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METHOD OF MULTI-COMPONENT SPINNING

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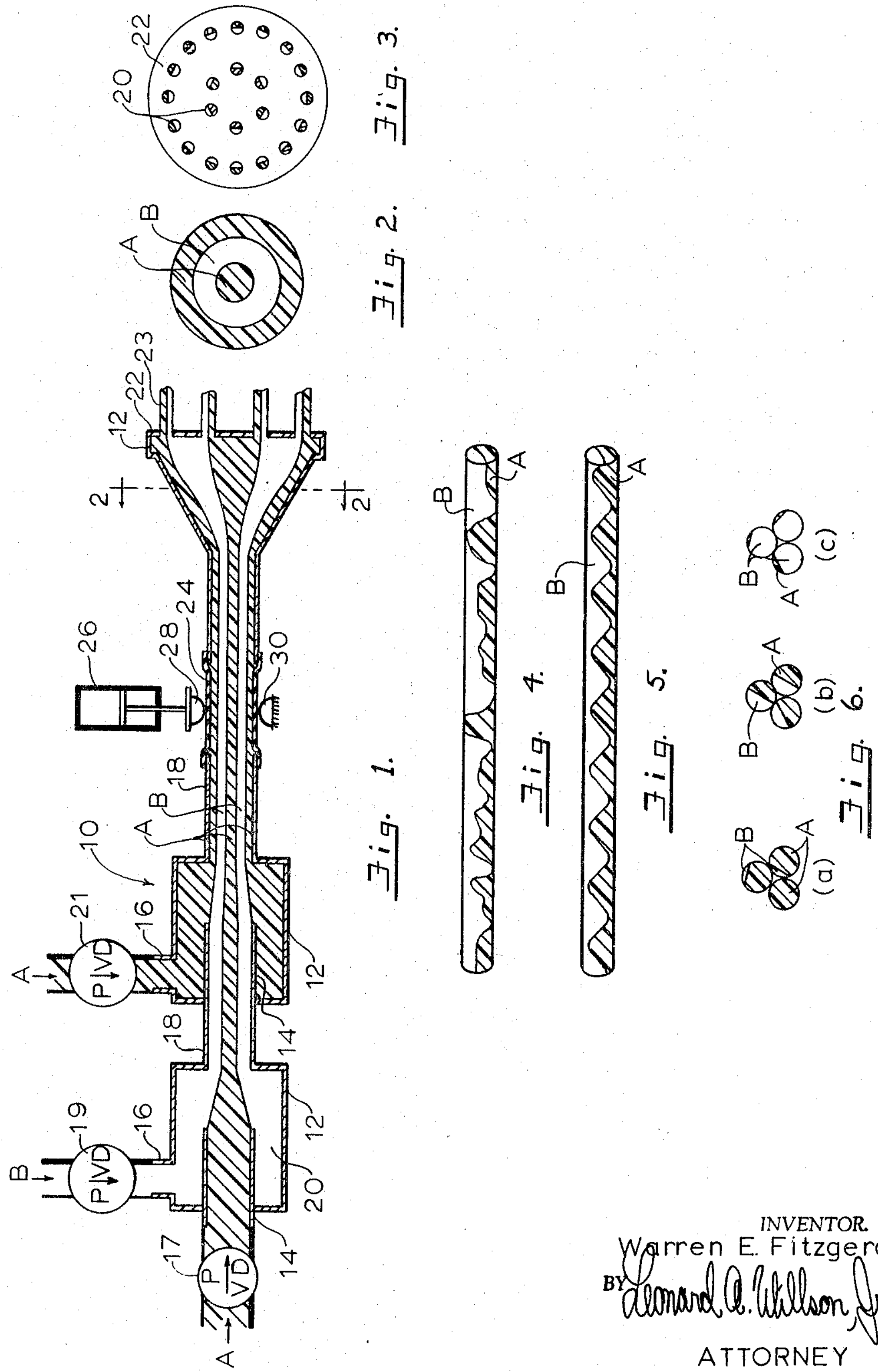

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METHOD OF MULTI-COMPONENT SPINNING

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This invention relates to synthetic textile processes and products and particularly to a novel method of spinning multi-component filaments and the filaments thereby produced wherein each filament exhibits a controlled variation in the ratio of component distribution along its length.

Within the textile industry, a substantial effort is presently directed towards the preparation and production of yarn and fabric from synthetic filaments and fibers such as those formed from polyacrylonitrile, polyamide and polyester polymers and the like. These synthetic filaments have a number of highly desirable characteristics such as low cost, long wear, high modulus and the like. However, due to their synthetic nature and their surface characteristics, certain desirable properties common to the natural fibers, such as wool and cotton, are not present in the synthetic filaments. As an instance, the fibers of wool, in their natural form, contain a plurality of crimps consisting of waves which are approximately sinusoidal in form, with the number of crimps per inch in the individual fibers varying widely in the different grades of wool. It has been determined that these crimps are primarily responsible for the softer feel and warmth in wool by virtue of the tendency of the crimps to hold the individual fibers in the wool yarn apart. Fabrics of wool, because of such naturally occurring crimp, have excellent bulk and cover obtainable at a relatively low shrinkage, a processing factor of considerable economic appeal. Also, the attributes of stretchability, compressional resilience and liveliness of wool have long been recognized.

Although a self-crimping synthetic filament is one of the prime objectives that may be accomplished by the practice of various multi-component spinning techniques in an attempt to simulate one or more of the attributes of natural fibers, it is to be understood that other objectives may as well be realized. For example, by using components identical to one an other save for their color, a filament or bundle may be produced which exhibits a color variegation along its length. It is also possible to produce multi-component filaments wherein one or more components are chosen to impart flame retardance and the remaining component or components chosen for their load bearing capabilities. In general, multi-component spinning, particularly in the manner of the present invention, has been found a most advantageous approach in obtaining filamentary structures exhibiting a concordance of properties not heretofore obtainable in mono-component structures.

A variety of methods and apparatus have been proposed to crimp or texturized synthetic filaments, both in the form of continuous filaments and in the form of spun yarns. These methods comprise mechanical treatments of filaments spun in normal fashion, as well as the use of special spinning conditions and/or after-treatments which bring about differential physical properties over the cross-section of the individual filaments to thereby cause the filaments to crimp, usually in a helical fashion. It has also been proposed to extrude two or more different materials together to form a conjugated or composite filament which contains the components in an eccentric relation over the cross-section of the filaments. When the two components chosen to be so joined are of substantially different shrinkages, a crimp is generated due to the differential shinkage of the spun and drawn component filaments.

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It may here be noted that in the following discussion, the term "multi-component" shall be taken to denote structures, both in the form of solution or melt streams of spinnable mediums and in the form of filaments obtainable therefrom, composed of a plurality of components wherein each such component appears, in cross-section, as a discrete, unblended mass which may or may not vary in its distribution, either linearly of a given structure or relative to the component distribution of similar structures; the term "conjugate " shall denote such multi-component structures which exhibit a relatively substantial uniformity of component distribution, both longitudinally of a given structure and relative to similar structures; "composite" shall denote such multi-component structures, each of which exhibits substantial uniformity in component distribution along its length, but may vary in such distribution as between similar structures; "variable multi-component," "variable conjugate" and "variable composite" shall be taken to denote the structures above defined but which exhibit, either randomly or periodically, a variation in their component distribution ratio along their respective lengths.

In multi-component spinning generally, divorced from any particular method or apparatus, two or more filament-forming materials having possibly diverse chemical and/or physical properties, in a fused or plasticized state, or in the form of solutions thereof, are extruded in separate or only partially intermingled phases through a common orifice or a plurality thereof, at which point they are joined together in an eccentric or side-by-side relation and passed into a setting medium, which may be either gaseous or liquid, functioning either by cooling, precipitating, or evaporating effect, to thereby form unitary filaments, in each of which the different materials form separate, unblended, eccentrically disposed portions of the body of the filament cross-section.

Any of the filament forming materials or solutions may be utilized, including viscoses, proteins, such as caseins and soybean proteins, cellulose derivatives, such as cellulose acetate and ethyl celluloses, and resins such as nylons, the vinyl resins, especially the copolymers of vinyl chloride and vinyl acetate, and the vinylidine halides. Where different cellulose xanthates or viscoses are used, they may differ as to either age, cellulose content, sodium hydroxide content, carbon disulfide content, or as to the type of cellulose from which they are made, such as wood pulp or cotton pulp, or as to any two or more of these factors. Where other cellulose derivatives such as the esters or ethers are used, they or their solutions may differ as to viscosity, cellulose content, or as to the degree of polymerization or substitution of the cellulose chains therein. Where resin solutions are used, the solutions may differ as to the kind of resin, viscosity, and the degree of polymerization of the resin. Two spinning materials of different classes may be combined, such as a protein with a viscose, a protein with a cellulose acetate, or a cellulose acetate with a vinyl resin. It is only necessary that the materials in the form employed, fused or in solution, do not mutually precipitate each other and that they adhere together in the final filaments.

Where it is desired to develop the latent crimpability of multi-component filaments having a favorable component distribution, such filaments, shortly after extrusion, are stretched and are either immediately thereafter permitted to relax or, after formation of the filaments, they are softened, such as by wetting in a relaxed condition, in order to effect shrinkage. Again, completely set filaments, whether stretched or not during formation, may be subsequently stretched, softened and relaxed to effect shrinkage and crimping. Various forms of apparatus may be used for stretching the filaments, such as a pair of positively driven rollers succeeded by rollers being driven at higher speeds.

Alternatively, a thread-storing, thread advancing device about which the filaments continuously travel in a helical path, the individual convolutions of which become progressively larger, may be used.

The stretching procedure orients the molecules of the several component materials making up the filament to different degrees and, where it is performed as an after-stretching procedure, it is carried to such an extent that at least one, and preferably all components of the filament, are stretched beyond the elastic limit so that the filament is in an unbalanced condition whereby, upon relaxation during a shrinking process, the several components of the filament will shrink or contact to different degrees, with the result that the filament will have an appreciable crimp which is generally such that the filament takes the form of a regular or irregular helical coil which may reverse itself in direction at more or less frequent intervals of regular or irregular occurrence. The component material undergoing the greater shrinkage during the crimp formation forms the inner portions of the filament at the bends of the crimp therein.

The individual crimped filaments so produced are characterized in their state of normalcy by a stabilized condition having an inherent distortion which makes the crimp one of a permanent or permanently recoverable character. The filaments, whether crimped or not, have a unitary structure having a cross-section at all points of the filament length, which cross-section comprises two or more substantially distinct zones, each of which is of a different composition than that of one or more of the remaining zones and at least one of which is eccentrically disposed with respect to the filament cross-section. At least two of the component zones are composed of materials having distinct differences in properties, especially in those properties which given rise to differential shrinkage or differential elastic recovery from a stretched condition. Also, where end-use requirements dictate, it is possible to produce such a multi-component, self-crimping filament wherein the crimp is rendered non-reversible or wholly or partially reversible, a result accomplished by the proper selection of component materials making up the filament.

Heretofore, the use of multi-component spinning techniques as one avenue of approach for imparting the beneficial characteristics of natural spun yarns to that of synthetic yarns, both in the continuous filament and staple forms, has been accomplished by the use of expensive, delicate, complicated spinneret assemblies wherein the normally diverse spinnable mediums used to form each filament must be precisely delivered to the individual jet holes by means of intricate passageways necessary to maintain the individual streams discrete from one another up to their points of simultaneous extrusion, or each jet cavity must be precisely split by a delicate septum designed to terminate at the spinneret opening to thereby prevent premature intermingling of the heretofore discrete streams. Again, some systems have utilized the principles of two co-axially mounted, tandemly spaced jet nozzles arranged to allow one to feed centrally of the other to obtain sheath-core structures, a particular variety of conjugate filaments.

In all these cases, however, the equipment, due to its complexity, is very difficult to maintain. Conjugate spinnerets as conventionally known are delicate, easily damaged and quite difficult to repair. The knife-edge septum variety are particularly susceptible to damage, misalignment, etc. Further, conventional conjugate spinning techniques employing the use of such complicated spinneret assemblies suffer an inherent lacking in the desired degree of controlled flexibility to operate in varying modes to obtain a controlled variation in the component distribution ratio along and between the individual filaments.

A new approach in the field of multi-component spinning which serves to eliminate, inter alia, the above related shortcomings is disclosed in my co-pending application Ser. No. 307,449, filed Sept. 9, 1963, wherein it is proposed to obtain various multi-component filamentary structures by the practice of a novel method based on the concept of generating, by any of several suitable means, a patterned, multi-component stream composed of two or more spinnable mediums have differing physical and/or chemical properties, the pattern of such a stream having a predetermined and controllable geometric alignment with the orifice pattern of a spinneret conventionally employed in typical mono-component spinning operations. Where the interface between two normally disperate zones of spinnable mediums is caused to intersect a chosen spinning orifice at a chosen position, a multi-component filament exhibiting the desired ratio of component distribution will be obtained.

It has been found that in the practice of the just briefly delineated process of multi-component spinning, particularly as the numbers of orifices to be supplied by each patterned stream is increased, one necessarily encounters limitations in the degree of uniformity with which the various bi-component interfaces may be caused to intersect each of the orifices with the result that, in spinning heavy denier tows, there may be countered an undesired degree of inter-filament variation in the component distribution ratio. A further limitation encountered in the spinning of heavy denier tows by such a process is that of an uncontrolled variation in the alignment of a given bi-component interface with a given set of orifices which, in aggravated instances, may result in a tow having, for example, non-uniform self-crimpability. Such a non-uniformity is magnified when such a heavy denier tow is reduced to the staple form preparatory to processing into a spun yarn. This is because staple lengths of certain numbers of the filaments comprising such a tow may exhibit an adverse component distribution, insofar as optimum self-crimpability is desired. Taken from another aspect, it is to be recognized that, in the practice of the multi-component spinning process described in the above identified co-pending application under steady-state conditions, a certain amount of variation in the component distribution, both across a filament bundle and along the length of the individual filaments, is not to be avoided. Under steady-state conditions, it is the nature of these two modes of variation in component distribution to interact in such fashion as to possibly result in a filamentary tow which exhibits an undesired degree of non-uniformity of crimp. Thus, no matter the pains taken to maintain a substantially steady-state flow condition, a bi-component interface of the patterned dope stream may drift, though ever so slowly, in an uncontrolled fashion across the mouth of a plurality of orifices to extrude a multi-filament tow along the length of which the average ratio of component distribution may be such as to produce an undesired degree of variation in crimpability. The need, therefore, becomes apparent for some provision by which it may be assured that the average ratio of component distribution across a multi-filament tow will exhibit a high degree of uniformity along successive lengths.

It is therefore one object of the present invention to provide a novel multi-component spinning process operable to produce multi-component filaments exhibiting a positively controlled variation in component distribution along their lengths.

A further object of this invention is a variable multi-component spinning process susceptible to simplified implementation, increased flexibility of execution and high production rates without undue sacrifice to uniformity of quality.

A still further object is a simplified variable multi-component spinning process, by the practice of which there is eliminated a need for complicated multi-component spinnerets of conventional construction, which process may be carried out by the use of conventional mono-component-type spinnerets in combination with a patterned stream generating device.

Another object is a novel process of variable multi-component spinning which circumvents the necessity of maintaining separate the component spinnable mediums until a point at or immediately prior to their simultaneous extrusion through a common orifice.

Yet another object is to produce a muilti-filamentary tow exhibiting a high degree of uniformity in the average ratio of component distribution along its length.

Still another object is the production of a multi-filament tow, the individual filaments of which exhibit a controlled variation, either periodically or randomly, in the ratio of component distribution along their lengths.

According to the present invention, the foregoing and other objects are attained in the practice of a novel and simplified variable multi-component spinning process wherein there is generated a patterned, multi-component stream of spinnable mediums having a predetermined and controlled cross-sectional geometry, the pattern of which is subjected to controlled, random or periodic fluctuations in size and/or configuration. Such a stream is then conveyed as a laminar flow to a remote spinneret or spinnerets, wherein the spinning orifices are arranged in a pattern complementing, to a predetermined degree, that of the stream. By this scheme, a given interface between two adjacent component zones of the patterned stream may be caused to hunt or play in a controlled fashion across each of a plurality of spinning orifices in a manner to produce multi-component filaments which exhibit the desired degree of random or periodic variation in component distribution along their respective lengths. The cross-sectional size and configuration of the patterned stream may be varied by one or more of several modes to accomplish such a lengthwise variation in the component distribution of each of the filaments. It is further contemplated that, by varying the geometric correspondence between the pattern of the multi-component stream and the pattern of the spinning orifices, there may be obtained a controlled variation in the degree of inter-filament uniformity of component distribution of a multi-filament bundle issuing from a given spinneret.

The present process and product resulting therefrom are to be distinguished from that disclosed in United States Patent No. 2,805,465 to Miller, wherein a multi-component stream of spinnable mediums is sheer-mixed to generate a marbled or blended mass which is presented to a conventional spinneret with the result that filaments extruded therefrom are said to exhibit a haphazard variation in their cross-sectional composition, which variation takes place over random lengths of each individual filament. The present invention, on the other hand, is addressed to the concept of generating a patterned, multi-component stream of spinnable mediums having a predetermined and controlled cross-sectional geometry which is designed to complement, to a predetermined and controllably varying degree, the geometric pattern of a spinning orifice arrangement, whereby the interface between adjacent components is caused to play across the mouth of each orifice in a controlled periodic or random fashion to thereby form a multi-component filament exhibiting a varying component distribution along its length. This concept is obviously repugnant to the stated mode of execution of the Miller patent, a mode incapable of producing a controlled, periodic variation in component distribution and is only capable of producing a randomly variegated yarn, the individual filaments of which necessarily exhibit a hodge-podge variation in color. This is to also recognize the distinctions between the instant method of component spinning and that employed to obtain the product of the Miller patent.

That there be gained a better understanding of the present invention, reference will now be had to the accompanying drawings as being illustrative, but not limitative, of one possible embodiment of an apparatus which may be utilized in carrying out the present invention, and in which:

FIG. 1 is a simplified schematic of a pipe-in-pipe type patterned stream generator which may be employed in the practice of the present invention where it is desired to generate a multi-component stream having a concentric ring pattern;

FIG. 2 is a cross-sectional view taken on line **2—2** of FIG. 1 and shows one possible configuration of the multi-component stream;

FIG. 3 is a full-face view of the spinneret shown edgewise in FIG. 1 and depicts one possible component distribution within the individual filaments at a given point in time;

FIG. 4 is a length-wise view of a filamentary structure produced by the method of the present invention and exhibits a random variation in component distribution along the length thereof;

FIG. 5 is a view similar to that of FIG. 4 wherein the component distribution has been caused to vary periodically, and

FIGS. 6*a, b, c* are views of filament cross-sections taken at spaced points along the lengths of three filaments produced by the practice of and embodying the present invention.

Turning now to a more detailed description of my invention, there will first be described one of many possible structural embodiments which may be employed in the practice thereof. FIG. 1 is a schematic depiction of a pipe-in-pipe-type patterned stream generator **10** comprising a plurality of merging stages or elements **12** arranged in tandem relationship, there being two stages illustrated. Each stage or element **12** comprises two inlets **14, 16** communicating with a common outlet **18**, which outlet constitutes one of the two inlets of the next succeeding stage. In the particular two-stage generator illustrated in FIG. 1, a solution or melt A is supplied to inlet **14** by means of a positive displacement type, variable speed driven pump **17** and a solution or melt B is supplied through inlet **16** by means of a similar pump into chamber **20** under conditions assuring a laminar flow. By selecting a suitable length of the inlet conduit **14**, the streams, A and B, are caused to merge in a streamline fashion at a merger zone preferably located downstream of the inlet **16**. This mode of merging two independent streams of spinnable mediums is such as to produce a portion of the concentric-ring pattern illustrated in FIG. 2, wherein stream A defines a circular core and stream B defines a co-axially surrounding annulus. As is clear from the showing of FIG. 1, the outlet flow of the first stage, in the form of a single ring B co-axially enclosing a core A, becomes the inlet flow for the next succeeding stage, which single ring and core flow are similarly merged with a third stream of solution or melt by way of pump **19**, which third stream may or may not have the same composition as that of the core material A. The discharge from this second stage will have the cross-sectional pattern illustrated in FIG. 2, wherein the core A is surrounded by two concentric rings, adjacent layers differing in chosen physical and/or chemical properties, depending upon the effect it is desired to obtain in the final filament. Once a pattern containing the desired number of layers has been generated, which is determined by the number of merger stages arranged to cooperate sequentially, such pattern is conveyed in laminar-flow fashion to a conventional spinneret **22**, which may be located a distance of up to five or more feed from the last merging stage.

Given a patterned, multi-component stream so generated, there shall now be described for purposes of illustration and not limitation, one of several modes of accomplishing a timed variation in its configuration. In one such mode, at a point intermediate the generator **10** and the spinneret assembly **22**, conduit **18** is interrupted by a flexible segment **24**, which may be in the form of a cylindrical sleeve completely interrupting two spaced segments of conduit **18**, or may as well take the form of a cylindrical element occupying a slot formed in the wall of the conduit. Other deformable structures are as well visualized and, insofar as this particular mode of practicing my invention is concerned, the only essential is that some portion of conduit **18** be rendered deformable to thereby vary the multi-component stream pattern in the desired manner. A reciprocating differential motor, symbolically indicated at **26**, is arranged to reciprocate a shoe **28** in a random or periodic fashion, to cooperate with sole member **30** to selectively compress the flexible member **24** to thereby pulse a fluid stream passing therethrough. It is recognized that the means employed to compress the flexible member is susceptible to many innovations other than that shown, such as a constricting ring or even by hand. Also, the details of the particular mechanism employed to actuate the constricting means may take many forms and may be operated through a variety of programs.

As previously noted, it has been found that the distance between the patterned stream generator **10** and the spinneret assembly **22** is not critical and may vary up to five feet, or more, so long as laminar flow is maintained. It has also been found possible to effect a controlled distortion of the multi-component stream pattern by forming bends of the desired curvature in the conduit **18** interconnecting the generator **10** and the spinneret assembly **22**. Further, the stream may be conducted through other than linear paths between the generator and the spinneret assembly with zero net distortion to the extent that such curvatures in the conduit, taken in summation, are of such sense and magnitude as to result in no net change in the direction of flow. In the particular arrangement of FIG. 1, the conduit **18** is straightlined and the concentric-ring pattern undistorted from the time it leaves the generator until the point of its presentation to the spinneret assembly **22**, assuming, of course, that the mechanism, either in the form of the variable speed pumps **17**, **19**, **21** or the flexible conduit **24**, employed to effect a controlled variation in the stream pattern is not operated. It will further be appreciated from a study of FIG. 1 that a dimensional variation in the conduit **18** is reflected in a proportionate variation in the dimension of the stream pattern, while its configuration remains unchanged. This characteristic is depicted in the cross-section of FIG. 2, which is on a larger diameter relative to points upstream thereto. This is to demonstrate that, due to the normally high viscosity of the compositions and the consequent ease of maintaining laminar flow, relatively gradual changes in the size, configuration and direction of the conduit may be effected without destroying the sharp interface desired to be maintained between two adjacent component layers. It is further to be recognized that, where the stream and orifice patterns are discordant and where the flow rates of the individual compositions are maintained constant, the streams will reflect an adjustment in their flow patterns to accommodate the particular orifice pattern which, in the case of an excessive discordance, may result in a normally undesired blending or mixing of the components in the vicinity immediately adjacent the upstream side of the spinneret, although it is conceived that certain end-product requirements may dictate the extrusion of such a random-blended, multi-component stream.

Another structurally simplified mode of causing a bi-component interface of a patterned, multi-component stream to hunt across a chosen group of orifices in a random or periodic fashion is accomplished by effecting a complementary variation in the relative pump speeds of the component mediums. By the use of variable speed, positive displacement type pumps **17**, **19**, **21**, the rate of delivery of each component medium may readily be varied with respect to time to accomplish a controlled fluctuation in the multi-component stream pattern, with consequent bi-component interface fluctuation about each orifice, resulting in the extrusion of filaments exhibiting a variation in component distribution along their respective lengths.

For example, assume that it is desired to extrude a plurality of filaments from a given spinneret station having a predetermined average ratio of component distribution on the order of two parts A to one part B. It is necessary to adjust the component stream flow rates to take into account the number of orifices to be supplied by a given pair of component streams. In the relatively simple case of a spinneret having an orifice pattern in the form of two concentric rings, the inner ring containing nine orifices and the outer ring containing eighteen orifices, a total of twenty-seven, which spinneret is supplied by a multi-component stream having a concentric ring pattern composed of two components arranged, as in FIG. 2, in the form of a core A, intermediate ring B and outer ring A. It follows that an average flow rate of core A must be adjusted, relative to that of intermediate ring B, to supply an average of two-thirds of the flow discharging from the inner ring of nine orifices and the average flow rate of the outer ring A must be adjusted, again relative to that of the intermediate ring B, to supply an average of two-thirds of the discharge through the outer ring of eighteen orifices. Similarly, the average flow rate of intermediate ring B must be adjusted, relative to the average flow rate of core A and outer ring A, to supply an average of one-third of the discharge from both the inner and outer rings of orifices. It follows, therefore, that the average relative flow rates of the common streams must be in the ratio of 2:3:4, from core to outer ring, in order to produce filaments having an average component distribution ratio along their individual lengths of two parts A to one part B.

As previously discussed, under steady-state flow conditions, any drifting of a given bi-component interface across a given orifice is normally very gradual and, of course, uncontrolled with the result that filamentary lengths sometimes on the order of several feet may be extruded which exhibit an undesirable component distribution, insofar as optimum self-crimpability is concerned. Such adverse distribution occurring over uncontrolled lengths of time may be further aggravated by an inter-filament variation in component distribution to result in a filamentary tow exhibiting an undesirable level of non-uniformity of crimp or other phenomena attributable to the diversity of properties of the component mediums. Therefore, by inducing a controlled fluctuation of each interface with respect to the orifices supplied thereby, there is assured an average component distribution along the length of the filamentary tow. To accomplish this, in the example given, by effecting a complementary variation of the component pump rates, involves nothing more than reducing the rate of delivery of a component by the same amount as the rate of an adjacent component is increased, resulting in no net change in the combined flow rates of the two adjacent component mediums. Of course, in the case of an intermediate ring or layer juxtaposed by two other component mediums, it will be necessary to adjust the flow rates of any two mediums in accordance with the change in the third to maintain a constant total flow rate within such three layers or rings.

Modes other than those employing a periodically distorted flexible segment or a complementary variation in the flow rates of the component mediums are as well visualized, the common denominator of all such modes being the inducement of a random or periodic fluctuation of the position of a given bi-component interface relative to the group of orifices supplied thereby. For example, the same result might as well be accomplished by arranging the spinneret assembly to be periodically or randomly shifted transversely of a steady-state stream of unvarying pattern. Such a transverse shifting or vibration of the spinneret assembly will effect the same relative displacement between the orifices and the bi-component interfaces. The same result may as well be accomplished by mounting the spinneret assembly to rotate or oscillate eccentrically with respect to a multi-component stream having a concentric ring pattern, a given group of orifices being thereby caused to shift relative to its associated interface.

Still another mode of causing a bi-component interface to play across a group of orifices may be practiced where there is employed a concentric ring, laminated plate generator operative to generate a multi-component stream having a concentric ring pattern, such a generator being the subject matter of co-pending applications Ser. No. 204,707, filed June 25, 1962 and Ser. No. 307,386, filed Sept. 9, 1963, now U.S. Patent No. 3,217,734. The generator disclosed in application Ser. No. 204,707 may be operated to generate a pattern of parallel layers, while that of Ser. No. 307,386 is operable to provide a concentric ring pattern, or variations thereon. Due to their laminated-plate construction, chosen stages of these generators may be selectively brought in and out of register to thereby control the flow rate of component streams at each point of merger, which manipulation will have the same ultimate effect as is accomplished by a previously discussed complementary variation in relative pump speeds.

Reference shall now be had to FIGS. 4–6 for a better understanding of some typical filamentary structures that may be obtained by the practice of the present invention. FIG. 4 depicts a filamentary structure resulting from a randomly induced fluctuation of the bi-component interface over the orifice through which the filament was extruded, whereas the filamentary structure depicted in FIG. 5 shows the component distribution resulting from a periodic fluctuation of an interface, either mode of fluctuation being obtained by one or more of the above referred to procedures, or equivalents thereof. The frequency and amplitude of the variation may take place over wide ranges according to the characteristic it is desired to obtain in the end product. As a particular instance, in the case where it is desired to produce spun yarns from the normal staple lengths, it will be desirable, in the case of a periodic variation in component distribution, to accomplish at least one complete cycle within the chosen staple length. The frequency of interface fluctuation will, therefore, be directly proportional to the rate of extrusion, as well as a function of the staple length desired to be obtained.

FIGS. 6*a*, *b*, and *c* show three typical cross-sections taken at spaced points along the lengths of three filaments issuing from a common spinneret station. It is seen that in FIG. 6*a*, A is the predominant component with very minor portions of component B appearing in, possibly, two of the three filaments. At a later position along the length of these same three filaments, the component distribution is seen to have changed to approximately 1:1 and, in FIG. 6*c*, the distribution has again changed to one of predominantly component B. As previously discussed, this variation in distribution may be caused to take place over filamentary lengths ranging from fractions of an inch up to several feet, according to the dictates of ultimate usage. It is also to be noted that the typical cross-sections of FIG. 6 exhibit a minor variation in the interfilament component distribution wherein a given filament contains a slightly different ratio of A to B than that of adjacent filaments. As previously related, any adverse effects resulting from such an interfilament variation are minimized by effecting a controlled variation along the lengths of the filaments in the manner of the present invention.

It may now be appreciated that there has been herewith disclosed a novel multi-component spinning process of new found simplicity and flexibility of operation wherein a bi-component interface defined between two adjacent, possibly diverse, mediums of a patterned, multi-component stream of spinnable materials is caused to play across a chosen group of orifices in a random or periodic manner to produce multi-component filamentary structures exhibiting a controlled variation in the ratio of component distribution along their respective lengths. Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. An improved process for producing multi-component filamentary structures which exhibit a controlled variation in component distribution ratio along their respective lengths comprising the steps of successively merging in a laminar fashion two or more diverse spinnable components in alternating sequence to thereby generate a multi-component stream composed of at least three unblended components arranged in a pre-determined pattern and having sharp lines of demarcation between adjacent components, conveying said pattern stream to a remotely positioned spinneret having an orifice pattern of a predetermined degree of correspondence with the pattern of said stream, whereby each line of demarcation is caused to intersect a chosen group of said orifices, inducing a timed fluctuation in the position of at least one of said lines of demarcation relative to its associated group of orifices to thereby effect a timed variation in the ratio of component mediums issuing from a given orifice.

2. The process of claim 1 wherein the step of inducing fluctuation is performed cyclically.

3. The process of claim 1 wherein the step of inducing fluctuation is performed randomly.

4. The process defined in claim 1 wherein the step of inducing a fluctuation in the position of a line of demarcation relative to its associated group of orifices is characterized by a complementary variation in the relative flow rates of the component mediums.

5. The process defined in claim 1 wherein the step of inducing a fluctuation in the position of a line of demarcation relative to its associated group of orifices is characterized by distorting the multi-component stream pattern at a point intermediate its point of origination and its point of presentation to the spinneret.

6. A process as defined in claim 1 wherein the step of inducing a fluctuation in the position of a line of demarcation relative to its associated group of orifices is characterized by a timed rotation of the spinneret about an axis perpendicular to the plane thereof.

7. The process defined in claim 4 wherein said spinneret rotation is performed cyclically.

8. The process defined in claim 6 wherein the step of rotating said spinneret is performed randomly.

9. The process defined in claim 5 wherein the step of distorting the multi-component stream pattern is performed cyclically.

10. The process defined in claim 5 wherein the step of distorting the multi-component stream pattern is performed randomly.

11. The process defined in claim 4 wherein the step of complementary varying the relative flow rates of the component mediums is performed cyclically.

12. The process defined in claim 4 wherein the step of complementary varying the relative flow rates of the component mediums is performed randomly.

13. The filament produced by the process of claim 1.

14. The process as defined in claim 1 wherein at least two of the component mediums differ as to their physical properties.

15. The process as defined in claim 1 wherein at least two of the component mediums differ as to their chemical properties.

16. The process as defined in claim 1 wherein at least two of the component mediums differ as to their color.

17. An improved process for producing multi-component filamentary structures which exhibit a controlled variation in component distribution ratio along their respective lengths comprising the steps of successively merging in laminar fashion two or more disparate spinnable mediums in alternating sequence to thereby generate a multi-component stream composed of at least three unblended components arranged a predetermined pattern of discrete, unblended components defining sharp lines of demarcation therebetween, presenting said patterned stream to a remotely positioned spinneret having an orifice pattern complementing that of said stream, whereby each line of demarcation is caused to intersect a chosen group of said orifices, inducing a timed fluctuation in the position of at least one of said lines of demarcation relative to its associated group of orifices to thereby effect a timed variation of the ratio of component mediums issuing from the given orifice.

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