United States Patent

[11] 3,581,486

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[54] **SPLICING OF MULTIFILAMENT STRANDS BY TURBULENT GASEOUS FLUID**
11 Claims, 11 Drawing Figs.

[52] U.S. Cl. 57/22, 57/159
[51] Int. Cl. D01h 15/00
[50] Field of Search 57/22, 23, 159

[56] **References Cited**

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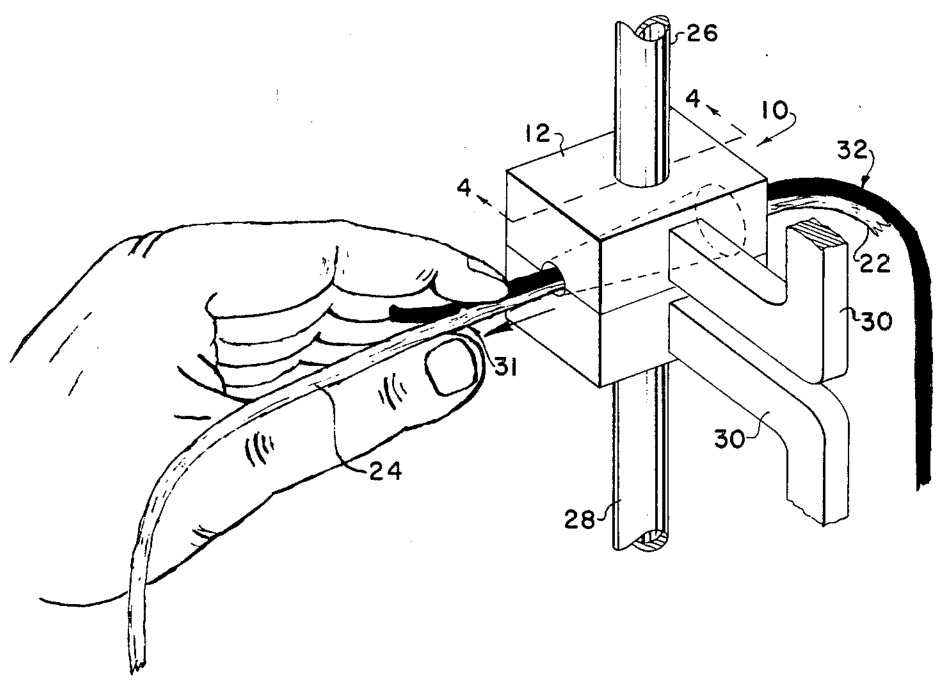
Primary Examiner—Donald E. Watkins
Attorneys—William T. French and Malcolm G. Dunn

ABSTRACT: Method, article of the method and apparatus for practicing the method by which overlapped strands of multifilament material are spliced together by a turbulent gaseous fluid with the resulting splice being about at least 80 percent of the strength of one of the unspliced strands and being only slightly increased in cross-sectional size than that of an unspliced strand; the splice being characterized by a false interweaving.



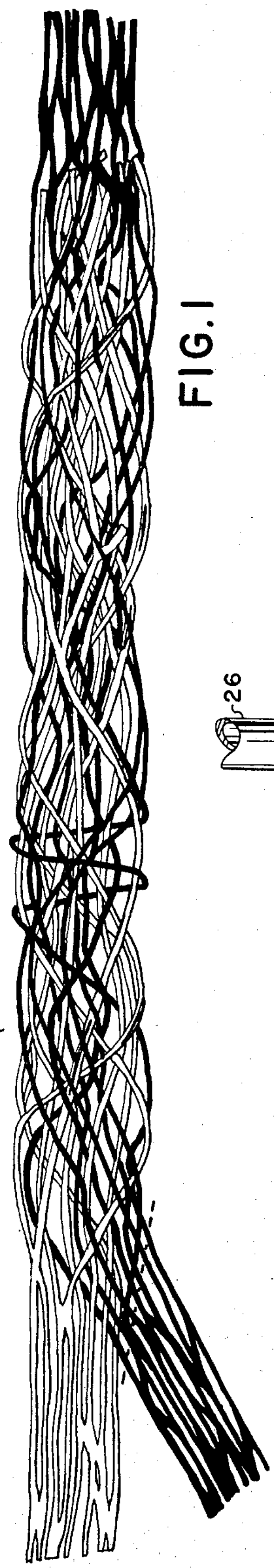


FIG. 1

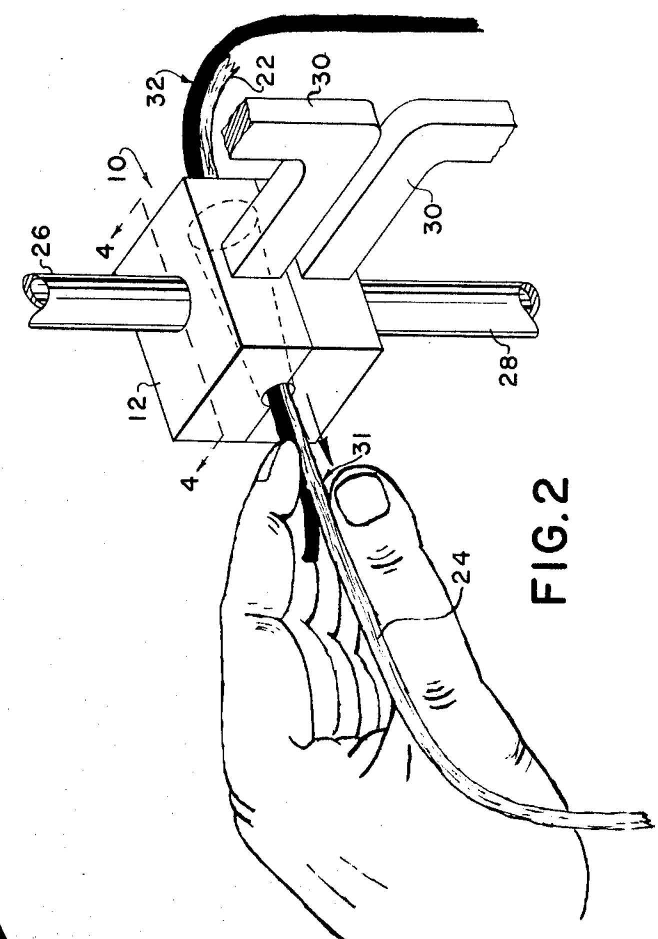


FIG. 2

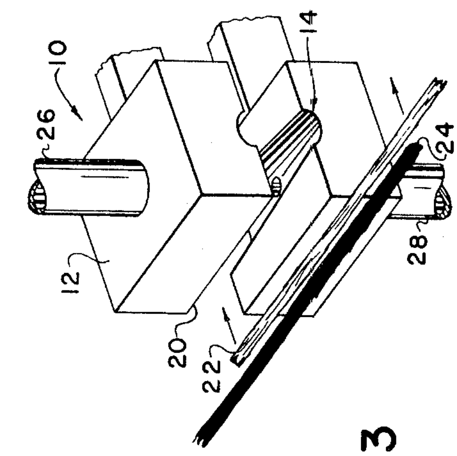


FIG. 3

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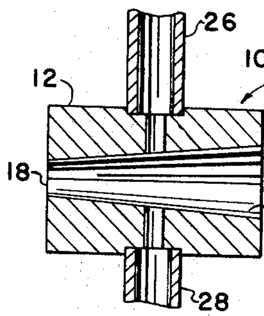

FIG. 4

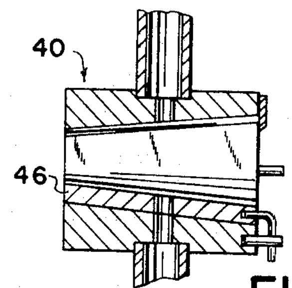

FIG. 6

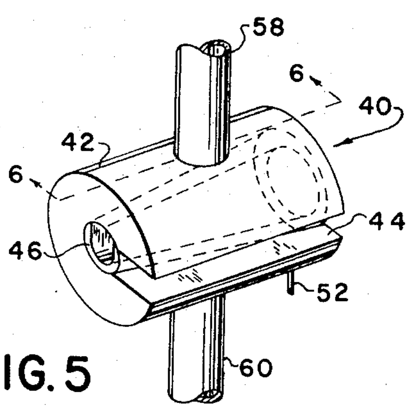

FIG. 5

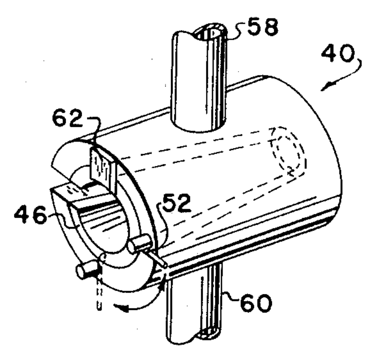

FIG. 7

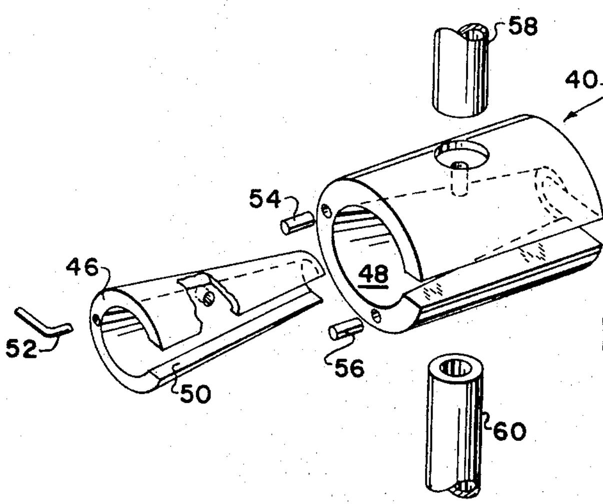

FIG. 8

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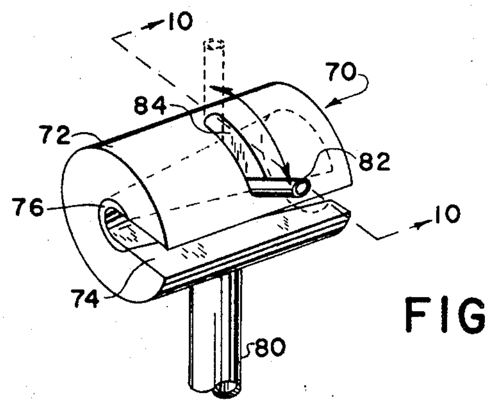

FIG. 9

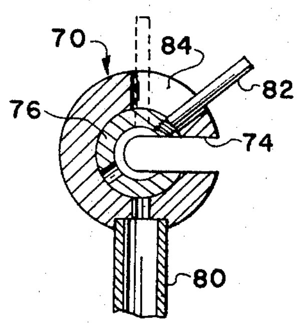

FIG. 10

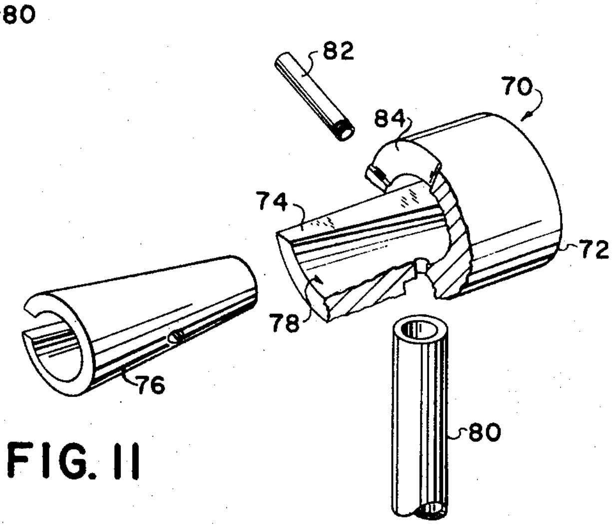

FIG. 11

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SPLICING OF MULTIFILAMENT STRANDS BY TURBULENT GASEOUS FLUID

The present invention is directed to a method, the article of the method and apparatus for practicing the method by which strands of material may be spliced together by a turbulent gaseous fluid, such strands being multifilament yarn, industrial twine or other material having a fiberlike constituency and especially strand material known as "fractured film."

In some operations involving the use of strand materials, it is often inconvenient if the operation cannot be made continuous because it usually means shutting down a machine until a fresh supply of strand material can be loaded into the machine and possibly threaded through the machine before the machine can be restarted. For example, in the manufacture of electrical cable having an extruded plastic sheath, an industrial twine can be used as the stuffing material between the insulated conductors. The stuffing material should be continuous because it is not practical to stop the sheath extrusion process. In still another instance, in textile processing, it is often necessary to join yarns because of breakage or for the purpose of joining a yarn from a fresh bobbin to the yarn from an exhausted bobbin so as to maintain a continuous supply of yarn for a textile machine.

One of the objects of the invention, therefore, is to provide a method and an apparatus for practice of the method by which such strand materials may be easily spliced together by a turbulent gaseous fluid in a manner sufficient to provide the desired continuity between the end of one supply of strand material and the beginning of another supply of such material to avoid shutting down an operation, such as described above.

The use of turbulent flows of air or other suitable gaseous fluids for producing yarn entanglement and splices has been practiced in relatively recent years. The apparatus shown by such U.S. patents as the Gonsalves U.S. Pat. No. 3,274,764; Rosenstein U.S. Pat. Nos. 3,306,020 and 3,379,002; Dodsen, Jr., et al. U.S. Pat. No. 3,339,362; and Iwnicki British Pat. No. 956, 992 (complete specification published Apr. 29, 1964) have been tried for the purpose of splicing industrial twine that is made of "fractured film", but without success. In the instance of the apparatus similar to that shown by the Iwnicki British patent, when overlapped end portions of strands of "-fractured film" were operated upon, the two overlapped portions were fluffed so that the result was that the splice was twice or more the diameter of the original strands and the apparent intertwining of the filamentlike portions or fibrils of the strands came apart readily and thus would not hold together for passage through an operating machine. "Fractured film" for purposes of making a distinction from conventional continuous filament yarn and yarn spun from chopped-up filaments of staple fibers, may be high-strength flexible flat, randomly partially fractured and substantially continuous polymeric ribbons. The ribbons may be partially fractured by a mechanical operation or by subjecting a film or sheeting of polymeric material to the fracturing or slitting action of a gaseous media, the latter being discussed in the Wininger et al. U.S. Pat. No. 3,214,899. The film or sheeting is partially and randomly fractured in a longitudinal direction but not laterally so that a plurality of flat partially fractured ribbons or fibrils are obtained and which are subsequently taken up on a conventional twister, the twisting action serving to impart greater tensile strength by uniting the plurality of ribbons or fibrils into one strand. "Fractured film" may be made from polypropylene film that has a high degree of longitudinal molecular orientation. Such fractured film when spread out flat and before twisting, will reveal numbers of long flat fractured ribbons that are connected at their ends to other fractured ribbons and thus are capable of being further fractured, whether by twisting, by action of a fluid or by other types of treatment. In other words, the film or sheeting has been randomly slit in the longitudinal direction but with no one slit necessarily extending for any substantial length of the film or sheeting. For purposes of claiming the invention, the term "multifilament" will be used to refer not only to continuous filament material and material formed of staple fibers, but also to "fractured film".

It is another object to provide a method and an apparatus for practice of the method by which "fractured film" formed into cordage such as industrial twine may be spliced by a turbulent gaseous fluid without producing an excessive increase in cross-sectional size in the spliced area and having tensile strength of at least 80 percent of the unspliced twine.

It is a further object to produce a splice between overlapped strand end portions of high strength, longitudinally molecularly oriented polymeric film or ribbon, either partially fractured in longitudinal manner and twisted in form as twine or in the tow or web form before twisting by false interweaving of the fractured portions of the overlapping strands.

It is still a further object to produce a splice between overlapped end portions of multifilament strands of material, the splice being characterized by a false interweaving of the filaments.

Other objects inherent in the nature of the invention disclosed will become apparent to those skilled in the art to which this invention pertains from the drawings and the description in the specification.

In the drawings:

FIG. 1 is a view of the splice produced between two overlapped strands of fractured film with one strand being shown in white and the other strand in black;

FIG. 2 is a perspective view of the apparatus illustrating manual holding of one end of the two overlapped strands at one end of the housing;

FIG. 3 is a perspective view of the apparatus illustrating separation of the two halves making up the housing for enabling the overlapped strands to be inserted laterally of their length into the chamber of the housing;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 2;

FIG. 5 is a perspective view of an alternate embodiment illustrating a movable sleeve within the housing;

FIG. 6 is a cross-sectional view of the apparatus taken along line 6—6 of FIG. 5;

FIG. 7 is a perspective view of the embodiment of FIG. 5 but oriented illustrating the ends of the housing reversed;

FIG. 8 is an exploded perspective view of the FIG. 5 embodiment and as illustrated in the view shown in FIG. 7 but without the tab shown in FIG. 7;

FIG. 9 is a perspective view of a further alternate embodiment of the apparatus illustrating a movable sleeve within the chamber of the housing and the handle serving also as one of the conduits;

FIG. 10 is a cross-sectional view of the apparatus taken along line 10—10 of FIG. 9; and

FIG. 11 is a perspective exploded partly broken away view of the apparatus illustrated in FIG. 9 but oriented with the ends of the housing reversed from that shown in FIG. 9.

In reference to the drawings, the splicing apparatus 10 involves a housing 12 that may be separable into halves as shown in FIGS. 1 to 4 and that defines therewithin a chamber 14, the chamber being open at its ends through the housing and having at one end an opening 16 that is larger than the opening 18 at the opposite end. The two halves of the housing provide a closeable opening 20 that extends the length of the housing and through which closeable opening overlapped end portions 22, 24 of strands to be spliced or joined may be inserted laterally of their length into the chamber wherein they are loosely confined. The chamber may have the shape of a truncated cone since it is easier to fabricate such shape chamber by a tapered reaming tool than one having interior sidewalls that may curve in exponential or other suitable nonlinear manner so as to provide one end opening of the chamber larger than that of the opposite end opening. The housing is further provided with opposed conduits 26, 28 through which a suitable gaseous fluid such as air may be introduced into the chamber for creating therein a turbulence. The two halves of the housing may be moved apart and moved together by suitable means such as by C-clamps, only a portion of the clamps being shown at 30.

In the operation of the apparatus, the two overlapped end portions 22, 24 of the strands to be joined or spliced are positioned within the chamber 14 by insertion through the closeable opening 20, the overlapped strands being held at their one end, as shown in FIG. 2 at 31, while the other end indicated at 32 in FIG. 2 remains free. Although the overlapped strands are shown as being manually held, any other suitable holding means may serve the same purpose, which holding means may also be caused to move the overlapped strands through the apparatus during the splicing operation. When the overlapped strands are positioned within the chamber, the closeable opening 20 of the housing is closed into operable position and a microswitch (not shown) or other suitable means may be used to energize the flow of a suitable gaseous fluid, such as air, through the conduits and into the chamber. The opposed streams of gaseous fluid tend to support the overlapped strands free from resting contact with the chamber walls as the streams impinge upon the strands at their opposite sides at one location along their axes. The strands are moved or pulled through the chamber relative to this one location for exit from the smaller end opening 18 of the chamber at the rate of about 10 f.p.m. (feet per minute). Since one end opening 16 is larger than the other end opening 18, a preponderance of the gaseous fluid will flow out the larger end opening 16. The resultant flow of the turbulent flow will be at a diverging angle relative to the axes of the overlapped strands.

It cannot be fully explained why the splice shown at 34 in FIG. 1 is obtained by use of a housing having a chamber therein as the configuration disclosed. Perhaps at some point during its operation a tensionless state is produced along the length of the overlapped strands so as to bring about the splice shown in FIG. 1. It has been observed during operation of the apparatus that at the free end of the overlapped strands a ballooning effect occurs before they are pulled or moved into the chamber, and it may be possible that the entanglement finally takes place at the small opening 18 of the housing prior to emergence of that portion of the overlapped strands that was initially positioned within the chamber. The tensionless state may be partially brought about by the partial self-feeding effect on the overlapped strands by the lesser amount of gaseous fluid that exits from the smaller end opening 18.

The resulting splice 34 is characterized generally by a false interweaving, since any given fiber or fibril has been manipulated at some point along its length, and the end of the fibril, particularly if it is "fractured film," due to the webby nature of "fractured film," would not have been available to have been passed through portions of the strands as is generally done in forming splices in ropes and cordage. Thus, for every wrap of one fibril around another in one direction there must be a wrap in the opposite direction with the consequence that repeated shock loading will cause the false interweaving to come undone and therefore free the strands that were spliced or joined in this manner. It is also observed that a group of fibrils from one strand will wrap around a group of fibrils from another strand with only the end of the fibrils at the ends of the strand tending to be more truly interwoven on a one fibril to one fibril basis. The strength of the splice is at least about 80 percent of that an unspliced strand; the cross-sectional size or diameter of the splice is nearly the same as that of an unspliced strand or only slightly increased. Thus, the splice is capable of passing through most operating machines that use strand materials without causing any difficulty. With respect to "fractured film," a splice would be further characterized by some weakening of the resulting spliced strands because the turbulent gaseous fluid would have to have caused a further fibrillation of the randomly slit ribbon in order to obtain the splice.

The amount of pressure used is dependent upon the size of the chamber and of the strand material being spliced. The following examples are illustrative of some of the results attained by practice of the invention:

EXAMPLE I

Two strands of industrial twine were joined or spliced in a housing having a truncated cone-shape chamber about 1 inch in length with the smaller end opening being about 3/16 inch in diameter and the larger end opening being about 7/16 inch in diameter. The twine was polypropylene "fractured film" of 13,400 denier, having a film thickness of about 3 mils and having been twisted about 0.9 turns per inch. A gaseous fluid, air, was used at about 60 p.s.i.g. (pounds per square inch gauge). A Scott pendulum-type tester, Model J, was used to determine the breaking strength of a strand of the twine, which proved to be about 83 pounds, and the breaking strength of the splice proved to be about 76 pounds; the splice thus being a little more than 91 percent as strong as the unspliced strand. The diameter of the strand was about ⅛inch and the diameter of the splice without tension was about 3/16 inch but under about 40 -pounds tension, the diameter of the splice proved to be about 5/32 inch.

EXAMPLE II

Two strands of industrial "fractured film" were spliced similar to that described in Example I except that the denier was 24,500. The configuration and length of the chamber was the same, but the smaller end opening was about 7/16 inch in diameter and the larger end opening was about 11/16 inch in diameter. A gaseous fluid, air, was used at a pressure of about 75 p.s.i.g. The Scott tester was used, which proved breaking strength of the twine to be about 186 pounds and the breaking strength of the splice to be about 172 pounds; the splice thus being a little more than 92 percent as strong as the unspliced strand. The diameter of the strand was about less than 3/16 inch and the diameter of the splice was about ¼inch, but under about 40 pounds tension the splice diameter was lessened by about 1/32 inch.

EXAMPLE III

Two strands of foamed continuous-filament polypropylene twine were spliced, each strand containing 70 filaments and being of 14,000 denier. The configuration and length as well as the end openings of the chamber were the same as that given in Example II. The gaseous fluid, air, was used at a pressure of about 70 p.s.i.g. A floor model Instron tester was used, which proved the breaking strength of the unspliced strand to be about 123 pounds while the breaking strength of the splice proved to be about 118 pounds; the splice thus being a little more than 95 percent as strong as the unspliced strand. The strand diameter was about 150 inch and the resulting spliced diameter was about ⅜inch which lessened to about 3/16 inch when placed under tension of about 40 pounds. Since the filaments were relatively stiff, this is thought to account for the unusually large diameter of the splice obtained. It could be, also, that a greater gaseous fluid pressure might result in a splice having a smaller diameter.

EXAMPLE IV

Two dissimilar strands were spliced, one being sisal with a breaking strength of about 330 pounds on the Instron tester and having a strand diameter of about 3/16 inch; the other strand being foamed continuous-filament polypropylene twine having 70 filaments, being of 14,000 denier and having a strand diameter of about ⅛inch, as described in Example III. The configuration, length and size of end openings of the chamber were also the same as employed in Example III, and the air pressure was 70 p.s.i.g. The breaking strength of the splice on the Instron tester was about 123 pounds; the splice diameter was about ¼inch, and under about 40 pounds tension the diameter of the splice was lessened about 1/32 inch. It can be seen from this Example that a splice occurring between dissimilar strands tended to result in a splice breaking strength that was about the same as that of the breaking strength of the weaker strand.

EXAMPLE V

Two dissimilar strands were spliced, one being sisal with a breaking strength of about 330 pounds and same physical characteristics as that described in Example IV: and the other strand being industrial twine of polypropylene "fractured film" 24,500 denier twine having the same characteristics as that described in Example II. The same apparatus and air pressure of 70 p.s.i.g. was used as in Example II. The breaking strength on the Instron tester of the sisal was again about 330 pounds, and the breaking strength of the twine was about 152 pounds. The splice breaking strength was about 155 pounds, the splice diameter being about ¼inch and under about 40 pounds tension lessening in diameter by about 1/32 inch. It is thought that the difference in the breaking strength between the twine of the same denier described in Example II and that described in this Example may possibly be attributed to the manner in which the two different testing devices operate. In the Instron tester, the strands are clamped between two flat pieces of metal, and it could be that there is some fracturing of the strands caused by the edges of the clamps. In the Scott pendulum tester, the strands are wrapped 180° before clamping.

EXAMPLE VI

Two dissimilar strands were spliced, one being the foamed continuous-filament polypropylene 14,000 denier twine described in Example III, and the other being polypropylene "fractured film" 15,800 denier twine with a film thickness of about 3 mils and having been twisted about 0.9 turns per inch. The same size and configuration of chamber as that described in Example III was used as well as the same amount of air pressure, 70 p.s.i.g. The diameter of the strand of "fractured film" twine was still only about ⅛inch and the resulting splice diameter was about 3/16 inch which lessened in diameter by about 1/32 inch under 40 pounds tension. The breaking strength of the "fractured film" on the Instron tester was about 97 pounds and the breaking strength of the splice was about 88 pounds.

EXAMPLE VII

Two strands of polypropylene "fractured film" 15,800 denier industrial twine were spliced by an apparatus having the same configuration and size of chamber as that described in Example II but using an air pressure of about 30 p.s.i.g. A Scott pendulum tester was used and the breaking strength of a single unspliced strand was about 105 pounds while the breaking strength of the splice proved to be about 90 pounds. The diameter of the resulting splice was about ¼inch and under 40 pounds tension lessened to a diameter of about 7/32 inch. The splice in this instance was thus a little more than 85 percent as strong as the unspliced strand.

EXAMPLE VIII

The same experiment as set forth in Example VII was tried but using an air pressure of 50 p.s.i.g. The splice breaking strength on the Scott tester proved to be about 90 pounds, the splice thus being a little more than 85 percent as strong as the unspliced strand. The spliced diameter was about 5/16 inch, and under 40 pounds tension lessen to about 3/16 inch in diameter.

In the above described Examples, the 40-pound tension placed on the spliced strands would be greater than that generally exerted by machines using continuous strand materials such as knot-tying machines, for example. No particular correlation could be determined from the experiments ran without making many test runs and by varying the variables such as size of chambers, size of chamber end openings, gaseous fluid pressure and the like. It is believed that the examples, however, do show that for the most part by practice of the invention the diameter of the resulting splice was only slightly increased over that of the normal unspliced diameter of a strand, and that the splice breaking strength usually ran to at least 80 percent of the breaking strength of the unspliced strand.

The splicing apparatus is simply constructed and thus may be formed in different ways that are suitable for producing an effective splice. The drawings illustrate some of these ways.

FIG. 5 illustrates an apparatus 40 having an integral housing 42 that is cylindrical in exterior configuration and which is provided with a closeable opening 44 which is closed by a movable sleeve 46 that may be rotated to open and closed positions. The nature of the sleeve is shown more clearly in FIG. 8 and it can be seen that the sleeve has the same configuration as that of the interior wall 48 of the housing and fits coextensively therewithin, and is provided with a single opening 50 extending the length of the sleeve which may be brought into alignment to be coextensive with the opening 44 of the housing 42 when it is desired to introduce overlapped end portions of strands to be spliced. The sleeve 46 may be rotated by the handle 52 which comes into abutment against either pin 54 or pin 56 so as to assure alignment of the sleeve opening with that of the housing opening or to close the housing opening. The conduits 58, 60 connect to either side of the housing. FIG. 7 illustrates in solid line the position of the handle 52 when both the opening in the sleeve and the opening in the housing are in alignment with each other for the purpose of introducing the strand portions to be spliced. A tab 62 extending from the housing retains the sleeve within the housing.

FIGS. 9, 10 and 11 disclose a further embodiment similar to that shown in FIGS. 5 to 8 but differing in certain structural features. The apparatus 70 comprises a housing 72 having a closeable opening 74, a movable sleeve 76 that fits within the interior wall 78 of the housing, and conduits 80, 82. One of the conduits 82 also serves as a handle and is connected to the sleeve 76 through the elongated slot 84 formed in the housing for movement of the sleeve to open and close the closeable opening 74 of the housing.

The advantages of the practice of this invention are that a splice may be accomplished at a faster rate than what might be accomplished by manual knotting or by the use of adhesives and the like; it is less expensive to form a splice in this manner; the splice is less bulky; the splice is more flexible and would not result in "skin backs" as would be true, for example, in a hot melt adhesive splice.

The portion of the overlapped strands that is held is usually not spliced and it is considered to be more efficient to trim the unspliced overlapped ends rather than to attempt splicing them.

Although the invention has been described in considerable detail with reference to certain preferred embodiments thereof, it will be understood that variations and modifications can be effected without departing from the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. Method of joining multifilament strands of material comprising the steps of positioning the end portions of said strands in overlapping relationship within a chamber that loosely confines the overlapped strands;

holding the overlapped strands at their one end while leaving the other end free;

creating in the chamber a turbulence of gaseous fluid in such manner that a preponderance of the fluid flows more in one direction toward the free end of the overlapped strands and relative to the axes of the strands than in the opposite direction; and

moving the overlapped strands against the preponderance of fluid flow in said opposite direction.

2. Method of joining multifilament strands of material, comprising the steps of positioning the end portions of said strands in overlapping relationship within a chamber that loosely confines the overlapped strands;

holding the overlapped strands at their one end while leaving the other end free;

supporting the overlapped strands within the chamber free from resting contact with the chamber walls by opposed streams of gaseous fluid that impinge the overlapped strands at opposite sides at one location along their axes; and

moving the overlapped strands relative to the supporting opposed streams and in a direction that will bring their free end past said one location.

3. Method for joining two or more strands each comprising multifilamentary material, and comprising the steps of initially securing against axial movement a portion of each of the strands in stationary overlapping relationship and agitating the filaments of said overlapping strands by a turbulent flow of gaseous fluid within a confined space which loosely restricts the strands with reference to the cross-sectional area which they may occupy, and which causes the turbulent flow of gaseous fluid to possess a resultant direction of flow at an angle other than parallel to the axes of the overlapping strands, and then moving the overlapping strands through the turbulent flow whereby the filaments of each of the strands become intertwined and randomly interwoven.

4. A method as defined in claim 3 and wherein the turbulent flow of gaseous fluid is constrained to possess a resultant direction of flow at a diverging angle relative to the axes of the overlapping strands.

5. A splice produced between two overlapped end portions of two strands of materials in accordance with the method defined in claim 4.

6. An apparatus for splicing overlapped end portions of strands of material, each strand having a plurality of fibrils and comprising:

a housing defining therewithin a chamber that is open at its ends through the housing, one end opening being larger than the other;

said housing also defining a closeable opening that extends the length of the housing and into said chamber, and which closeable opening is adapted to receive therethrough into said chamber the overlapped strand end portions to be spliced with the remaining portions of the strands extending outside the housing through the chamber end openings; and

said housing further defining conduits that extend through the housing and open into said chamber at opposed locations, said conduits being adapted to conduct therethrough into said chamber a gaseous fluid for creating a turbulence in the chamber.

7. An apparatus as defined in claim 6 and wherein said housing is formed of two halves that may be temporarily separated and brought together again to provide said closeable opening.

8. An apparatus as defined in claim 6 and wherein said housing has a movable sleeve that fits coextensively within the chamber and is adapted to close said closeable opening.

9. An apparatus as defined in claim 8 and wherein said movable sleeve defines along its length an opening that is coextensive with the closeable opening of said housing when the sleeve is moved to open position to enable admission into the chamber of said overlapped strand end portions.

10. An apparatus as defined in claim 9 and wherein said movable sleeve has a handle for moving the sleeve to an open position wherein the opening of the sleeve is coextensive with the closeable opening of the housing and to a closed position for closing said closeable opening, said handle further forming one of said conduits through which said gaseous fluid may be conducted.

11. An apparatus as defined in claim 6 and wherein the chamber defined within said housing has the configuration of a truncated cone.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,581,486 Dated June 1, 1971

Inventor(s) Merton L. Dibble

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 61, after "that" insert ---of---;
Column 4, line 50, "150" should be ---1/8---.

Signed and sealed this 19th day of October 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

TEC 10261