves from the melting unit toward the spinnerets, the intermediate stages of apparatus (e.g. distributors, metering pumps) and all the conduits connecting one of these stages to the other are designed to keep the molten streamlets going through them at the same temperature and to give them the same transit time. In other words, in the flow system for each polymer, the apparatus is designed to maintain the same thermal history at all corresponding points at the same level in the flow system.

II. Each spinneret receives one streamlet of molten polymer originating in each melting unit.

What is claimed is:

1. In a process for melt-spinning of composite textile filaments form a plurality of heat-fusible, fiber-forming, synthetic polymers, the improvement which consists of providing and maintaining identical thermal histories for all streamlets of the melt of a given polymer component of said filaments, as they move from the point of melting said polymer to the point of extrusion through a spinneret.

2. A process for melt-spinning of composite textile filaments, which comprises melting continuously and separately, each of a plurality of heat-fusible, fiber-forming synthetic polymers in a uniformly heated heating zone, subdividing and metering the molten stream from each polymer in progressive stages, and delivering each portion continuously to points of entry in each of several spinneret assemblies, and extruding a molten filament stream from each spinneret, said operations of subdividing, metering and delivering being conducted in a single, uniformly heated zone and being regulated as to rate of flow so that each portion of molten liquid being fed to one spinneret assembly from a given polymer undergoes the same heat exposure, in time and temperature, during its transit from the initial melting zone to the spinneret, as the other portions from the same polymer being fed simultaneously to any of the other spinneret assemblies.

3. A process for melt-spinning of composite textile filaments, which comprises: melting continuously and separately, each of a plurality of heat-fusible, fiber-forming synthetic polymers; subdividing the molten stream from each polymer; delivering each portion continuously to points of entry in each of several spinneret assemblies; and extruding a molten filament stream from each spinneret; said operations of subdividing and delivering for each polymer being conducted in its own heated zone so that all molten streamlets of any particular polymer are maintained at the same temperature at all mutually corresponding points along the path of flow to the level of said spinneret assemblies; and said operations of subdividing and delivering for all polymers being so regulated as to rate of flow as to give all molten streamlets of all polymers through correspondingly located conduits the same length of transit time.

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