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APPARATUS FOR GENERATING PATTERNED FLUID STREAMS

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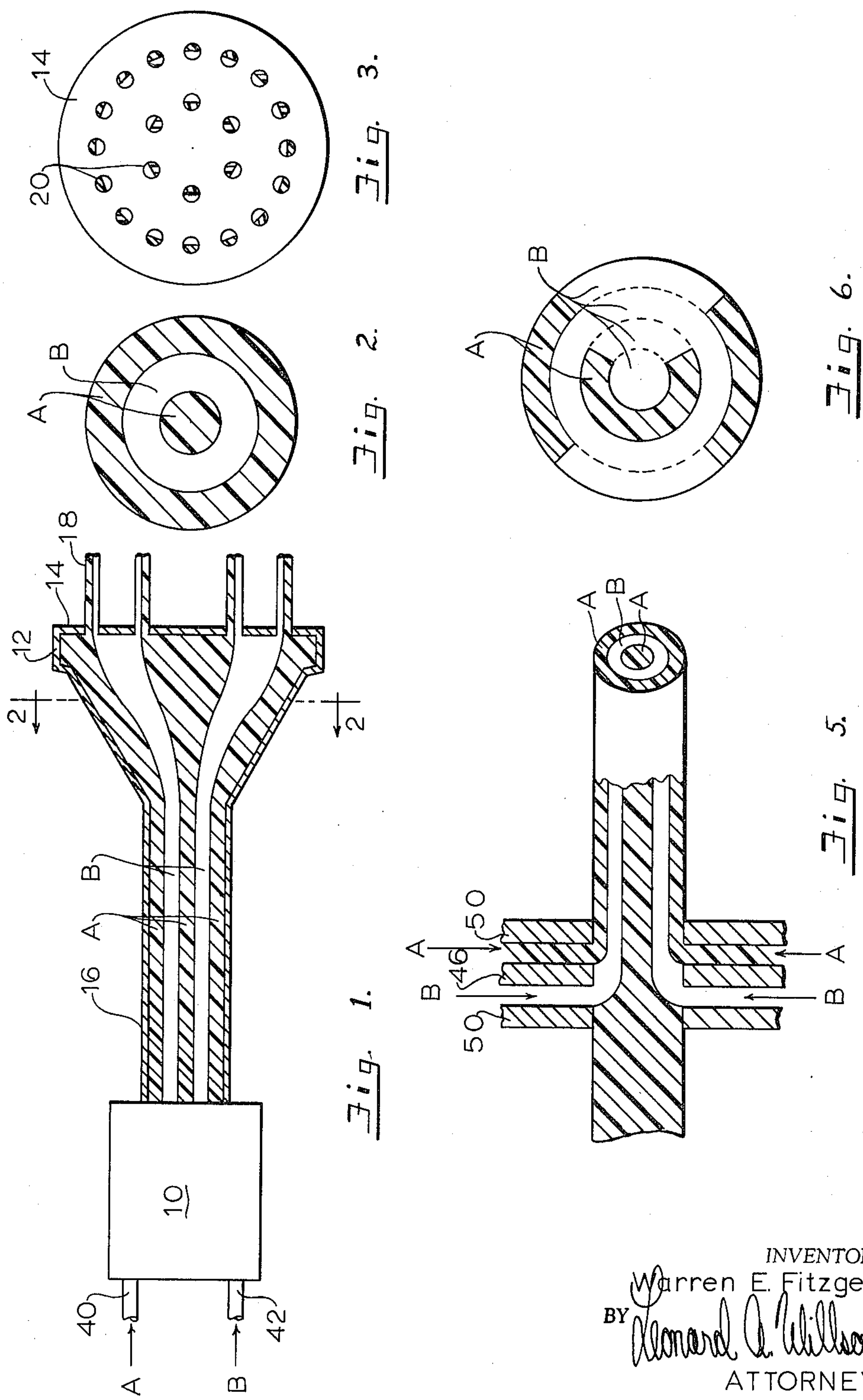

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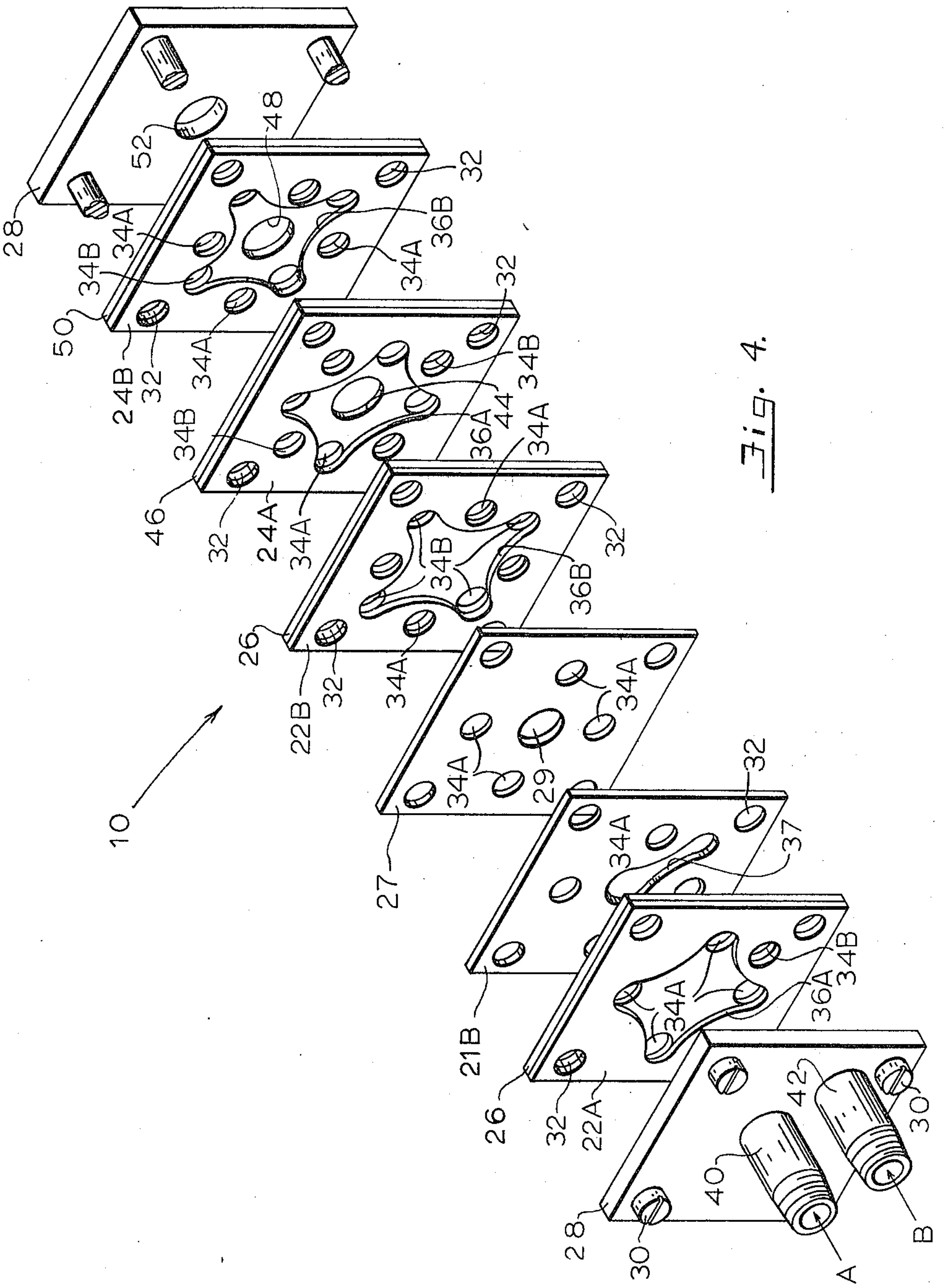

Fig. 4.

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APPARATUS FOR GENERATING PATTERNED FLUID STREAMS

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5 Claims. (Cl. 137—271)

This invention relates to an apparatus for producing multi-component synthetic fibers which exhibit a controlled degree of uniformity in component distribution, both between individual filaments and/or along the length of each filament. More particularly, this invention concerns a controlled merging apparatus for use in generating multi-component streams of spinnable mediums exhibiting selectively variable patterns having predetermined and precisely controllable degrees of geometric correspondence with the orifice paterns of spinnerets conventionally employed in mono-component filamentary spinning.

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 with 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.

A variety of methods and apparatus have been proposed to crimp or texturize 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 helical crimp is generated due to the differential shrinkage of the spun and drawn components.

Although a self-crimping filament is one of the prime objectives of multi-component spinning techniques, it is to be understood other objects may as well be realized. For example, by using components identical to one another save for their color a filament or bundle may be produced which exhibits a color variation 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 chosen for its 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.

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It may here be noted that in the following disclosure 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 vary in such distribution as between similar structures.

Heretofore, the use of multi-component spinning techniques as one avenue of approach towards 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 point 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 feed streams. Again, some systems have utilized the principle 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 filament. In all of the cases, however, the equipment 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 spinnert assemblies suffer the inherent disadvantage of a 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 ali, the above related shortcomings is disclosed in my copending application Serial Number 307,449 filed September 9, 1963, wherein it is proposed to obtain various multi-component conjugated and composite filamentary structures by the practice of a novel method based on the concept of generating, by any suitable means, a patterned, multi-component stream composed of two or more spinnable mediums having 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 mono-component spinning. Where the interface between two normally disparate zones of spinnable mediums is caused to intersect a chosen spinning orifice at a chosen position, a conjugated filament exhibiting the desired ratio of component distribution will be attained. By varying the flow rates of the individual spinning mediums and by varying the degree of geometric alignment between the pattern of the composite stream and that of the spinneret orifices, there may be easily obtained a controllable range of inter-filament variation in the ratio of component distribution, which inter-filament variation may also be varied, as to time, along the lenth of each filament to produce a filamentary bundle exhibiting a variation in the ratio of component distribution both across the bundle and along its length, resulting in a bundle of varying crimpability, a characteristic to be desired in certain end uses. This concept of spinning a filamentary bundle exhibiting a variable ratio of component distribution constitutes the subject matter of my copending application Serial Number 307,-532, filed September 9, 1963.

In the practice of the above referred to multi-component spinning techniques, it becomes necessary to provide an apparatus capable of generating the desired multi-component stream pattern. A simplified form of one such type of apparatus is described in the last-identified copending application in the form of a "pipe-in-pipe" arrangement, whereby a downstream medium is merged centrally or externally of one or more upstream mediums to provide a composite stream having the pattern of concentric rings. Another such apparatus is disclosed in copending application Serial Number 204,707, filed June 25, 1962, wherein a series of aligned, perforated plates defines a system of passageways for the merging of a plurality of spinnable mediums into alternating parallel layers. Although a parallel-layered stream will be found desirable in many multi-component spinning operations, it has been found that the concentric-ring pattern is to be preferred where it is desired to play a bi-component interface across a given spinneret orifice to accomplish a variation in the ratio of component distribution along the length of each filament issuing therefrom. Further, it has been found that the concentric-ring pattern is amenable to more precise control and is less susceptible to undesired variations in component distribution, both along each individual filament and across a plurality of filaments, which variations may result, for example, from minor, uncontrolled pulsations of the feed pressures of the individual mediums, causing deviations in the geometric alignment of the stream and spinneret orifice patterns. Also, localized deviations of a bi-component interface are found to be minimized where the dope stream pattern is similar to that of the conduit along which it is conveyed between the mixing apparatus and the spinneret assembly, which conduit is normally circular in cross-section.

With these considerations in mind, it is therefore an object of the present invention to provide fluid merging apparatus operable to generate a patterned stream.

Another object of this invention is to provide an apparatus operable to merge in a streamline fashion a plurality of spinnable mediums supplied thereto into a concentric-ring pattern, which pattern may be expediently modified by convenient manipulation of the mixing apparatus to provide controlled segmentation of selected rings.

Still another object of this invention is a fluid merging apparatus operative to generate a multi-component stream having a basic concentric-ring pattern, or variations thereon, which apparatus is of a laminated plate construction wherein the component plates may be of a unit thickness to allow ready manipulation of the flow rate within a given ring-like layer.

According to the present invention, the foregoing and other objects are attained by providing a fluid merging apparatus of laminated plate construction, the individual plates of which are preferably of unit thickness and have voids of a particular configuration defined therein which, when a chosen plurality of such plates are assembled in face-to-face relationship, define a system of passageways designed to accommodate a plurality of separate supplies of spinnable mediums and to merge these mediums, one externally of the other, into a concentric-ring or concentric segment pattern of alternating components. By the use of this apparatus, a concentric-ring, multi-component stream pattern is easily controlled to have a predetermined geometric alignment with a chosen spinneret orifice pattern of a conventional, mono-component filament spinneret. With this apparatus, it has been found that the concept of multi-component spinning by means of intersecting a plurality of orifices with an interface of a multi-component stream of predetermined pattern may be practiced with new-found facility and flexibility.

For a better understanding of my invention, reference shall now be had to a detailed description of one possible embodiment thereof, taken in conjunction with the accompanying drawings as being illustrative, but not limitative, thereof and in which:

FIG. 1 depicts, more or less symbolically, one possible multi-component spinning operation employing the use of my concentric-ring-merging apparatus;

FIG. 2 is a cross-section taken on line 2—2 of FIG. 1 showing the multi-component stream configuration;

FIG. 3 is a full-face view of the spinneret shown edgewise in FIG. 1 and depicts the component distribution in the individual filaments;

FIG. 4 is an exploded perspective view showing the details of one possible embodiment of the concentric-ring-merging apparatus;

FIG. 5 is a partial, sectionalized view of an assembled mixing apparatus of the type illustrated in FIG. 4 and showing the laminar merger of a plurality of component stream, and

FIG. 6 is a cross-section view of a multi-component dope stream similar to that of FIG. 2 and exemplifying one of many possible variations on the basic concentric-ring pattern, which variation is easily accomplished by the apparatus of the present invention.

Turning now to the drawings and particularly to FIG. 1, there is depicted symbolically one possible arrangement of a multi-component spinning system wherein a multi-component stream of spinnable mediums in the form of concentric rings of alternating layers is generated and presented to a conventional spinneret in such a fashion that the interface between two component layers is caused to intersect each spinning orifice. More particularly, a plurality of discrete spinnable mediums, there being two, A and B, illustrated, are introduced to the patterned stream generator 10 comprising the present invention which, as will be more fully described hereinbelow, is operative to merge the two streams, A and B, into a plurality of concentric rings of alternate composition. In the arrangement depicted in FIG. 1, a two-stage generator has been employed to generate a multi-component dope or melt stream having a core and outer ring of composition A and an intervening ring of composition B, as best shown in FIG. 2. It is, of course, to be understood that any number of stages may be employed to generate any number of concentric rings of alternating composition, which alternation may be in any sequence and composed of two, three or more different mediums, due consideration being given to the geometric alignment of the spinneret orifice pattern with the stream pattern so generated. On departing the generator 10, the multi-component stream of the desired pattern is then conveyed to a remotely positioned spinneret assembly 12 having a conventional mono-component-filament-type spinneret 14 best illustrated in FIG. 3. It has been found that the distance between the mixing apparatus 10 and the spinneret assembly 12 is not critical and may vary up to five feet, or more, so long as laminar flow is maintained. It is also possible to effect a controlled distortion of the multi-component stream pattern by forming bends of the desired curvature in the conduit 16 interconnecting the mixer with the spinneret assembly. Further, the dope stream may be conducted through a non-linear path between the mixer and the spinneret with zero net distortion to the extent that curvatures in the conduit 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 16 is straight-lined and the concentric ring pattern undistorted from the time it leaves the mixer until the point of its presentation to the spinneret 14. It will further be appreciated from a study of FIG. 1 that a dimensional variation in the conduit 16 is reflected in a proportionate variation in the dimensions 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. Similarly, controlled distortions in the configuration of the patterned stream may be accomplished by distorting the cross-sectional configuration of the conduit. 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 sharpness of the interface desired to be maintained between two adjacent 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 is maintained constant by means of some positive displacement pump device, 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 of the components in the vicinity immediately adjacent the upstream face of the spinneret, although it is conceived that certain end-product requirements may dictate the extrusion of such a random-blended, multi-component stream.

As best seen in FIG. 3, the number of spinneret orifices 20 comprising each ring is proportional to the combined flow rates of the two layers of spinnable mediums supplying that particular ring. In the case of the particular spinneret of FIG. 3, which has an inner ring of six orifices and an outer ring of sixteen orifices supplied by a tri-layered dope stream comprising core A, intermediate ring B and outer ring A, the flow rates of the individual streams must be in the ratio of 3:11:8, from core to outer ring where a 1:1 ratio of component distribution of the individual filaments is desired. Obviously, this ratio of component distribution may be varied by varying the ratio of the flow rates of the individual streams.

Turning now to FIG. 4 for a better understanding of the details of the concentric-ring patterned stream generator 10 comprising the present invention, it is seen that such a generator takes the form of a series of laminated structures in the form of distribution plates 22A, 22B, manifold plates 24A, 24B, shuttle plate 21B, centrally apertured plates 27, 46, 50 and spacer plates 26 which are bracketed by relatively massive end plates or blocks 28 which serve as a rigid means to clamp the intervening, relatively thin plates. The various plates are maintained in their assembled condition by means of stud bolts 30 which extend through bolt holes 32 formed in each of the various plates. Each of the various distribution and manifold plates 22, 24, respectively, which are to be distinguished only by their position within the assembly and not by their configuration, along with the spacer plates 26, are provided with a plurality of aligned distribution apertures 34A, 34B, half 34A of which lie within the periphery of cut-outs 36A of distribution plate 22A and manifold plate 24A and the remaining half 34B of which lie within the periphery of and communicate with cut-outs 36B of distribution plate 22B and manifold plate 24B. It is to be understood that the cut-outs 36A, 36B of manifold plates 24A and 24B are not of critical configuration, the only criterion being that each cut-out portion communicate with its respective distribution apertures 34A, 34B. For convenience, the manifold plates 24A, 24B may have cut-outs 36A, 36B so configured that the plates are interchangeable by the simple expedient of rotating them 90° about an axis perpendicular to their plane. It will further be appreciated that such plates can economically be produced from mass stampings. The spacer plates 26 are identical to the manifold and distribution plates 22, 24 save for the cut-outs 36 and function to fluidly isolate the various manifold and distribution plates from one another.

In the assembled condition, a spinnable medium A is passed through end plate 28 by means of supply fitting 40 to communicate centrally of cut-out 36A of distribution plate 22A, whereupon the fluid is distributed throughout the cut-out to pass through alternate numbers of distribution apertures 34A of spacer plate 26 and similarly aligned apertures in intervening plates until it encounters manifold plate 24A having a cut-out 36A of a configuration overlapping the cut-out of distribution plate 22A, where it is merged from four different points of supply thereto to be discharged through port 44 located centrally of plate 46. Similarly, a second spinnable medium B is introduced through end plate 28 by way of supply fitting 42 and through distribution plate 22A and its associated spacer plate 26 by way of aligned distribution apertures 34B to thereby reach shuttle slot 37 formed in shuttle plate 21B, which latter plate functions to centralize the feed from laterally displaced fitting 42 preparatory to its being redistributed by plate 22B. Flow B is then conveyed, by way of port 29 of centrally apertured plate 27, to the cut-out 36B in manifold plate 22B, which cut-out may be identical to that of plate 22A, only displaced 90 degrees relative thereto. The medium B is then distributed throughout the cut-out 36B to be conveyed by way of suitably aligned distribution apertures 34B to communicate with a similarly configured and oriented cut-out 36A in manifold plate 24B, whereat it merges with the discharge from port 44 in the form of a sheath concentric to the previously formed core of medium A to be discharged through port 48 in centrally apertured plate 50. The merged streams are then conveyed through the downstream end block 28 by way of terminal port 52 to be conveyed to a remote spinneret of suitable orifice configuration.

It is, of course, to be understood that the laminated plate generator just described is merely illustrative of a relatively simplified embodiment of my invention wherein there is accomplished only a single stage merger of two separate mediums to form a core and single ring which, in the case of spinning a conjugated filament of high potential self-crimpability, would be presented to a spinneret containing a single ring of spinneret orifices aligned to intercept the interface between the core and concentric ring of diverse spinnable mediums A and B.

Consider, for example, the partial cross-section of an assembled stream generator shown in FIG. 5 similar to that of FIG. 4, but arranged to have two stages of merger to generate a pattern having a core A, intermediate ring B and outer ring A which, again, in the case of spinning filaments of optimum self-crimpability, would be presented to a spinneret having two concentric rings of orifices, each arranged to intercept one of the two interfaces of the tri-zoned stream pattern. It will be observed from a view of FIG. 5 that successive streams are caused to merge in a laminar fashion externally of previously generated layers rather than being introduced centrally thereof, which latter mode has been found difficult in the matter of avoiding local zones of turbulence, which are fatal to the successful operation of the present device where it is desired to produce conjugate filaments having well defined lines of inter-zone demarcation, a requisite to maximum crimpability.

It is clear from a consideration of FIGS. 4 and 5 that it will be quite expedient to generate a stream having any number of additional rings simply by incorporating additional sets of manifold and spacer plates which may be variously stacked to generate any desired sequential combination of component streams A and B, or the plates may be arranged to introduce three or more different mediums in any desired sequence. Further, it is contemplated that, by varying the supply pressures of the individual component mediums, there may be accomplished a variation in the individual flow rates which will be reflected in a variation of the multi-component stream pattern accompanied by a controlled variation in the alignment of the respective interfaces with the orifices which they supply, which serves to shift the distribution of the two component mediums supplying a given orifice to thereby provide a change in the component distribution ratio of the filament issuing therefrom. Also, as previously related, it is possible to produce individual filaments, each of which exhibits a variation in its component distribution ratio along its length. This is accomplished by causing one or more of the stream interfaces to cyclically fluctuate with respect to its line of orifice intersection.

It will be appreciated that, where it is desired to produce a plurality of filaments from a given spinneret having a pre-determined ratio of component distribution, it will be necessary to adjust the component stream flow rates accordingly, taking into account the number of orifices to be supplied by a given pair of component streams. Take, for example, the simple case of a spinneret having a 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. 1, in the form of a core A, intermediate ring B and outer ring A; assume that it is desired to produce filaments having a ratio of component distribution on the order of two parts A to one part B of a high degree of inter-filament uniformity. It follows that the flow rate of core A must be adjusted, relative to that of intermediate ring B, to supply two thirds of the flow discharging from the inner ring of nine orifices and the flow rate of the outer ring A must be adjusted, again relative to that of the intermediate ring B, to supply two thirds of the discharge through the outer ring of eighteen orifices. Similarly, the flow rate of intermediate ring B must be adjusted, relative to the flow rate of core A and outer ring A, to supply one third of the discharge from both the inner and outer rings of orifices. It follows, therefore, that the 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 a component distribution ratio of two parts A and one part B.

It is of course possible, although the previous discussion of my novel laminated plate generator has been largely taken up with the generation of multi-component streams having a concentric ring configuration, that variations on this basic configuration may be desired where a spinneret having other than a concentric ring arrangement of orifices is employed or where it is desired to extrude a bundle of filaments exhibiting a certain desired inter-filament variation in component distribution ratio, but where each filament exhibits a constant distribution ratio along its length. Such an inter-filament variation is easily accomplished employing the present apparatus simply by blocking selected flow passages as, for example, by employing masking plates which serve to partially mask appropriate areas of the cut-outs 36, 38 or distribution apertures 34. By such an expedient, a multi-component stream having the cross-sectional pattern shown in FIG. 6, and many other similar variations, are easily accomplished.

The following example will aid in a further understanding of one possible mode of operation of my device.

Example

Two separate solutions of acrylic polymer in dimethylacetamide were prepared by low temperature slurrying and mixing. Each solution consisted of approximately 25 percent by weight of a copolymer of approximately 94 percent arcylonitrile and 6 percent vinyl acetate, having a specific viscosity of 0.15, dissolved in dimethylacetamide. To one of the dopes there was added 0.25 percent by weight of a blue pigment. The dopes were separately fed, at equal flow rates, to a generator of the type shown in FIG. 4 arranged to produce a laminated dope stream in the form of a core and one concentric ring, which was fed to a spinneret having a single ring of holes. The configuration of the dope stream was ascertained by observing the pattern retained on a nylon cloth filter placed just upstream of the spinneret. Bi-component filaments containing polymer distribution very closely approximating a 1:1 ratio and having a hemispheric configuration were obtained. Longitudinal sections of the filaments so formed were found to be composed of the same distribution of the two polymers throughout their lengths. Thus, each separate component was found to be continuous throughout the length of the extruded filaments.

It may now be appreciated that there has been herewith disclosed a novel apparatus for use in generating concentric-ring patterned streams of diverse spinnable mediums which are particularly suited to the multi-component filamentary spinning technique, wherein the interface between two adjacent mediums is caused to intersect one or more orifices of predetermined arrangement to produce filaments having a desired ratio of component distribution. 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 apparatus for merging successive fluid streams in a laminar, peripheral fashion to generate a multi-component stream of a predetermined pattern, said apparatus comprising a body of laminated construction having at least two inlets and at least one outlet passage at least two multi-branched systems of passageways, each communicating between one of said inlets and a plurality of spaced, alternate points of merger along said outlet passage, whereby successive fluid streams of independent origin are peripherally merged in a predetermined sequence with a pre-established stream to generate a multi-component stream.

2. The apparatus as defined in claim 1 wherein said laminated construction takes the form of a plurality of apertured plate members secured in face-to-face relationship, each such plate being of a multiple-unit thickness.

3. The apparatus as defined in claim 1 wherein each of said points of merger is supplied by a pluaritly of the branch passages of one of said systems of passageways, which branch passages are substantially equi-spaced circumferentially relative to said outlet passage.

4. An apparatus as defined in claim 2 wherein each of said points of merger is supplied by a plurality of the branch passages of one of said systems of passageways, which branch passages are substantially equi-spaced circumferentially relative to said outlet passage.

5. A patterned stream generator operative to merge, in a laminar fashion, a plurality of components to form a substantially concentric-ring pattern, said generator comprising a laminated body member composed of a plurality of apertured plate members aligned to define at least two discrete, multi-branched systems of passageways, each said system terminating in a plurality of spaced merger points arranged in successively alternating sequence with the spaced points of merger of the other of said systems of passageways, each said merger point communicating with a plurality of branch passages of one of said systems of passageways, said plurality of branch passages being spaced circumferentially about said merger point, whereby there may be effected a plurality of successive laminar-flow mergers peripherally of a pre-established stream to thereby generate a ring-like pattern.

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