Sept. 5, 1967 W. C. DODSON, JR., ETAL 3,339,362

METHOD OF JOINING STRANDS

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FIG. 1

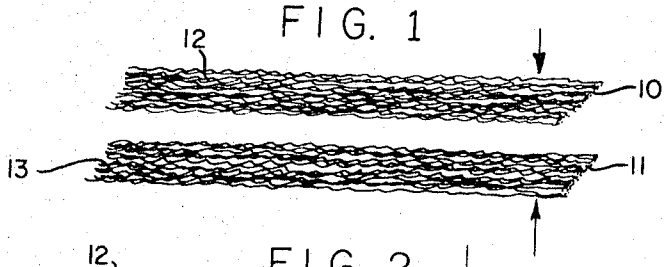


FIG. 2

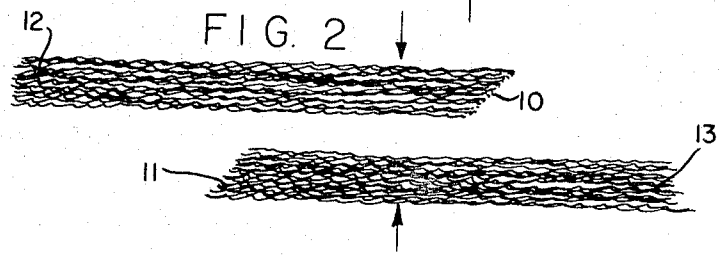


FIG. 3

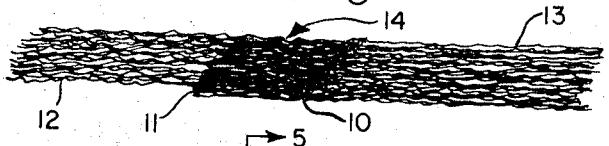


FIG. 4

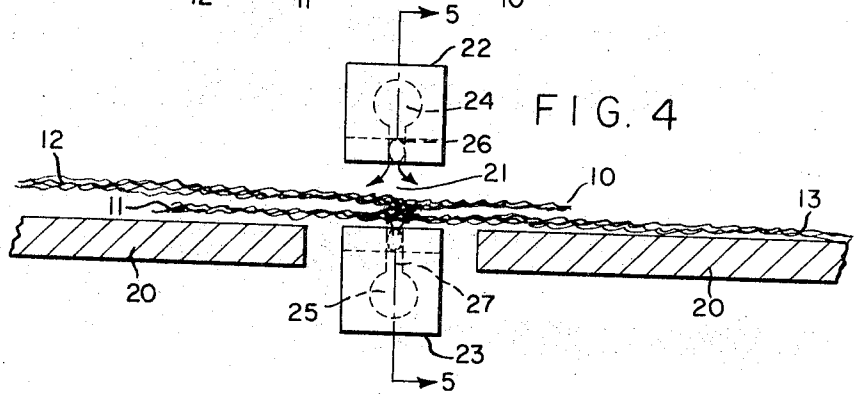
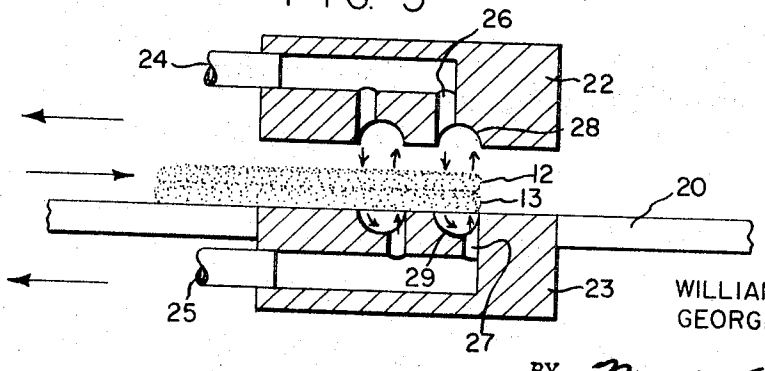


FIG. 5



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FIG. 6

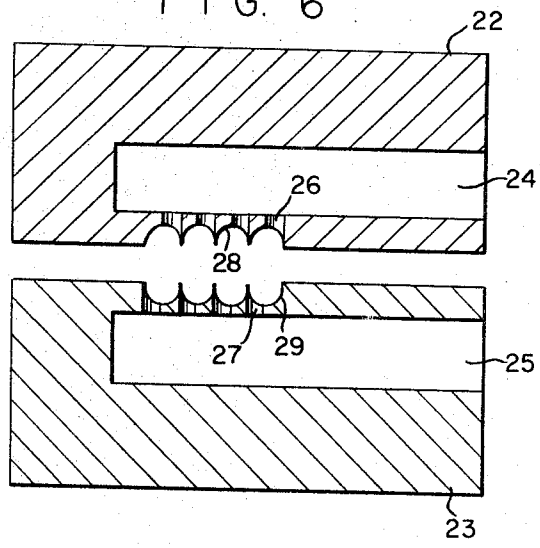


FIG. 7

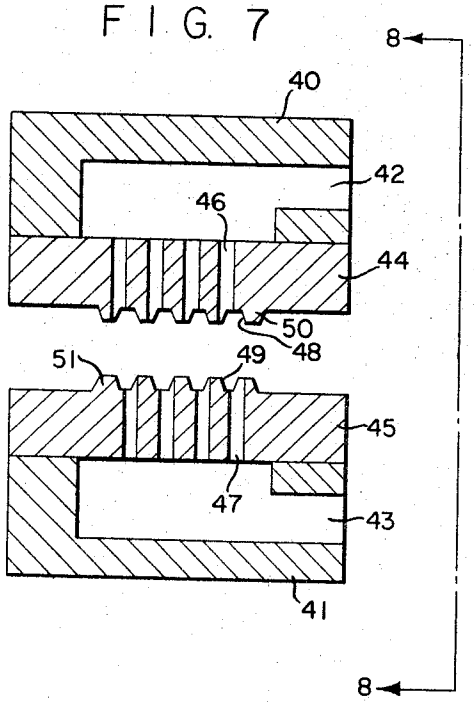
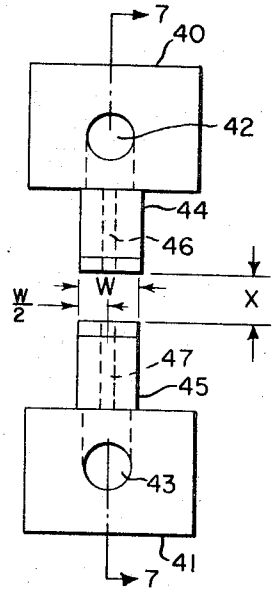


FIG. 8



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FIG. 9

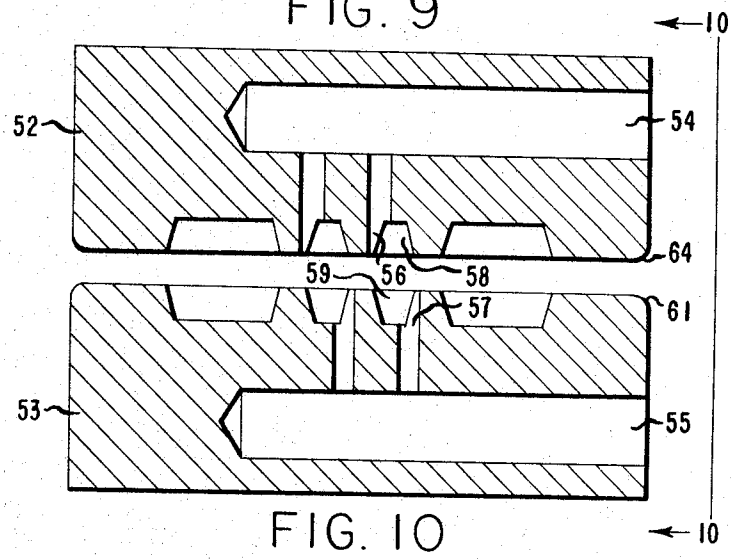


FIG. 10

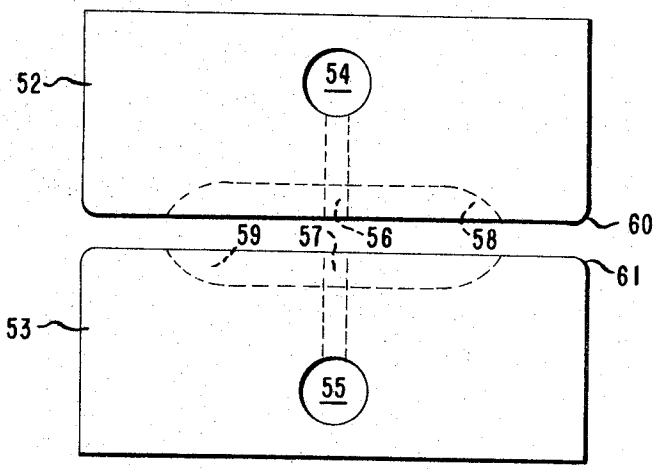
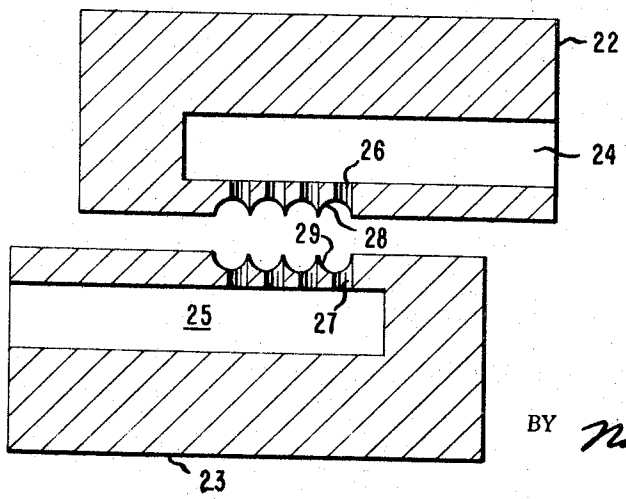


FIG. 11



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3,339,362

METHOD OF JOINING STRANDS

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4 Claims. (Cl. 57—159)

This is a continuation-in-part of application Ser. No. 490,387, filed Sept. 27, 1965, now abandoned. The invention relates to the production and handling of textile fibers and is particularly concerned with a jet treatment for joining of multifilament strands to provide continuous yarns and tows. More specifically, this invention relates to a novel and useful method for joining overlapped free ends of yarns or tows by forming a narrow swath of interentangled fibers transversely across the fiber bundle.

In the manufacture and processing of textile fibers it is usually desirable to maintain continuity of a running strand for efficient operation. Various methods have been devised in the textile industry to join yarns or tows when an interruption occurs or when a yarn end is reached and a new yarn supply is to be introduced. The oldest form of such joint is a hand-tied knot. Many mechanical devices for tying knots have been developed. Another method of joining yarns or tows is to cement the free ends together with an adhesive. For softenable materials, a firm connection can be made by fusing the ends together by heat or with a solvent. All of these joints are time consuming and wasteful. In addition, the knot introduces an enlargement in a strand which interferes with passage through guides, cutters or other subsequent steps in processing of the yarn or tow. The cemented joint introduces a contamination into the product. The fused joint contaminates the product with hardened clumps of filaments. Some of these methods are completely impractical for use with large filamentary ropes or tows.

This invention provides a simple and economical method for joining portions of filamentary strands. By making a joint quickly and simply, the labor required and the interruption in flow of material are minimized. The invention also reduces the waste resulting from sections of yarn or tow which are degraded or contaminated by the prior art methods. The improved splice of this invention eliminates the usual lump at the joint in the tow and facilitates passage of the joint through conventional processing machinery. The splice also provides a joint which is strong and flexible. Still another advantage is that the invention is useful to join together adjacent filamentary bundles at intermediate regions along their lengths.

In the process of this invention, strong joints are provided between multifilament strands, such as yarns or tows of fibers, by:

(1) Jetting a plurality of opposing high velocity fluid streams with the axes of the streams aligned in a common plane,

(2) Arranging a plurality of filamentary strands with portions in an overlapping, generally parallel relationship between the opposed fluid streams, and with the strands aligned to be nominally perpendicular to said common plane of the fluid streams, and

(3) Effecting relative motion between the overlapped strands and the opposed fluid streams in a direction substantially parallel to said common plane of the fluid streams so that fluid streams apply successive entangling forces against opposite sides of the overlapping strand portion and in the plane of passage of the overlapped strands through the streams, the treatment being continued to form a strong joint of interentangled fibers extending across the overlapped portions of the strands.

In this treatment, the fibers within the influence of the fluid streams are momentarily separated and whipped about to become intermingled, twisted and firmly entangled. The fibers of the different strands are so intermixed or twisted and ensnarled with each other that the strands are united into a strong joint in the treated region. The formation of the zone of fluid treatment is preferably accomplished with at least two pairs of opposed streams of air or steam in which the streams of each pair are slightly offset with respect to each other in the direction of motion of the strand. A plurality of such opposed arrangements may be used, or the process may be repeated several times, preferably at different places, to make a multiple splice. The process may be used for either yarns or tows. When large tows are being joined, the splicing is more effective if the filamentary bundle is spread out in the form of a flat band or a ribbon.

A preferred apparatus of this invention comprises conduit means for producing a plurality of opposing streams of compressible fluid aligned in a common plane, means for aligning the filaments of a plurality of strands in overlapping, generally parallel relationship between the opposed streams and substantially in a plane, which plane is nominally perpendicular to the plane of the axes of the fluid conduits, and means to effect relative motion between said strands and said fluid streams in a direction substantially parallel to the common plane of the fluid streams. The process may be more effectively operated by directing a compressible fluid at high velocity through a conduit essentially perpendicular to the plane of strand travel and directed against an inclined wall on the opposite side of the plane. Filaments or groups of filaments are randomly spread apart, oscillated, twisted and intermingled with adjacent filaments or filament groups by the interplay of the plural fluid streams.

A better understanding of the invention will be gained by reference to the drawings and description below.

FIGURE 1 and FIGURE 2 are schematic illustrations of two filamentary bundles in overlapping positions prior to making an end joint according to this invention.

FIGURE 3 is a schematic illustration of a joint made according to the invention.

FIGURE 4 is a side elevation of one form of apparatus which also schematically illustrates treatment of the filamentary bundles within the apparatus while making the joint of FIGURE 3.

FIGURE 5 is a sectional view taken on line 5—5 of FIGURE 4.

FIGURE 6 is a sectional view, similar to that of FIGURE 5, of another form of the apparatus for accomplishing this invention.

FIGURE 7 is a sectional view, taken on line 7—7 of FIGURE 8, of a preferred embodiment of apparatus for use in the process of this invention.

FIGURE 8 is a side elevation of the apparatus shown in FIGURE 7.

FIGURE 9 is a sectional view, similar to that of FIGURE 7, of another form of apparatus for accomplishing the invention.

FIGURE 10 is a side elevation of the apparatus shown in FIGURE 9.

FIGURE 11 is a sectional view, similar to that of FIGURE 6, of an alternative alignment of the apparatus components.

A variety of filamentary materials may be joined by the method of this invention. Multifilament structures of continuous filament or long staple fibers in the form of yarns or tows can be readily fastened together. The structures may be twisted or may have zero bundle twist. The filaments may be natural or synthetic, either in a compact form or in a relatively loose bulky state, and with

or without crimp. Usually only two strands are spliced together at a joint but a greater number can be combined if so desired. The filaments of the bundle are preferably in a generally parallel alignment but this is not a requirement; webs or mats of randomly-arranged filaments may be joined by this novel method.

To make the desired splice, the end portions **10** and **11** of the filamentary bundles to be connected are overlapped, either with the ends aligned in the same direction in juxtaposition as in FIGURE 1 where filament bundle **12** is shown above filament bundle **13**, or with the filament bundles **12** and **13** extending in opposite directions as shown in FIGURE 2. It is preferred that large bundles of filaments be spread out in ribbon-like form, to facilitate penetration of the treating fluid through the filamentary structure and to obtain a greater degree of interentanglement between the filaments in the ends to be joined. After being placed in the desired relationship, the loose assembly of filaments, in essentially tensionless condition, is held in position on both sides of the zone to be joined and is then pased through the fluid treatment zone. The filamentary assembly may be held by hand or by a suitable clamp for temporary support under little or no tension during the splicing process.

FIGURE 4 is a schematic illustration of an assembly of overlapping filaments undergoing the joining process in one form of apparatus. The overlapped region of filamentary bundles **12** and **13** is supported on platen **20** which is aligned with the fluid treating zone **21** between the spaced halves **22** and **23** of a plural jet apparatus. A gaseous treating fluid, such as air, is supplied under pressure through passages **24** and **25** and, in turn, is directed through orifices **26** and **27** into the treating zone **21** to impinge upon the filaments of bundles **12** and **13** so as to set up a turbulent action, causing them to separate, oscillate and become interentangled either singly or in groups.

FIGURE 5 shows a corresponding transverse sectional view of the process and apparatus taken along line **5—5** of FIGURE 4. The overlapping assembly of filamentary bundles **12** and **13** is moved relative to the fluid treating apparatus comprised of spaced halves **22** and **23**. The treating apparatus may be fixed while the filamentary material is moved across the platen **20** through the treatment passage, much as fabric is fed through a sewing machine and seamed. If desired, the material to be joined can be held in a fixed position while the treating device is moved across its width.

One effective treating apparatus employs fluid orifices **26** and **27** which are aligned, in the direction of fiber treatment, in a common plane essentially perpendicular to the treatment zone and which, when supplied with gaseous fluid under pressure will produce high velocity streams of gaseous fluid arranged in pairs so that each stream of a pair flows closely adjacent to, and in an opposed direction to, the other stream. In the path of each jet stream is a groove having an inclined surface, such as **28** or **29**, which will divert the jet stream so that it will merge and flow with the adjacent jet stream flowing in the opposed direction. This provides a turbulent fluid action which is believed to be most effective to produce the desired entangling action on the filaments. In FIGURE 5, for example, fluid flows from orifice **26** downward through the filaments, strikes inclined wall **29** and is diverted toward the mouth of orifice **27** where it joins the jet stream flowing upward through the filaments. The upwardly directed stream strikes inclined wall **28** and is directed toward the mouth of orifice **26** where the flow pattern continues around the circuit. The grooves contribute to the efficiency of the apparatus by providing escape passages for the treating fluid, directing the fluid in a plurality of paths generally lengthwise of the fibers and parallel to the plane of the fiber strand thus enabling the fluid to exert additional forces on the fibers and enhance the entangling action. The escaping fluid flows along the grooves sidewise out of the treating apparatus, subjecting the filaments to an aligning force which facilitates the interentanglement. Surprisingly, the intense interentanglement of filaments and twisting of groups of filaments occurs within the treating zone defined by the apparatus and there is relatively little disturbance of the filament bundles outside this zone. The process may be repeated as often as desired in the overlapped region to provide a stronger joint.

FIGURE 6 is a cross-section of another fluid-treating device which closely resembles the apparatus of FIGURE 5, but which differs in the greater number of fluid conduits and the closer spacing of these conduits, providing more closely adjacent plural fluid streams. The discussion of FIGURE 5 also applies to FIGURE 6 and the same reference numerals have been used.

A particularly effective and preferred jet apparatus is illustrated in FIGURES 7 and 8. As with the apparatus of FIGURES 4, 5 and 6, the apparatus of FIGURES 7 and 8 comprises two cooperating halves. The upper half comprises a body **40** with fluid passage **42** and an orifice plate **44**. In this embodiment orifice plates are fabricated from sections of gear rack. Fluid ducts have axes perpendicular to plate **44** and off-center in the grooves formed by teeth **50**. The opposing half comprises body **41** with fluid passage **43** and orifice plate **45** and is similarly fabricated by providing fluid ducts **47** off-center in the grooves formed by teeth **51**. The two halves are so aligned that the axis of each fluid conduit intersects the face of a tooth in the other half so that an inclined wall is presented to the fluid stream issuing from the fluid conduit, as illustrated by the position of face **49** opposite the conduit **46** and face **48** opposite conduit **47**. The two halves are separated by distance X, sufficient for free movement of the filamentary material to be joined. In a typical assembly, each orifice plate has two or more grooves at a center-to-center spacing of 0.098 inch and a groove depth of 0.067 inch. Four grooves are illustrated. A 0.50-inch diameter fluid duct is located off-center in each groove. These have axes perpendicular to the face of the orifice plate along a straight line on 0.098 centers. The width W of the grooved portion, as viewed in FIGURE 8, is about 0.2 inch; it should be noted that the axes of the fluid ducts **46**, **47** are located a distance of about $W/2$ from the edge of the orifice plates **44**, **45**. The apparatus is assembled as shown in FIGURE 7 with the grooves in approximate alignment and with a separation distance X between the halves of 0.094 to 0.250 inch, preferably about 0.12 inch. The cross-sectional shape of the grooves in the orifice plate may have any of several forms. Other wave or tooth forms than the gear-teeth shown may be used, including curvilinear sinusoidal corrugations or gometrical sawtooth shape. The grooves may have curved walls with a parabolic or semicircular shape or flat planes to form a triangular, trapezoidal or other rectilinear cross-section.

FIGURE 9 is a sectional view of a form of the apparatus similar to FIGURE 7. FIGURE 10 is a side elevation of the apparatus shown in FIGURE 9. The assembly comprises two body members, having opposed planar faces, with suitable supporting structure. One half comprises a body **52** with grooves **58** formed in one face, a passage **54** for the introduction of the treating fluid and fluid ducts **56** to conduct the fluid from passages **54** to grooves **58** in a direction essentially perpendicular to the face of the body member. Similarly, the second half of the assembly is a body member **53** with a fluid supply passage **55**, and fluid ducts **57** communicating with grooves **59** in the face of the body. The grooves **58** and **59** should be sufficiently long to permit ready lateral flow of the spent fluid away from the zone of fluid treatment between the ducts **56** and **57**. As shown, the grooves extend about one-half the distance to the face edges. The edges of the body member are chamfered or rounded as at **60** and **61**. The advantage of this embodiment is that there is no ob-

struction to the free passage of filamentary material through the space between the two body members. With the grooves fully recessed in the faces and the edges of the body members rounded, individual filaments or groups of filaments will pass freely through the apparatus during the treatment.

In another embodiment in which the opposing streams are directly aligned, the filamentary splice is also obtained. Such an embodiment is shown in FIGURE 11. Opposed jet devices **22** and **23** are provided with fluid supply passages **24** and **25**. Fluid ducts **26** and **27** are positioned perpendicular to the face of the jet device and to one side of the center line of the grooves **28** and **29**. It will be noted that this embodiment is obtained by simply reversing the alignment of the two body members **22** and **23** from the relative positions shown in FIGURE 6.

In other embodiments of the apparatus it is possible for the fluid jets to be directly aligned and opposed or to intercept the grooves at the center line of the transverse section. Two or more counteracting streams, either directly aligned or slightly offset, will produce the splice. An odd number of fluid streams will also operate, such as a single stream directed between and counteracting a pair of opposite streams.

Although a gaseous treating fluid is preferred, any of the embodiments of this invention can be operated with liquid as the fluid. For example, they will produce effective joints with water at about 80 p.s.i.g. One of the advantages of using air is that a dry joint is obtained.

As indicated by the above dimensions, the apparatus is particularly compact and may be fabricated from conventional materials such as metals, plastics, ceramics or other common materials of construction.

The product of this invention is a joint between two or more filamentary bundles comprising a distinct zone of interentanglement of the filaments of each bundle with the filaments of the adjoining bundle. As illustrated in FIGURE 3, a linear zone of entangled filaments **14**, between the ends **10** and **11**, connects filament bundles **12** and **13** in an overlapping joint. Joints produced in the apparatus of FIGURES 6, 7 and 8 have demonstrated substantial strength. Nylon tows of 2.3 d.p.f. and 618,000 total denier; 3 d.p.f., 430,000 total denier and 18 d.p.f., 440,000 total denier, which have been joined by the process in a single pass of the tow using an air pressure of 90 p.s.i.g. in the apparatus of this invention, yield joints which withstand at least 200 pounds pull. A useful range of air pressures for this purpose is 25 to 500 p.s.i.g. In making tow joints as above, the relative velocity of the fiber strands with respect to the fluid streams is of the order of 5 to 20 inches per second. The relative velocity is governed by the fibrous material to be joined and the configuration of the apparatus. The material should pass through the fluid streams at a rate which will allow sufficient time for the streams to produce the desired entangling effect. This invention is not limited to nylon. Strong joints in polyester tows of 1½ d.p.f. fiber of 800,000 to 1,100,000 total denier and 3 d.p.f. fiber of 460,000 to 920,000 total denier have been made in the apparatus of FIGURES 10 and 11 using air at pressures in the range of 65–95 p.s.i.g. Any filamentary bundle of synthetic or natural fibers may be joined by this process. The process is not dependent on thermoplasticity, solubility, or other adhesive property of the fiber materials, and avoids the use of knots or cement. The fibers must have sufficient length to encompass the length of the joint. When continuous filament yarn is being joined, the absence of twist facilitates the joining process although a moderate degree of twist may be tolerated. After the joint has been made, free ends may be trimmed short with scissors or other cutting instrument, if desired. However, trimming is unnecessary, since the splicing treatment can extend to the tips of the filamentary bundles.

This invention may be utilized at any stage in textile fiber manufacture or use, wherever there is need for joining filamentary strands. This includes fiber spinning, stretching, relaxing, beaming, weaving, tow cutting, drying and the like. If desired, filamentary strands may be joined at any point along their respective lengths; use of this invention is not restricted to the joining of strands at the ends. For example, the free end of one yarn bundle may be incorporated into another yarn bundle at an intermediate region along its length in order to commence a plying operation without severing a continuous strand. It may also be desirable to join together adjacent filament bundles at predetermined regions along the lengths to provide coherency to the assembly of bundles at each region. The path of fluid treatment may traverse the strand either perpendicularly or diagonally with respect to the longitudinal axis of the filament bundles.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

We claim:

1. The process for joining portions of a plurality of multifilament strands which comprises jetting a plurality of opposing high velocity fluid streams with the axes of the streams aligned in a common plane; arranging a plurality of filamentary strands with portions in an overlapping, generally parallel relationship between the opposed fluid streams, and with the strands aligned to be normally perpendicular to said common plane of the fluid streams; moving the overlapped strand portions and the opposed fluid streams relative to each other in a direction substantially parallel to said common plane of the fluid streams to apply successive entangling forces against opposite sides of the overlapped strands and in the plane of passage of the overlapped strands through the streams; and continuing the treatment to form a strong joint of interentangled fibers extending across the overlapped strand portions.

2. The process as defined in claim **1** wherein the end portions of the strands are joined.

3. The process as defined in claim **1** wherein the end portion of one strand is joined to an intermediate portion of another strand.

4. The process as defined in claim **1** wherein said streams are arranged in pairs with each stream of a pair flowing closely adjacent and in opposed direction to the other stream, and each stream is diverted by an inclined surface into the path of the other stream.

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