

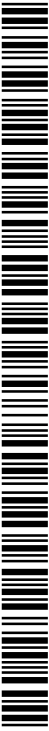


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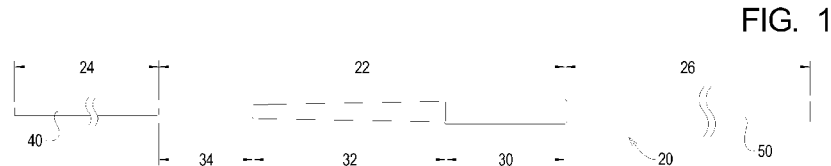
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(54) Title: TAPERED LINE SPLICE SYSTEMS AND METHODS



(57) **Abstract:** A tapered rope structure (20) comprises a first rope region (24), a second rope region (26), and a splice region (22). The splice region (22) is between the first and the second rope regions (24, 26) and comprises a taper portion (32), a finish portion (34), and an overlap portion (30). The finish portion (34) is arranged between the taper portion (32) and the first rope region (24). The overlap portion (30) is arranged between the taper portion (32) and the second rope region (26). A diameter of the first rope region is smaller than a diameter of the second rope region (26). A diameter of the overlap portion (30) is greater than the diameter of the second rope region (26). A diameter of the splice region (22) generally decreases from the overlap portion (30) to the first rope region (24).

TAPERED LINE SPLICE SYSTEMS AND METHODS

RELATED APPLICATIONS

[0001] This application (Attorney's Ref. No. P218718pct) claims benefit of U.S. Provisional Application Serial No. 62/092,166 filed December 15, 2014, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to tapered line splice systems and methods for forming a line having a tapered splice.

BACKGROUND

[0003] Tapered lines are long lengths of rope of one diameter attached to a shorter length of rope of a smaller diameter by way of a splice. In one example application, a tapered line is commonly used in riser pull-in applications in offshore applications. The long length of rope is used to do the bulk of the work during a riser pull-in. The smaller diameter line on the lead end improves winch efficiencies by decreasing the overall weight of the lifting system and increasing drum capacity. The small diameter line on the lead end is easier to handle when compared to using a rope that is a larger diameter the full length of the line.

[0004] The need thus exists for improved tapered lines and especially for tapered lines used in riser pull-in applications in the offshore market.

SUMMARY

[0005] The present invention may be embodied as a tapered rope

structure comprising a first rope region, a second rope region, and a splice region. The splice region is between the first and second rope regions and comprises a taper portion, a finish portion, and an overlap portion. The finish portion is arranged between the taper portion and the first rope region. The overlap portion is arranged between the taper portion and the second rope region. A diameter of the first rope region is smaller than a diameter of the second rope region. A diameter of the overlap portion is greater than the diameter of the second rope region. A diameter of the splice region generally decreases from the overlap portion to the first rope region.

[0006] The present invention may also be embodied as a method of forming a tapered rope structure comprising the following steps. First and second rope members are provided. A first portion of the first rope member partly inserted into the second rope member at an insertion point. A portion of the second rope member between the insertion point and a bitter end of the second rope member is unbraided. Sub-strands are formed from the unbraided portion of the second rope member. At least a portion of each of the sub-strands is tucked into a second portion of the first rope member.

[0007] The example taper systems and methods of the present invention are implemented by splicing two ropes of differing diameter together and works, for example, for both 12-strand single braid and 12-strand jacketed rope constructions. A gradual smooth transition takes place in the taper area. When the technique is used on a 12-strand single braid, the appearance is similar to a standard eye splice. Because the splice method of the present invention results in a continuous jacket covering the entire length of the tapered line, the appearance of the finished rope structure does not change in the taper region when used on a 12-strand jacketed rope.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 is a side elevation view of an example tapered rope structure of the present invention;

[0010] Figure 2 is a side elevation view of a small diameter rope used to form the example tapered rope structure;

[0011] Figure 3 is a close up view of a portion of Figure 2

[0012] Figure 4 is a side elevation view of a large diameter rope used to form the example tapered rope structure;

[0013] Figures 5-9 depict a step of inserting a portion of the small diameter rope into the large diameter rope;

[0014] Figures 10-17 depict a step of unbraiding a portion of the large diameter rope;

[0015] Figures 18-20 depict a step of forming sub-strands from the unbraided portion of the large diameter rope;

[0016] Figures 21-32 depict a step of tucking the sub-strands into the small diameter rope; and

[0017] Figure 33-38 depict a step of finishing a taper portion of a splice region of the example tapered rope structure.

DETAILED DESCRIPTION

[0018] Referring initially to Figure 1 of the drawing, depicted at 20 therein is an example tapered rope structure 20 constructed in accordance with, and embodying, the principles of the present invention. The tapered rope structure 20 comprises a splice region 22, a first rope region 24, and a second rope region 26. The example splice region 22 of the example tapered rope structure 20 comprises an overlap portion 30, a taper portion 32, and a finish portion 34. In the example tapered rope structure 20, a diameter of the first rope region 24 is smaller than a diameter of the second rope region 26, a diameter of the overlap portion 30 is greater than the diameter of the second rope region 26, and a diameter of the splice region 22 generally decreases from the overlap portion 30 to the first rope region 24.

[0019] As shown in Figure 2, the tapered rope structure 20 is formed in part by a small diameter (SD) rope 40 defining an SD rope body 42 and an SD rope bitter end 44. The example SD rope 40 is a 12-strand single braid rope, but other strand numbers and rope configurations may be used. The SD rope 40 comprises first SD rope subcomponents 46. The first rope subcomponents 46 will also be referred to herein as SD strands 46. As is conventional, the SD strands 46 will typically be comprised of discrete fibers (not shown) that are in turn combined, for example by twisting, into yarns (not shown). The yarns are in turn conventionally combined by twisting, braiding, or the like into the SD strands 46.

[0020] Figure 4 shows that the tapered rope structure 20 is further formed in part by a large diameter (LD) rope 50 defining an LD rope body 52 and an LD rope bitter end 54. The example LD rope 50 is also a 12-strand single braid rope, but other strand numbers and rope configurations may be used. The LD rope 50 comprises first LD rope subcomponents 56. The first rope

subcomponents 56 will also be referred to herein as LD strands 56. As is conventional, the LD strands 56 will typically be comprised of discrete fibers (not shown) that are in turn combined, for example by twisting, into second rope subcomponents 58. The second rope subcomponents 58 will also be referred to herein as LD yarns 58. The LD yarns are in turn conventionally combined by twisting, braiding, or the like into the LD strands 56.

[0021] The SD rope 40 and the LD rope 50 are combined or spliced together to form the example tapered rope structure 20 as follows.

Step 1: Measuring and Marking of SD and LD Ropes

[0022] Initially, the SD rope 40 and the LD rope 50 are measured and marked in preparation for formation of the splice region 22.

[0023] As will be discussed in further detail below, an inserted portion 60 (Figure 2) of the SD rope 40 is inserted into the LD rope 50 at an insertion location 62 (Figure 3) spaced from the LD rope bitter end 54. A insertion length LI of the inserted portion 60 of the SD rope 40 and an unbraided length LU corresponding to a distance of the insertion location 62 from the bitter end 54 of the LD rope 50 may initially be determined as follows.

[0024] The insertion length LI of the inserted portion 60 of the SD rope 40 is calculated to obtain sufficient overlap between the SD rope 40 and the LD rope 50 within the splice region 22. Overlap between the SD rope 40 and the LD rope 50 within the splice region 22 is sufficient when tension loads on the tapered rope structure 20 are adequately transferred through the splice region 22 while minimizing the overall length of the splice region 22. As shown in Figure 2, the insertion length LI of the inserted portion 60 used to form the example splice region 22 is five (5) fid lengths, so an SD mark 64 is formed on the SD rope 40

five (5) fid lengths from the SD rope bitter end 44. The insertion length LI of the inserted portion 60 will typically be in a first preferred range of between 3 and 7 fid lengths but may also be in a second preferred range of between 2 and 10 fid lengths. Other LI lengths and units may be used depending on a particular situation.

[0025] The SD mark 64 is formed by marking every S- and Z- strand around the circumference of the SD rope 40. In the example SD rope 40, six (6) strands are marked around the circumference of the SD rope 40 as shown in Figure 3.

[0026] The insertion length LI will generally correspond to a length of the overlap portion 30 of the splice region 22 as will be described in further detail below.

[0027] The unbraid length LU is determined to ensure that a sufficient length of the LD rope 50 is available for tucking to form the taper portion 32 and finishing to form the finish portion 34 as will be described in further detail below. The unbraid length LU may be calculated as follows.

[0028] First, a number of sub-strands to be used in a picking and tucking process is calculated or predetermined. As one example, the number of sub-strands to be used may be equal to a cross-sectional area of the LD rope 50 divided by a cross-sectional area of the SD rope 40.

[0029] Given the number of sub-strands to be used, a total number of picks of the SD rope 40 is determined. For each pick of the SD rope 40, one tuck process of the sub-strands of the LD rope 50 is performed, so the total number of picks is typically the same as the total number of tucks. In the example tapered rope structure 20 of the present invention, the total number of picks/tucks will be

equal to approximately 11-13 times the number of sub-strands to be used. However, the total number of picks/tucks may be calculated or predetermined using different methods. The following Table A provides one example method of determining the number of picks/tucks given typical numbers of sub-strands of the LD rope 50 formed as will be described in further detail below:

# of sub-strands	9	8	7	6	5	4
# of total picks	117	99	83	69	57	47

[0030] Once the total number of picks/tucks is determined, the unbraided length LU can be calculated or predetermined by as the total number of picks/tucks (TNPT) multiplied by the inverse of the picks per unit length of the SD rope 40 (e.g., picks per inch associated with SD rope or SDPPI) plus an arbitrary margin (e.g., 24”). One example formula for calculating the unbraided length LU is as follows:

$$LU = TNPT \times 1/SDPPI + 24''$$

[0031] Once the unbraided length LU is determined, the insertion location 62 is determined by forming an LD mark 66 on the LD rope 50 at the insertion location 62 as determined by measuring a distance corresponding to the unbraided length LU from the LD rope bitter end 54.

[0032] With the SD mark 64 and the LD mark 66 formed as described above, the SD rope 40 and LD rope 50 are measured and marked for splicing.

Step 2: Insertion of SD Rope into LD Rope

[0001] After the SD rope 40 and SD rope 50 have been measured and marked, the SD rope 40 is inserted into the LD rope 50 as described in Figures

5-8. As shown in Figure 5, using a fid (not shown) the bitter end 44 of the SD rope 40 is inserted into the body 52 of the LD rope 50 adjacent to the LD mark 66 at the insertion location 62, which is located between the LD mark 66 on the LD rope 50 and the bitter end 54 of the LD rope 50. The SD rope 40 is then further inserted into the LD rope 50 as shown in Figure 6 until the SD mark 64 is within the body 52 of the LD rope 50 on an opposite side of the LD mark 66 from the LD rope bitter end 54 as shown in Figures 7 and 8.

[0002] At this point, a rope securing member 70 may be applied to the LD rope 50 adjacent to the insertion point 62 and the LD mark 66 as shown in Figure 9. In particular, the rope securing member 70 may be a short length of tape that is wrapped around the LD rope 50 such that the LD mark 66 is covered but the insertion point 62 is exposed. The rope securing member 70 limits unbraiding of the LD rope 50 as will be described in further detail below.

Step 3: Unbraiding and Pairing Strands of LD Rope

[0003] After the SD rope 40 has been inserted into the LD rope 50 as described above, a portion of the LD rope 50 is unbraided as follows. Initially, an S- series 80 of consecutive S- strand picks 82 is identified along the length of the LD rope 50 from the LD mark 66 towards the bitter end 54. The insertion location 62 is included between two of the S-strand picks 82 in the series of consecutive S- strand picks 82. Next, a Z- series 84 of consecutive Z- strand picks 86 is identified along the length of the LD rope 50 between the LD mark 66 and the bitter end 54.

[0004] In the following discussion, the use of a letter suffix appended to a numerical reference character indicates a particular instance of an element generally described by the numerical reference character and does not indicate a new element. Accordingly, a numerical reference character used in the text to

refer to an element in general (e.g., "S- strand pick 82") may not be found in the drawing without a corresponding reference character (e.g., "82a"). The use of a numerical reference character in this specification without a letter suffix should not be considered inconsistent with the drawing so long as that same reference character is used in the drawing with a reference character.

[0005] In the example LD rope 50, six (6) S- strand picks 82a, 82b, 82c, 82d, 82e, and 82f are identified and marked as shown in Figures 10 and 11. The insertion point 62 is defined between the second and third of these S- strand picks 82b and 82c. And as also shown in Figures 10 and 11, six (6) Z- strand picks 86a, 86b, 86c, 86d, 86e, and 86f adjacent to the S- strand picks 82a, 82b, 82c, 82d, 82e, and 82f are identified and marked.

[0006] Next, as shown in Figures 12-14, portions 90 of the LD rope strands 56 corresponding to one of the S- strand picks 82 and one of the Z- strand picks 86 is unbraided from the LD rope 50 to form pairs 92 of the unbraided portions 92 of the rope strands 56. A strand securing member 94 may be used to temporarily secure together the pairs of rope strands 56 forming the strand pairs 92.

[0007] In the example tapered line structure 20 as shown in Figures 12-14, the strand portion 90a corresponding to the S- strand pick 82a in the series 80 closest to the LD mark 66 is identified and removed, and the strand portion 90b corresponding to the Z- strand pick 86f in the series 84 farthest from the LD mark 66 is identified and removed. The two removed strands 56a and 56b form a first strand pair 92a. A strand securing member 94a is used to temporarily secure the rope strands 56a and 56b into the first strand pair 92a. And as shown in Figures 15 and 16, the strand portion 90c corresponding to the S- strand pick 82b in the series 80 closest to the strand portion 90a is identified and removed, and the strand portion 90d corresponding to the Z- strand pick 86e in the series 84

closest to the Z- strand pick 86f is identified and removed. The two removed strands 56c and 56d form a second strand pair 92b. A strand securing member 94b is used to temporarily secure the rope strands 56c and 56d into the second strand pair 92b.

[0008] Subsequent strand pairs 92 are formed in the manner generally described in the previous paragraph until the entire length of the LD rope 50 between the LD mark 66 and the LD bitter end 54 has been unbraided. In the example tapered line structure 20 in which the LD rope 50 is a 12-strand braided rope, first, second, third, fourth, fifth, and sixth strand pairs 92a, 92b, 92c, 92d, 92e, and 92f are formed of strand portions 90a and 90b, 90c and 90d, 90e and 90f, 90g and 90h, 90i and 90j, and 90k and 90l, respectively, as shown in Figure 17. The rope securing member 70 prevents further unbraiding or unraveling of the LD rope 50, while the strand securing members 94 ensure that the LD strand portions 90 are held in their respective strand pairs 92.

Step 4: Splicing of SD Rope and LD Rope to form Tapered Rope Structure

[0009] Starting with the SD rope 40 inserted into the LD rope 50 and the LD rope 50 partly unbraided as shown in Figure 17, the SD rope 40 is pulled slightly from the LD rope 50 until the SD mark 64 is exposed as shown in Figure 18. The portion of the SD rope 40 remaining within the LD rope 50 defines the overlap portion 30 of the example tapered rope structure 20.

[0010] The individual strand portions 90 forming each of the strand pairs 92 are then disassembled and reformed into a number of sub-strands 96 as generally described above in Step 1 and depicted Figures 19 and 20. In particular, for the example tapered rope structure 20 described herein, the calculations performed in Step 1 indicated that six (6) sub-strands 96 are requested for each of the strand pairs 92. Given that six (6) strand pairs 92 were

created in Step 3, a total of thirty six (36) of the sub-strands 96 will be formed. Figure 20 illustrates that the first strand pair 92a is divided into six (6) sub-strands 96a, 96b, 96c, 96d, 96e, and 96f. The remaining strand pairs 92b, 92c, 92d, 92e, and 92f are left intact for organizational purposes.

[0011] As described above, the example LD rope is formed of fibers that are in turn arranged in yarns 58. One method of forming the sub-strands 96 is to determine the number of total yarns 58 in each pair 92 of strand portions 90 and dividing this number of yarns by the number of sub-strands 96 required. In the example LD rope 50, each strand contains nine (9) yarns 58, yielding a total of eighteen yarns 58 in each pair 92. Dividing the total number of yarns 58 (18) by the number of sub-strands 96 required (6) for each pair 92 of strand portions 90 yields three (3) yarns per sub-strand 96. As yarns 58 and/or fibers are grouped into the sub-strands 96, yarns/fibers that are closest to each other are desirably arranged into the sub-strands 96. Sub-strand securing members 98 (e.g., tape) may be used to maintain the sub-strands 96 together during subsequent tucking and finishing operations.

[0012] The first group of sub-strands 96 formed will be identified as a signal strand. In the example depicted in Figure 20, the first sub-strand 96a is referred to as the signal strand, and the sub-strand securing member 98a associated with that signal strand 96a will be a different color than the sub-strand securing members 98b, 98c, 98d, 98e, and 98f associated with the other sub-strands 96b, 96c, 96d, 96e, and 96f.

[0013] If the number of yarns 58 per sub-strand 96 is not even, at least some of the yarns 58 may be separated into fibers and reformed as necessary to the proper number of sub-strands 96 to obtain sub-strands 96 of approximately even or substantially equivalent volume. Substantially equivalent volume may be obtained by arranging approximately the same number of yarns or fibers in each

of the sub-strands 96. The term “substantially volumetrically equivalent” as used herein means that the resulting splice region 22 is substantially, but not completely, symmetrical or balanced about an axis of rotation defined by the longitudinal axis of the tapered rope structure 20. Working with intact yarns or other sub groups is preferred to working with individual fibers for ease of fabrication.

[0014] Figures 21-30 show that a first S- strand pick 120a of the SD rope 40 adjacent to the SD mark 62 and between the SD mark 62 and the SD bitter end 44 is identified as shown in Figure 21. Subsequent S-strand picks 120b, 120c, 120d, 120e, 120f, 120g, 120h, 120i, 120j, 120k, and 120l defining a pic line 122 are also identified as shown in Figure 21. The pic line extends along the SD rope 40 past the S-strand pick 120l, and S-strand picks 120 in the pick line 122 beyond the pick line 120l will not be individually labeled herein for clarity.

[0015] The last sub-strand 96f formed from the first strand pair 92a is first tucked under the first S- strand 120a as shown in Figure 21. The sub-strands 96e, 96d, 96c, 96b, and 96a formed from that first strand pair 92a are then tucked in that order along the pic line 122 through the S-strand picks 120b, 120c, 120d, 120e, and 120f to obtain the structure depicted in Figure 22. The last sub-strand 96f (i.e., farthest from the signal strand 96a) is then tucked under the seventh S- strand 120g as shown in Figure 23. The sub-strands 96e, 96d, 96c, 96b, and 96a formed from that first strand pair 92a are then tucked in that order along the pic line 122 through the S-strand picks 120h, 120i, 120j, 120k, and 120l to obtain the structure depicted in Figure 24. At this point, each of the sub-strands 96a-f has been tucked twice along the pic line 122 under one of the succession of S-strand picks 120a-120l.

[0016] At this point, one of the sub-strands 96 is laid along the pic line 122 parallel to the axis of the SD rope 40 and another of the sub-strands 96 is tucked

along the pic line 122 as shown in Figure 25. In the example tapered rope structure 20, the sub-strand 96f farthest from the signal strand 96a is the sub-strand that is laid along the pic line 122, and the sub-strand 96e adjacent to the sub-strand 96f is wrapped over the parallel strand and then tucked first along the pic line 122 as shown in Figure 25. The remaining sub-strands 96d, 96c, 96b, and 96a are then similarly wrapped and tucked in that order along the pic line 122 over the strand 96f as shown in Figure 26. At that point, the end of the parallel sub-strand 96f is removed by cutting the sub-strand 96f at a cut location 124 as shown in Figure 27, and only the sub-strands 96a, 96b, 96c, 96d, and 96e remain.

[0017] The process of laying one of the sub-strands 96 parallel to the pic line 122, tucking the remaining sub-strands 96 around the parallel laid sub-strand 96, and then cutting the parallel laid sub-strand 96 to remove an exposed portion thereof may be repeated until only the pilot sub-strand 96a remains. In the example tapered rope structure 20, once the number of remaining sub-strands 96 reaches a predetermined number (e.g., 4) as shown in Figure 28, the signal strand 96a and any other remaining strands may be tucked three (3) times instead of two (2) times until there are only two (2) sub-strands left as shown in Figure 29. The tucking of the remaining strands three (3) times instead of two (2) times elongates the taper portion 32 of the splice region 22. When only two sub-strands 96 are left as shown in Figure 29, the remaining non-pilot strand 96 (in this case the sub-strand 96b) is laid parallel to the pic line 122, and the pilot strand 96a is tucked four (4) times around the parallel sub-strand 96b.

[0018] The sub-strand 96b is then cut such that, at this point, only the signal sub-strand 96a remains as shown in Figure 30. When only the signal strand 96a remains, the signal strand 96a is tucked into the SD rope 40 using an over 1/under 2 pattern three (3) times. At this point, the signal strand 96a is divided volumetrically into first and second finish strands 130 and 132. Finish

strand securing members 134 and 136 (e.g., wrapped tape) may be used to organize the first and second finish strands 130 and 132, respectively. The first finish strand 130 is left in place, and the second finish strand 132 is tucked using the over 1/under 2 pattern three (3) more times. The second finish strand 132 is left in place, and ends of the two finish strands 130 and 132 extend from the SD rope 40 as shown in Figure 31.

[0019] The sub-steps of Step 4 are repeated for each of the strand pairs 92 until all of the sub-strands 96 of all of the strand pairs 92a, 92b, 92c, 92d, 92e, and 92f have been spliced into the SD rope 40 as described above. Once all of the strand pairs 92 have been divided into sub-strands 96, tucked into the SD rope 40 along a unique pic line parallel to the example pic line 122, pruned down to only the respective pilot sub-strands 96a, and then divided into finish strands 130 and 132, a plurality of the finish strands 130 and 32 will extend from the SD rope 40. In the example depicted in Figure 32, six (6) of the first finish strands 130a, 130b, 130c, 130d, 130e, and 130f and six (6) of the second finish strands 132a, 132b, 132c, 132d, 132e, and 132f will extend from the SD rope after all of the strand pairs 92 are tucked along their respective pic lines.

Step 5: Finishing the Splice

[0020] To complete the splice, the first finish strands 130a, 130b, 130c, 130d, 130e, and 130f may be combined into three groups of first final strands 140a, 140b, and 140c, and the second finish strands 132a, 132b, 132c, 132d, 132e, and 132f may be combined into three groups of final strands 142a, 142b, and 142c as shown in Figure 33. Final finish strand securing members 144 and 146 (e.g., wrapped tape) may be used to organize the finish strands 140 and 142, respectively. As one example, the final strands 140 and 142 may be formed by combining pairs of first and second finish strands 130 and 132 closest to each other to form the final strands 140 and 142, respectively. In the example

depicted in Figures 32 and 33, the first finish strands 130a and 130b are combined to form the first final finish strand 140a, the first finish strands 130c and 130d are combined to form the first final finish strand 140b, and the first finish strands 130e and 130f are combined to form the first final finish strand 140c. Similarly, the second finish strands 132a and 132b are combined to form the second final finish strand 142a, the second finish strands 132c and 132d are combined to form the second final finish strand 142b, and the second finish strands 132e and 132f are combined to form the second final finish strand 142c.

[0021] With the finish strands 140 and 142 thus formed, the first finish strands 140 (e.g., closest to the SD mark 62) are each buried into the SD rope 40 until the tails of the strands 140 meet a first exit location 150 at which the second finish strands 142 (e.g., farthest from the SD mark 62) exit the SD rope 40 as shown in Figures 34 and 35. The second finish strands 142 (e.g., farthest from the SD mark 62) are next each buried into the SD rope 40 until away from the exit location 150 as shown in Figure 35 to a second exit location 152. Then, the tail portions of the final strands 140 and 142 are removed as shown in Figure 37 to complete the taper portion 32 of the splice region 22 of the rope structure as shown in Figure 38.

What is claimed is:

1. A tapered rope structure comprising:
a first rope region;
a second rope region; and
a splice region between the first and second rope regions, the splice region comprising
a taper portion,
a finish portion arranged between the taper portion and the first rope region, and
an overlap portion arranged between the taper portion and the second rope region; wherein
a diameter of the first rope region is smaller than a diameter of the second rope region,
a diameter of the overlap portion is greater than the diameter of the second rope region, and
a diameter of the splice region generally decreases from the overlap portion to the first rope region.
2. A tapered rope structure as recited in claim 1, in which:
the first rope region is formed by a first rope member;
the second rope region is formed by a second rope member; and
at least a portion of the first rope member is arranged within the second rope member to define the overlap portion.
3. A tapered rope structure as recited in claim 2, in which the taper portion is formed by the first rope member and a portion of the second rope member.
4. A tapered rope structure as recited in claim 2, in which:

the second rope member comprises a plurality of strands; and
the taper portion is formed by sub-strands comprising portions of the
plurality of strands.

5. A tapered rope structure as recited in claim 4, in which the sub-strands comprise portions of the plurality of strands.

6. A tapered rope structure as recited in claim 4, in which the sub-strands comprise portions of at least two of the plurality of strands.

7. A tapered rope structure as recited in claim 5, in which the sub-strands comprise portions of at least two of the plurality of strands.

8. A tapered rope structure as recited in claim 4, in which the sub-strands comprise a plurality of sub-components of the strands.

9. A tapered rope structure as recited in claim 8, in which the sub-strands comprise at least a portion of one yarn from a first one of the plurality of strands and at least a portion of one yarn from a second one of the plurality of strands.

10. A tapered rope structure as recited in claim 4, in which the sub-strands are tucked into the first rope member within the taper region.

11. A tapered rope structure as recited in claim 10, in which each sub-strand is tucked along a pic line defined by S- strands of the first rope member.

12. A tapered rope structure as recited in claim 4, in which:
a portion of at least a first one of the sub-strands is laid parallel to the first
rope member; and

a portion of at least a second one of the sub-strands is wrapped at least partly around the first one of the sub-strands.

13. A method of forming a tapered rope structure comprising the steps of:

providing first and second rope members;
inserting a first portion of the first rope member partly into the second rope member at an insertion point;
unbraiding a portion of the second rope member between the insertion point and a bitter end of the second rope member;
forming sub-strands from the unbraided portion of the second rope member; and
tucking at least a portion of each of the sub-strands into a second portion of the first rope member.

14. A method as recited in claim 13, in which the step of forming the sub-strands comprises the steps of:

determining a number of sub-strands based on a total number of picks within a splice region defined between the first and second rope members; and
dividing the unbraided portion of the second rope member into the determined number of sub-strands.

15. A method as recited in claim 14, in which each of the sub-strands are substantially volumetrically equivalent.

16. A method as recited in claim 14, in which step of dividing the unbraided portion of the second rope member into sub-strands comprises the step of arranging an equal number of yarns in each sub-strand.

17. A method as recited in claim 14, further comprising the step of cutting at least some of the sub-strands during the process of tucking the sub-strands into the first rope member.

18. A method as recited in claim 14, in which the step of determining the number of sub-strands is further based on a relationship between cross-sectional areas of the first and second rope members.

19. A method as recited in claim 14, in which the step of determining the number of sub-strands is further based on a pick per inch value associated with the first rope member.

20. A method as recited in claim 13, in which at least one of the sub-strands is divided into finish strands that are separately inserted into the first rope member.

21. A method as recited in claim 20, in which at least two of the finish strands are combined to form a final strand that is inserted into the first rope member.

FIG. 1

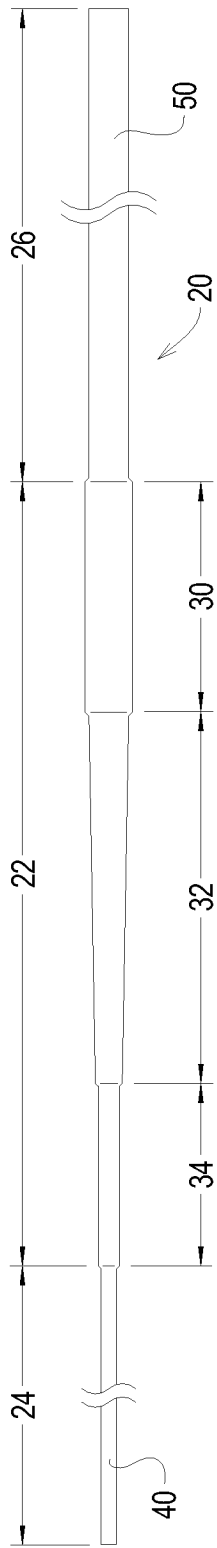


FIG. 2

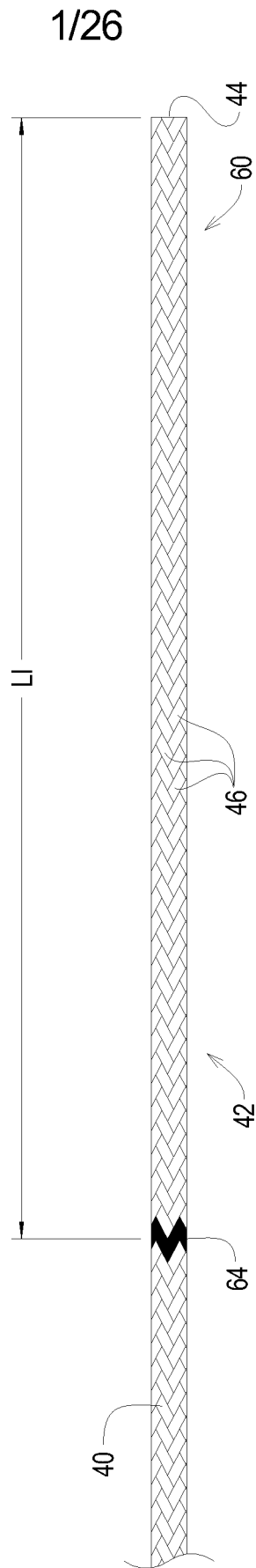
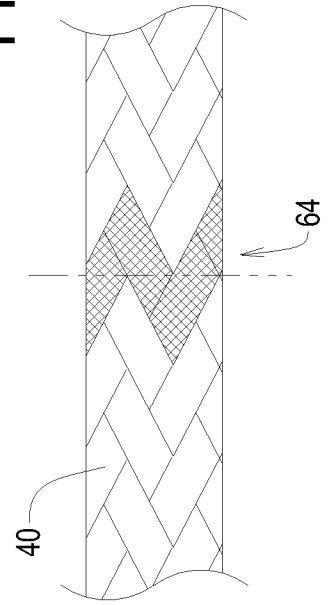


FIG. 3



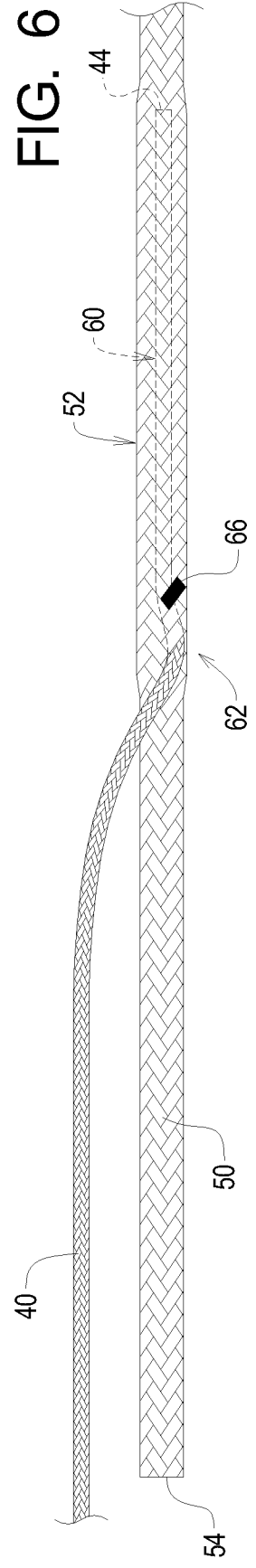
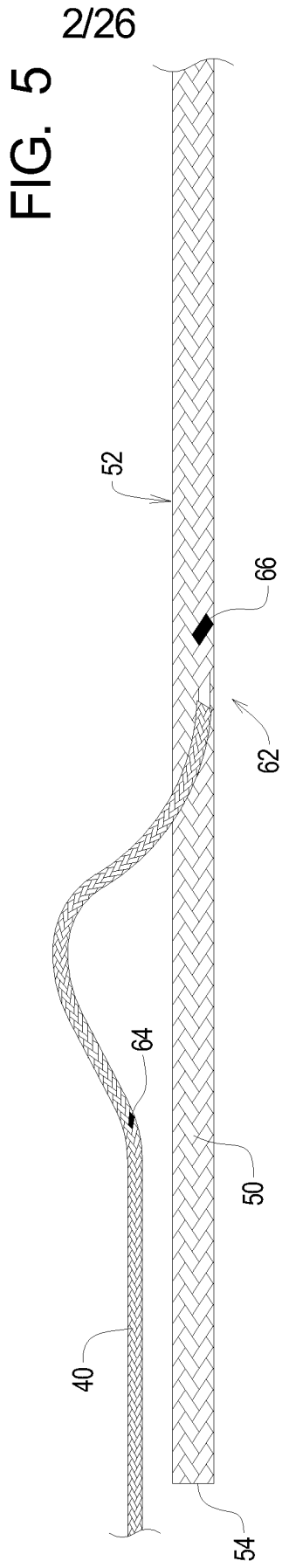
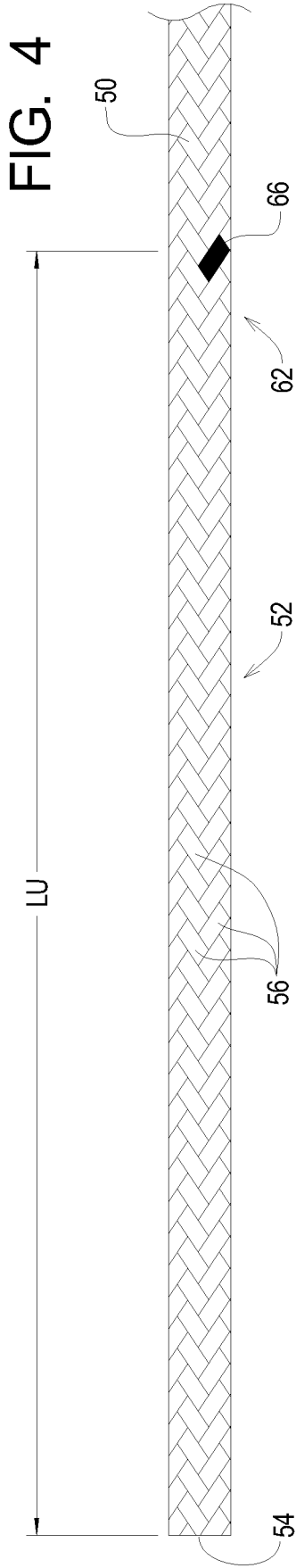


FIG. 7

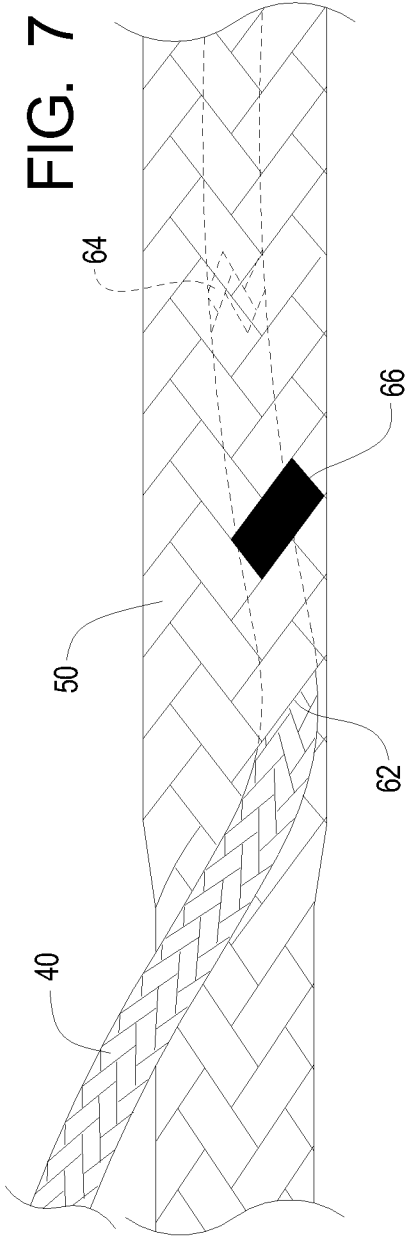


FIG. 8

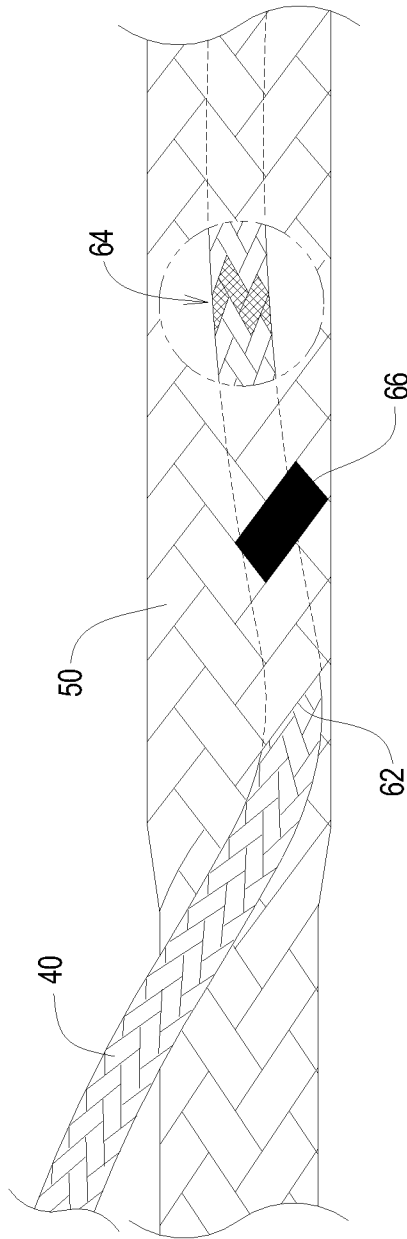


FIG. 9

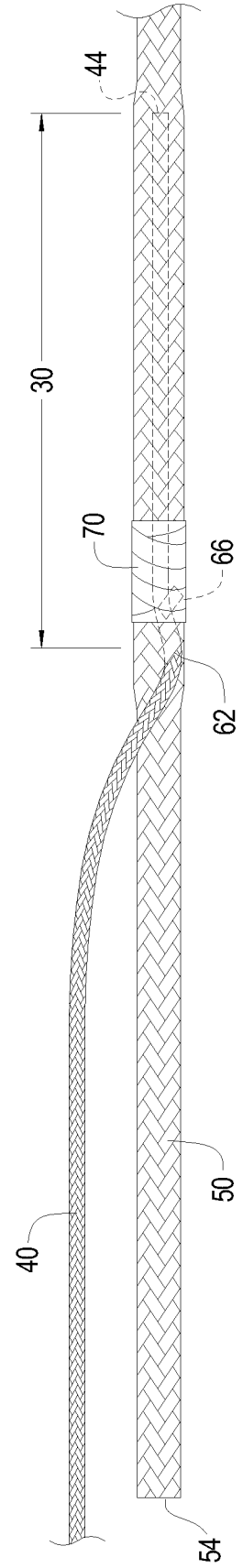


FIG. 10

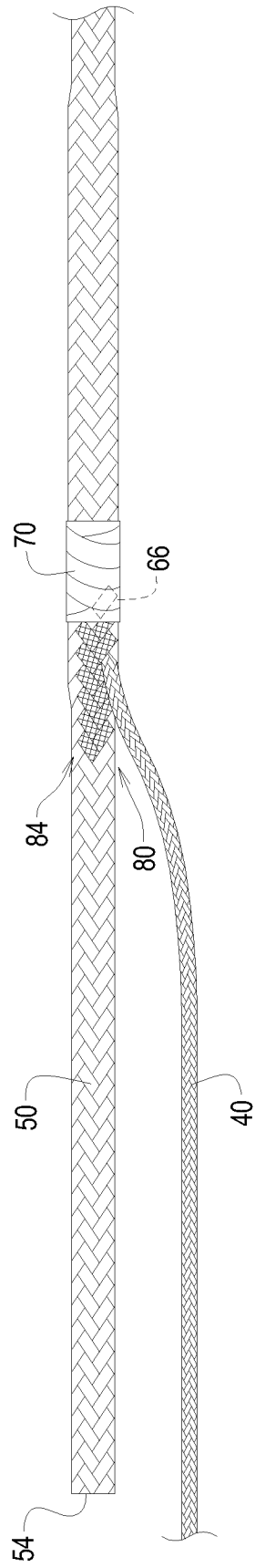


FIG. 11

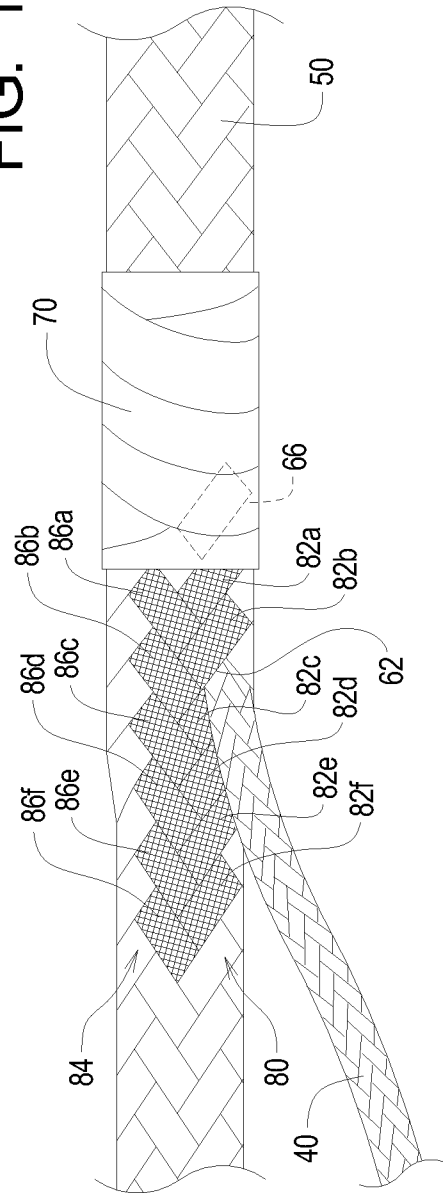


FIG. 12

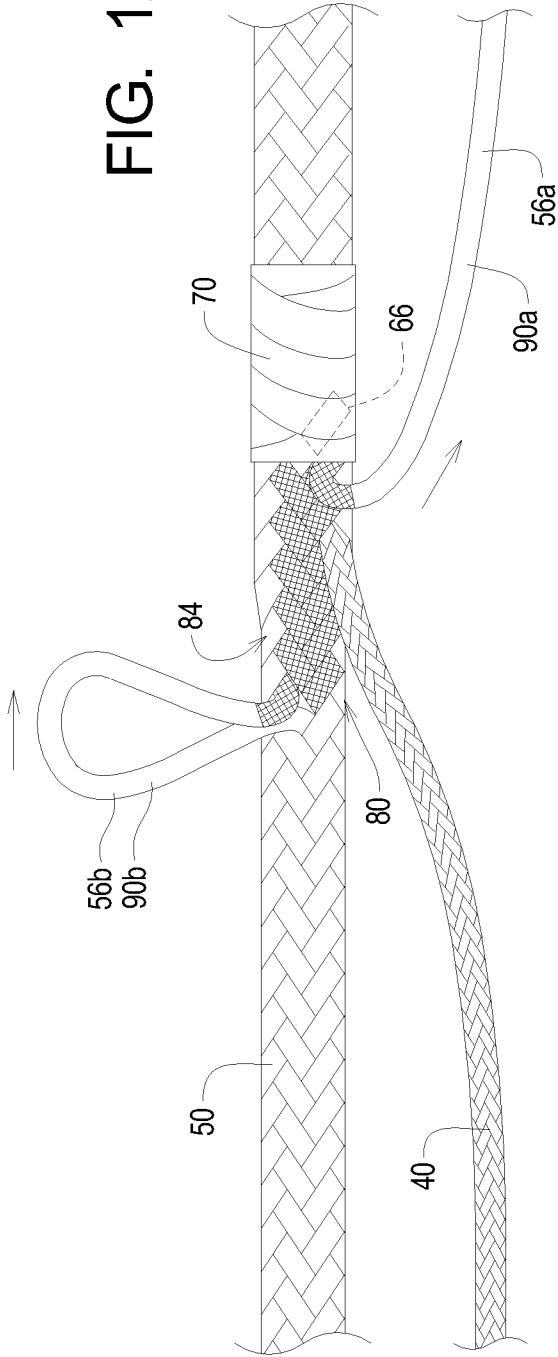


FIG. 13

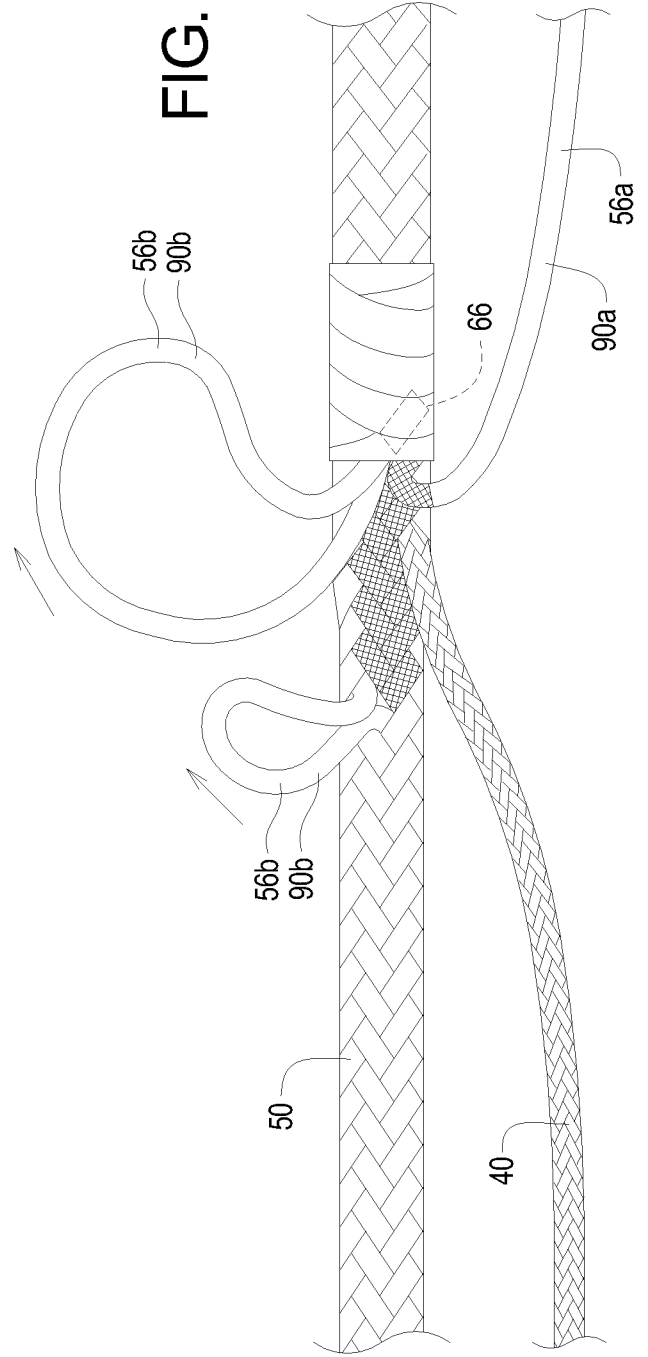
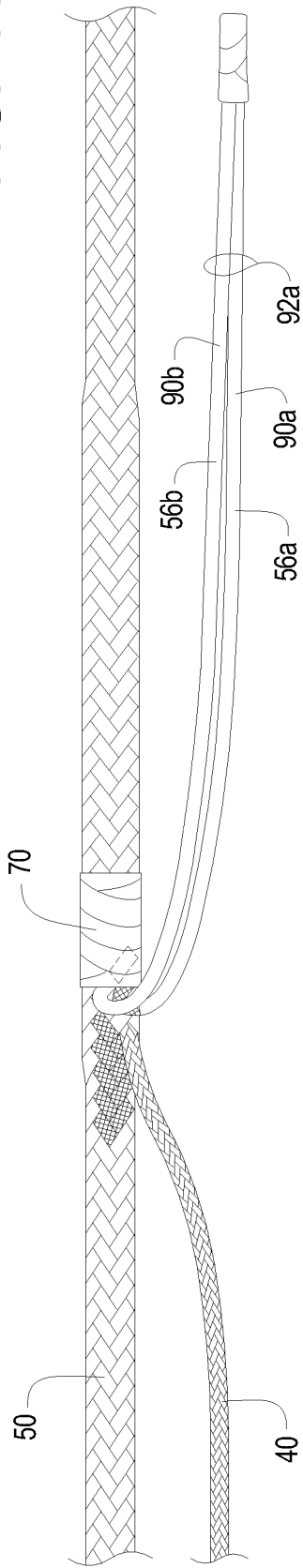


FIG. 14



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FIG. 15

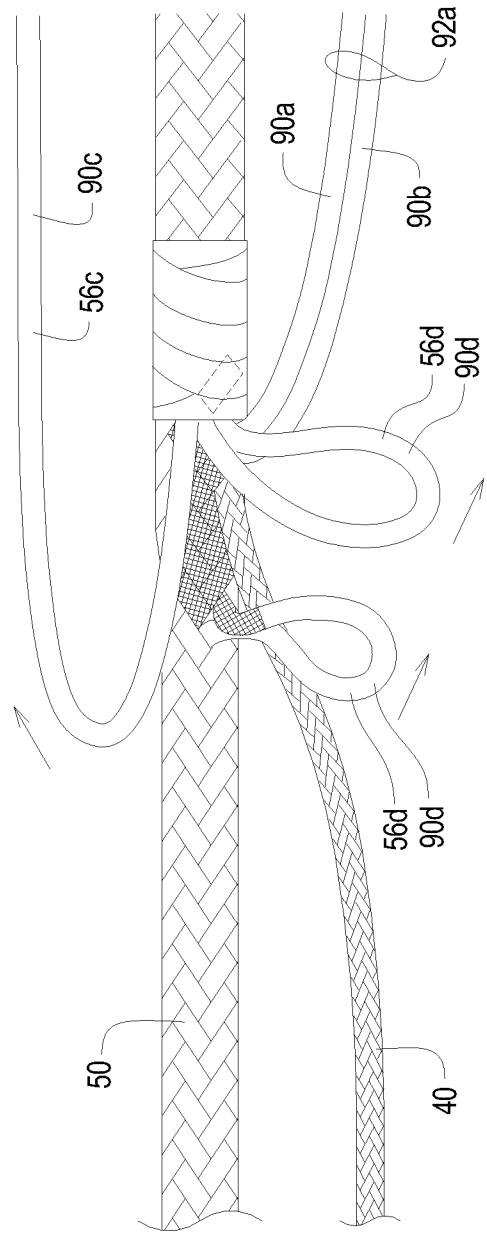
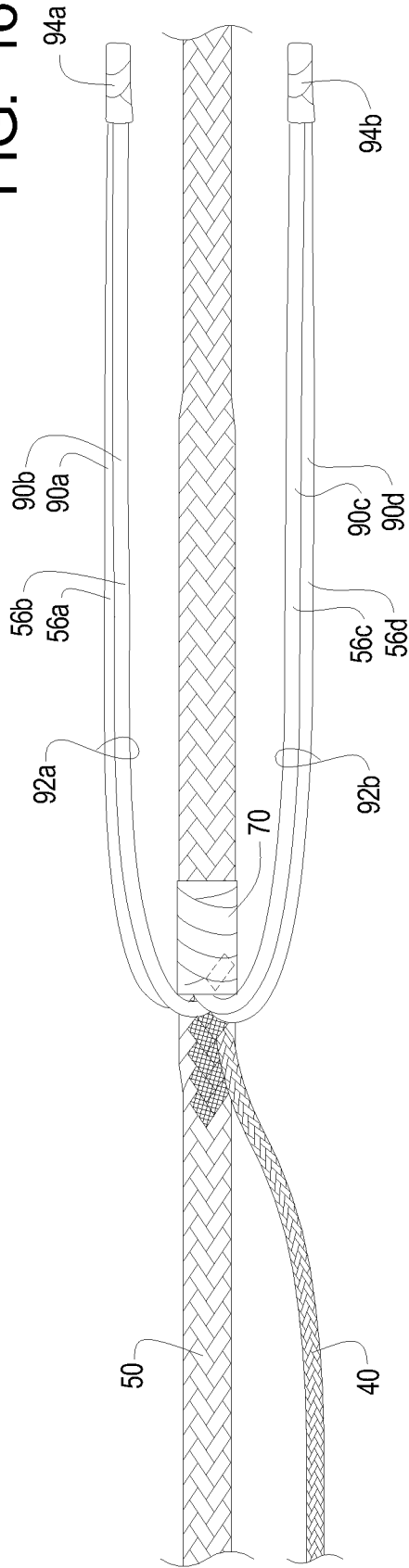
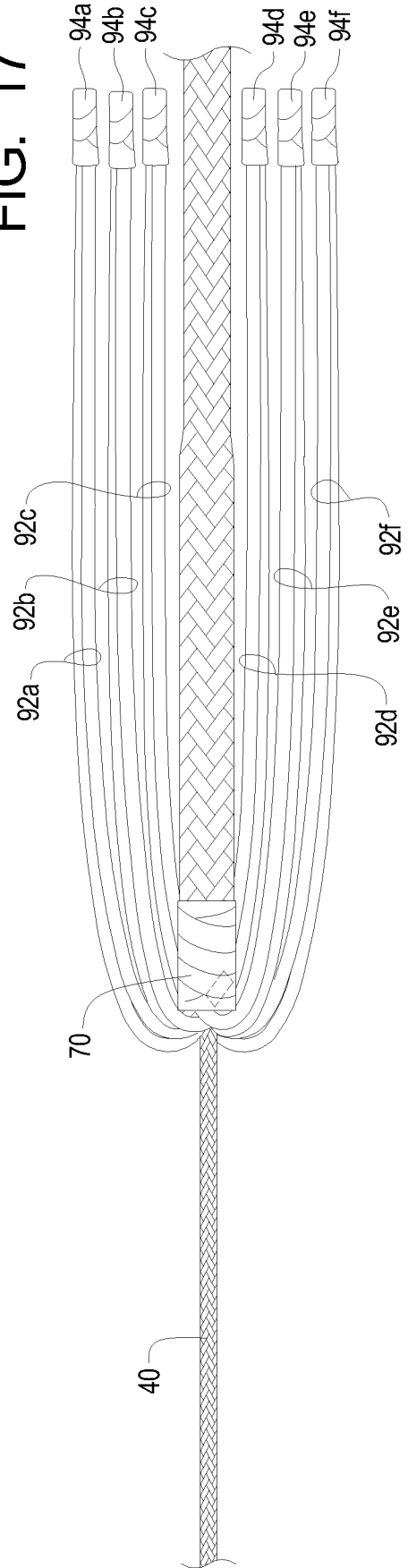


FIG. 16



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FIG. 17



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FIG. 18

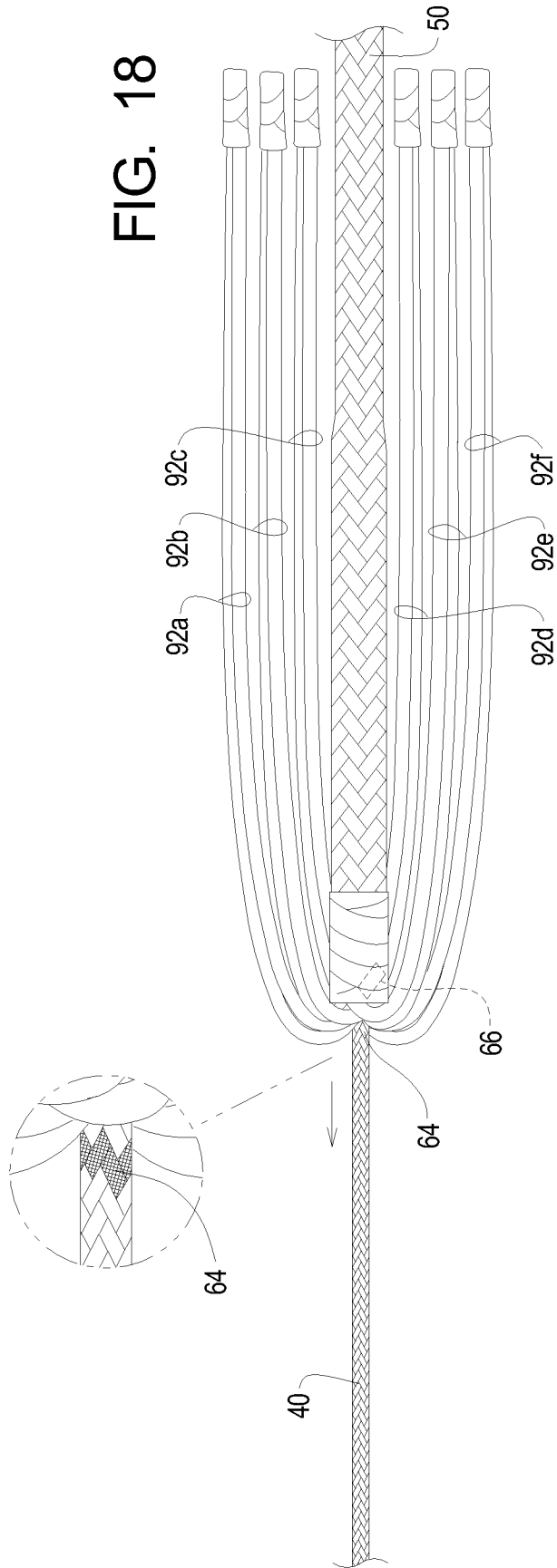


FIG. 19

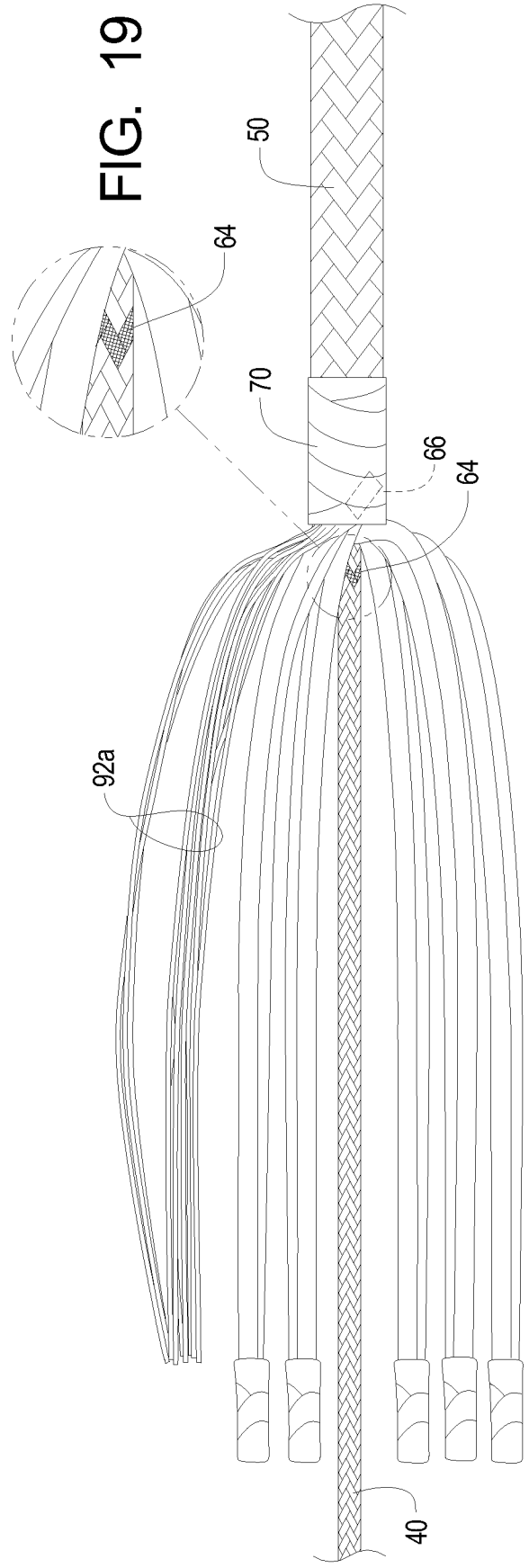
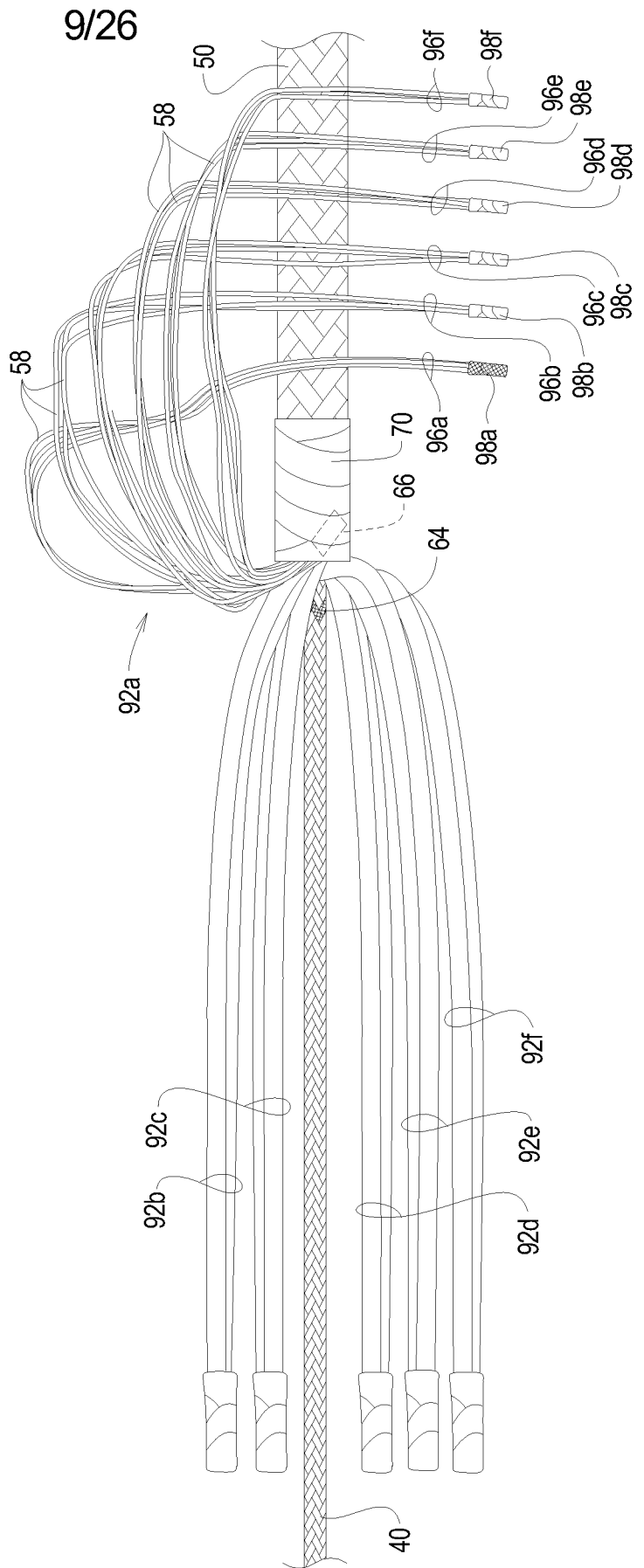


FIG. 20



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FIG. 21

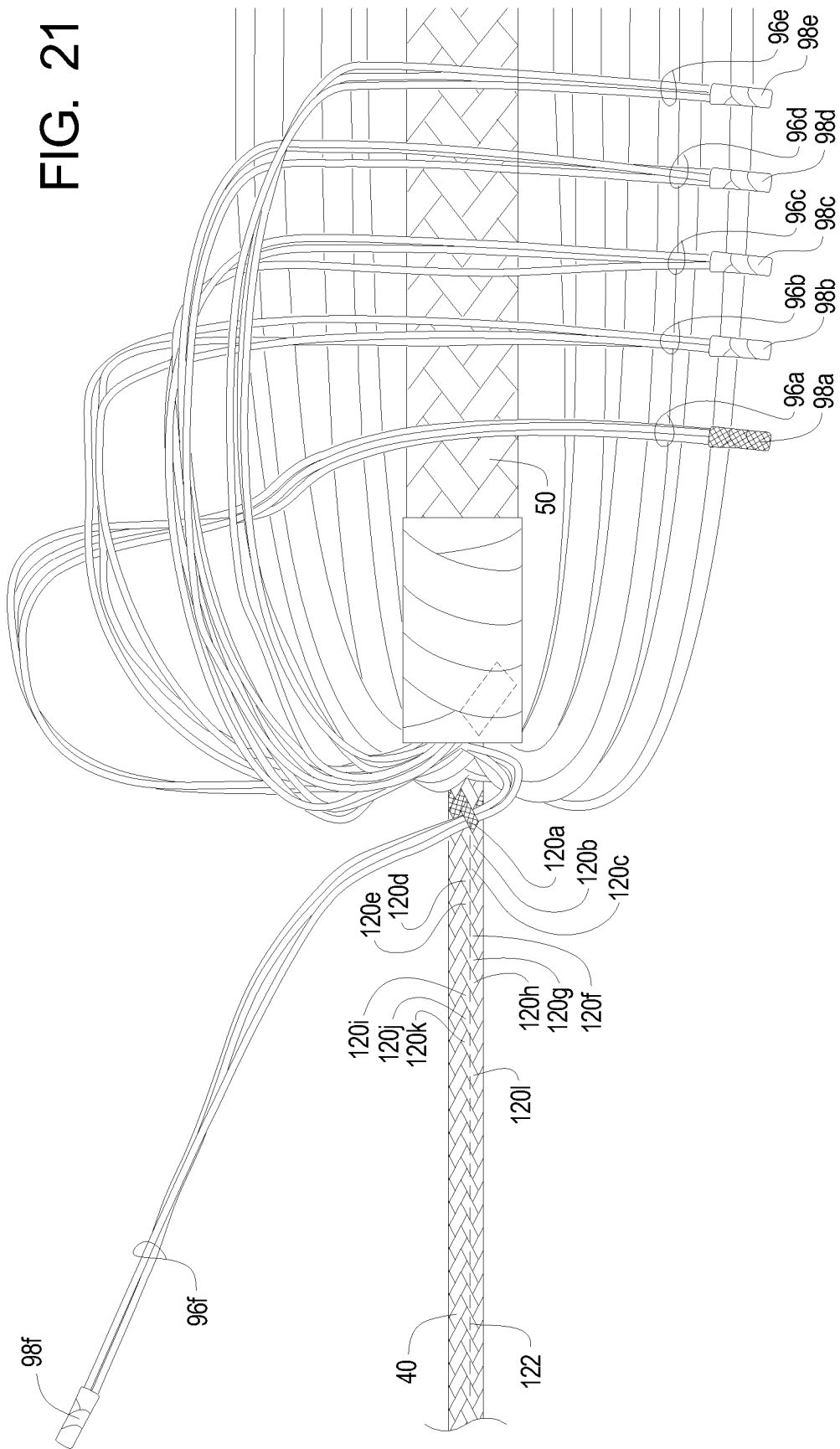


FIG. 22

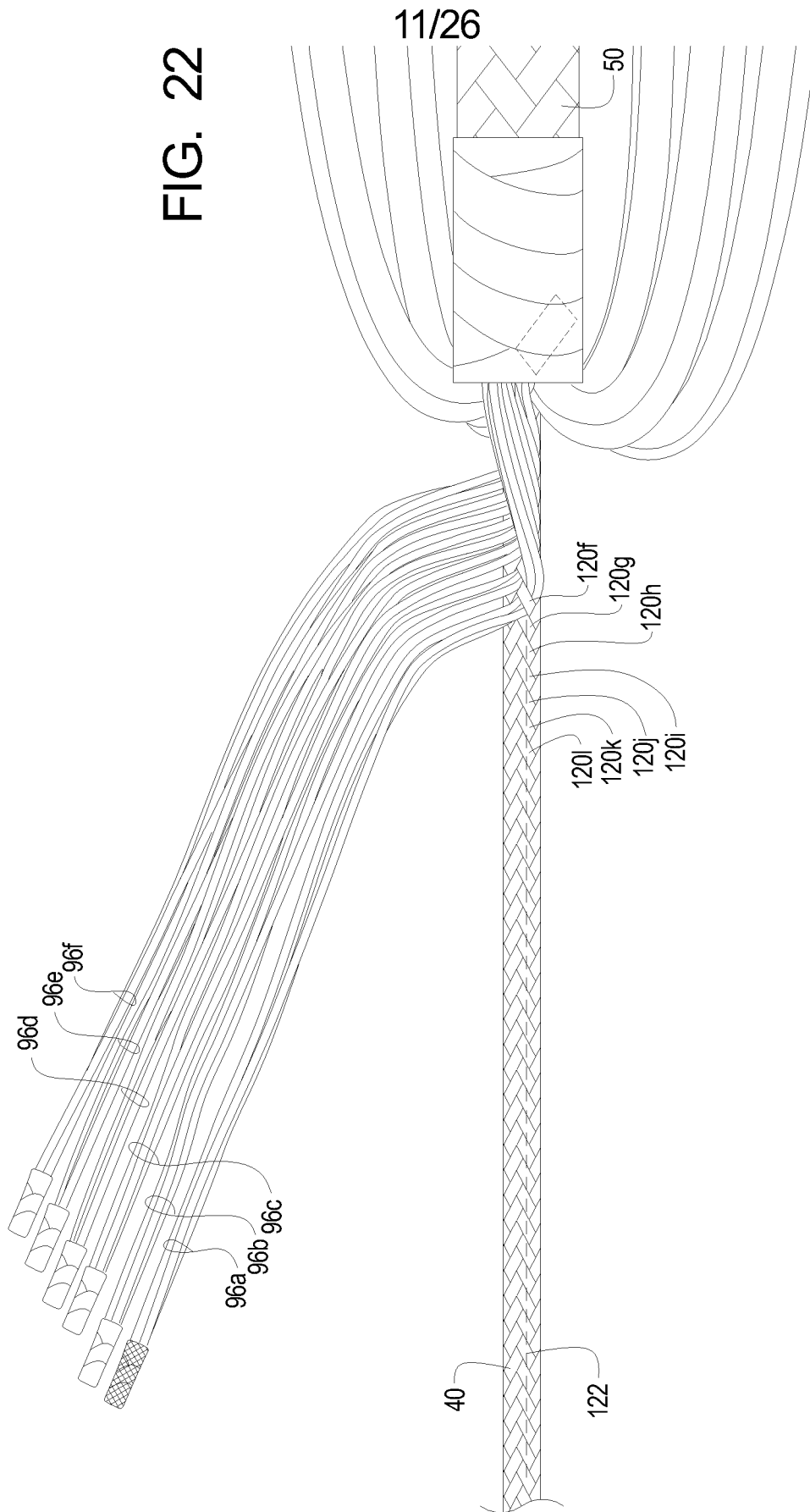


FIG. 23

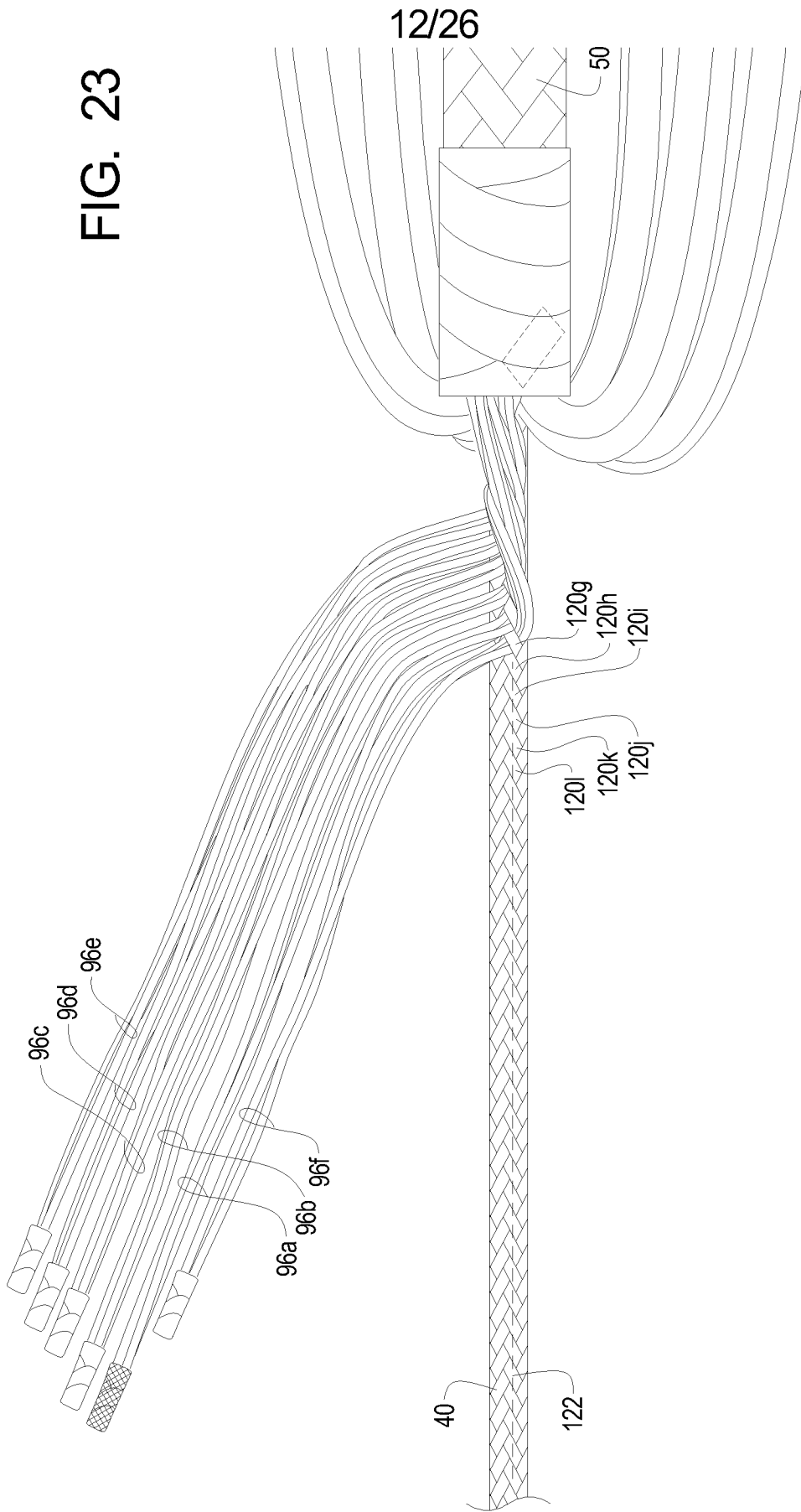


FIG. 24

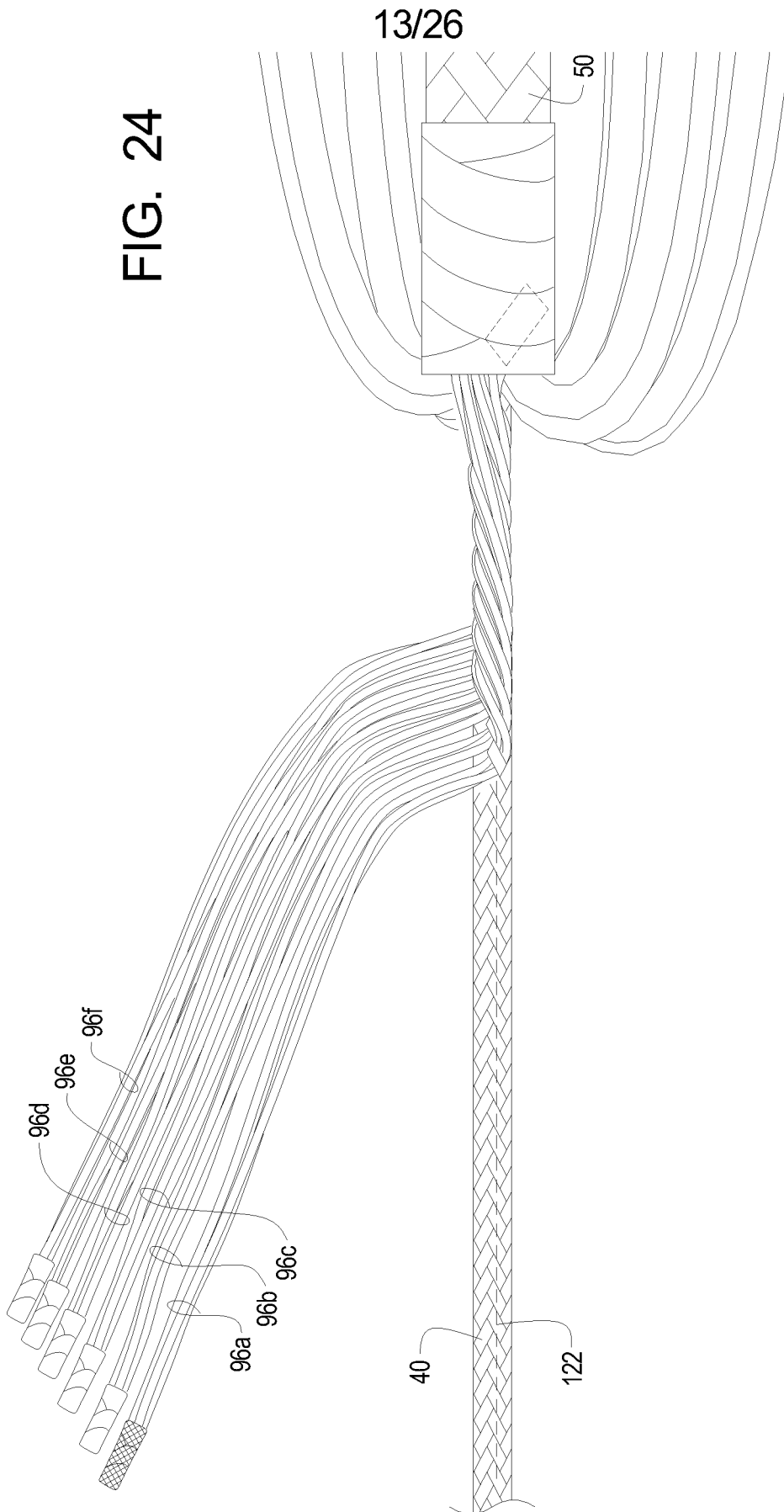


FIG. 25

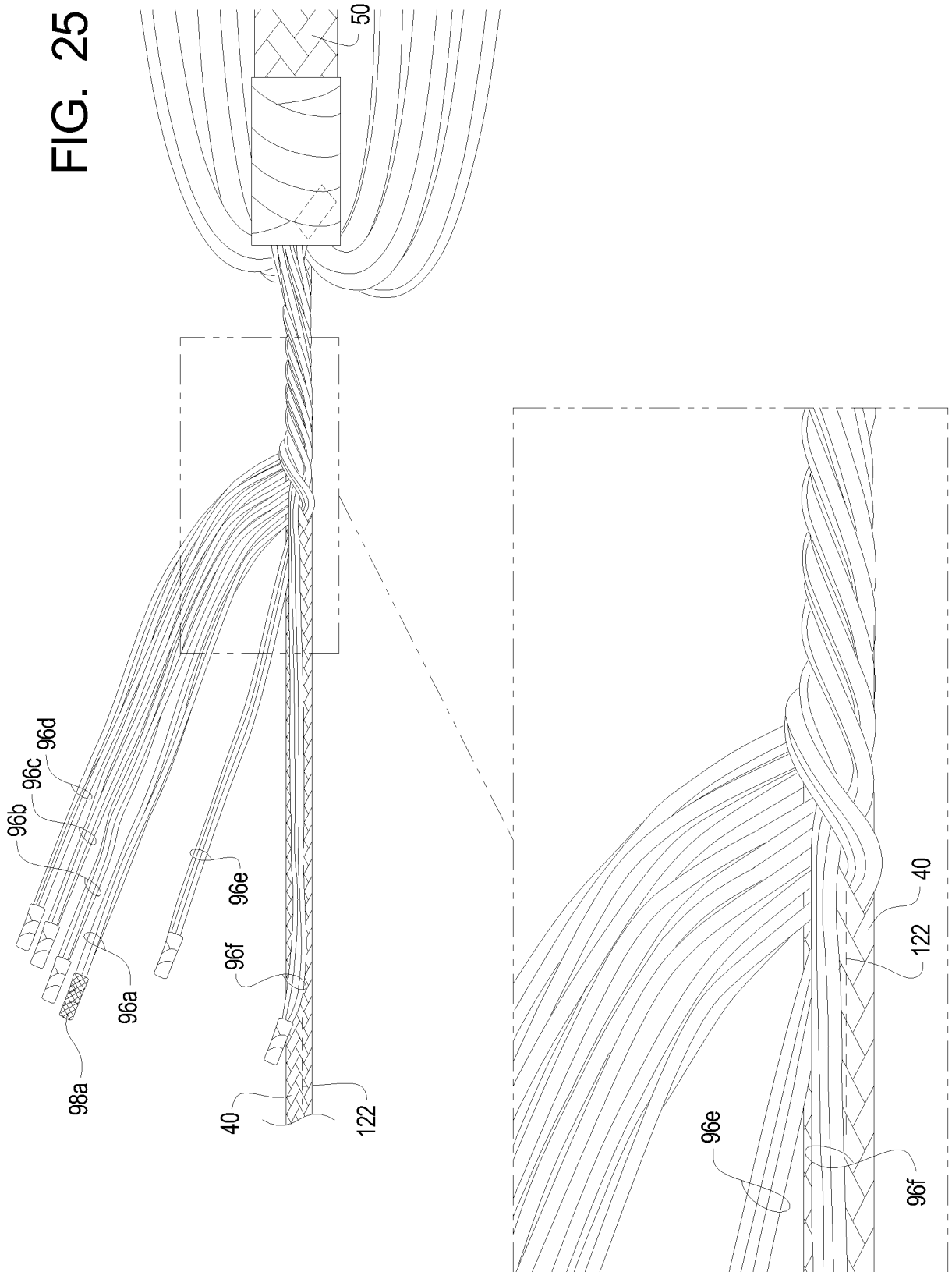


FIG. 27

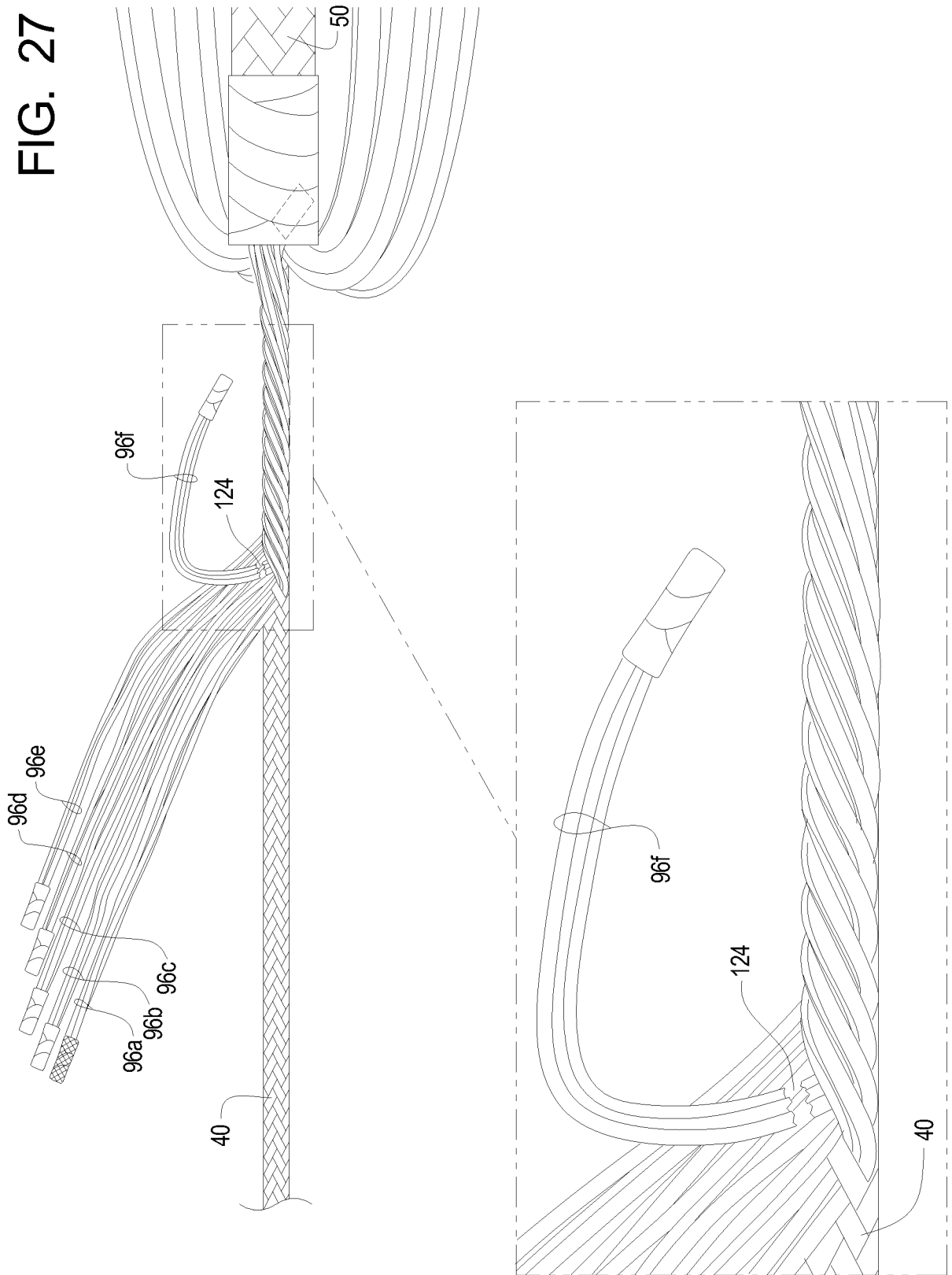


FIG. 28

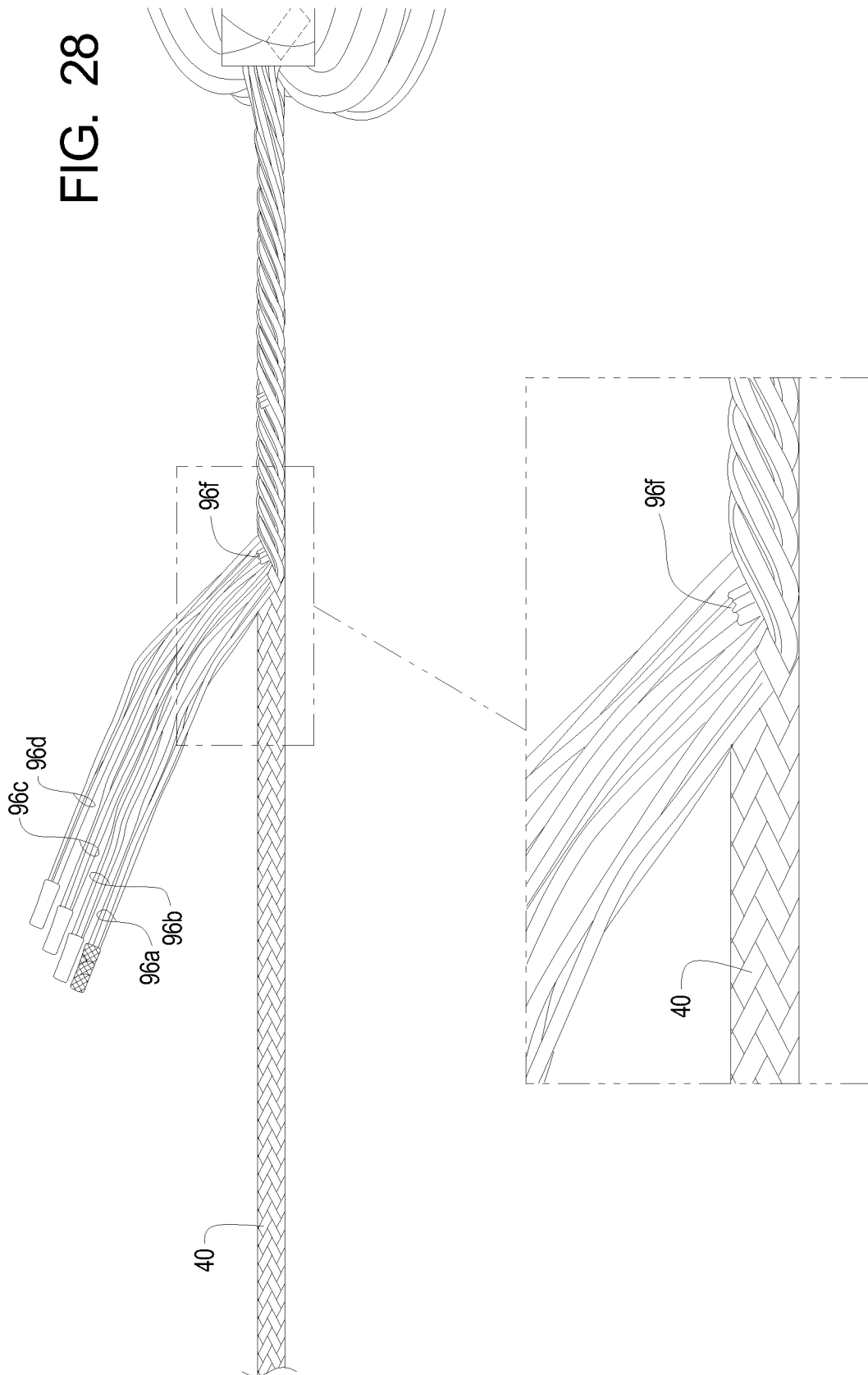


FIG. 29

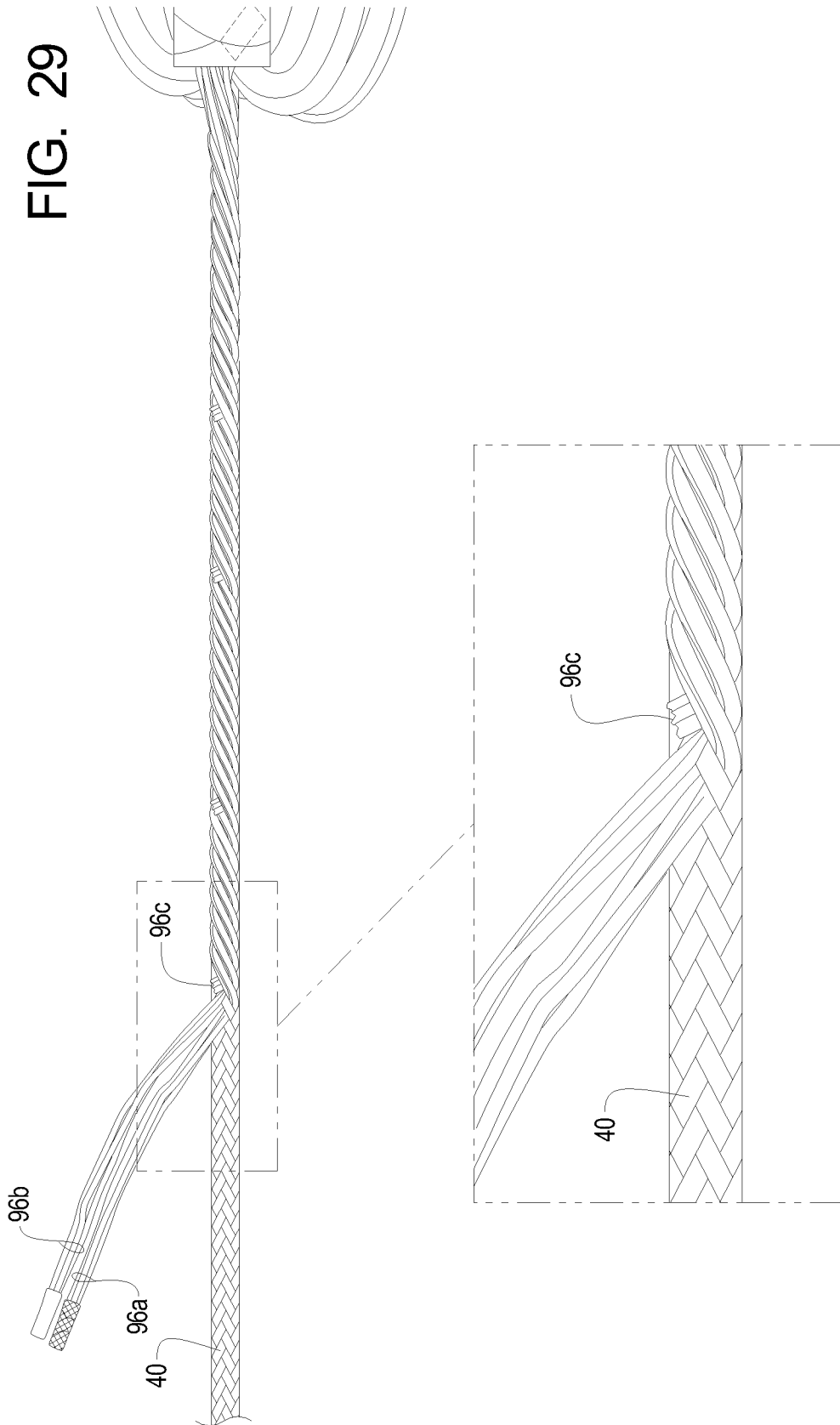


FIG. 30

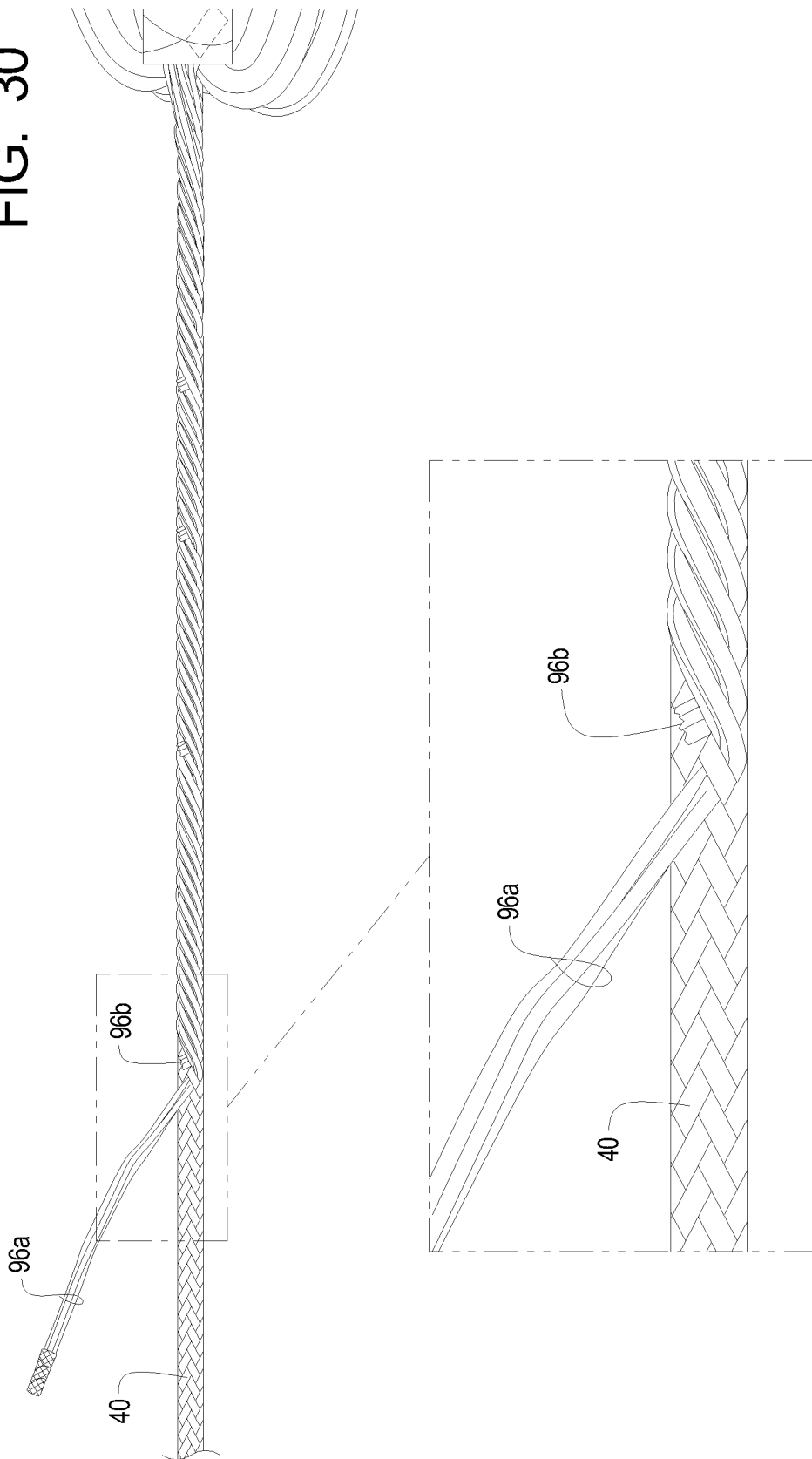


FIG. 31

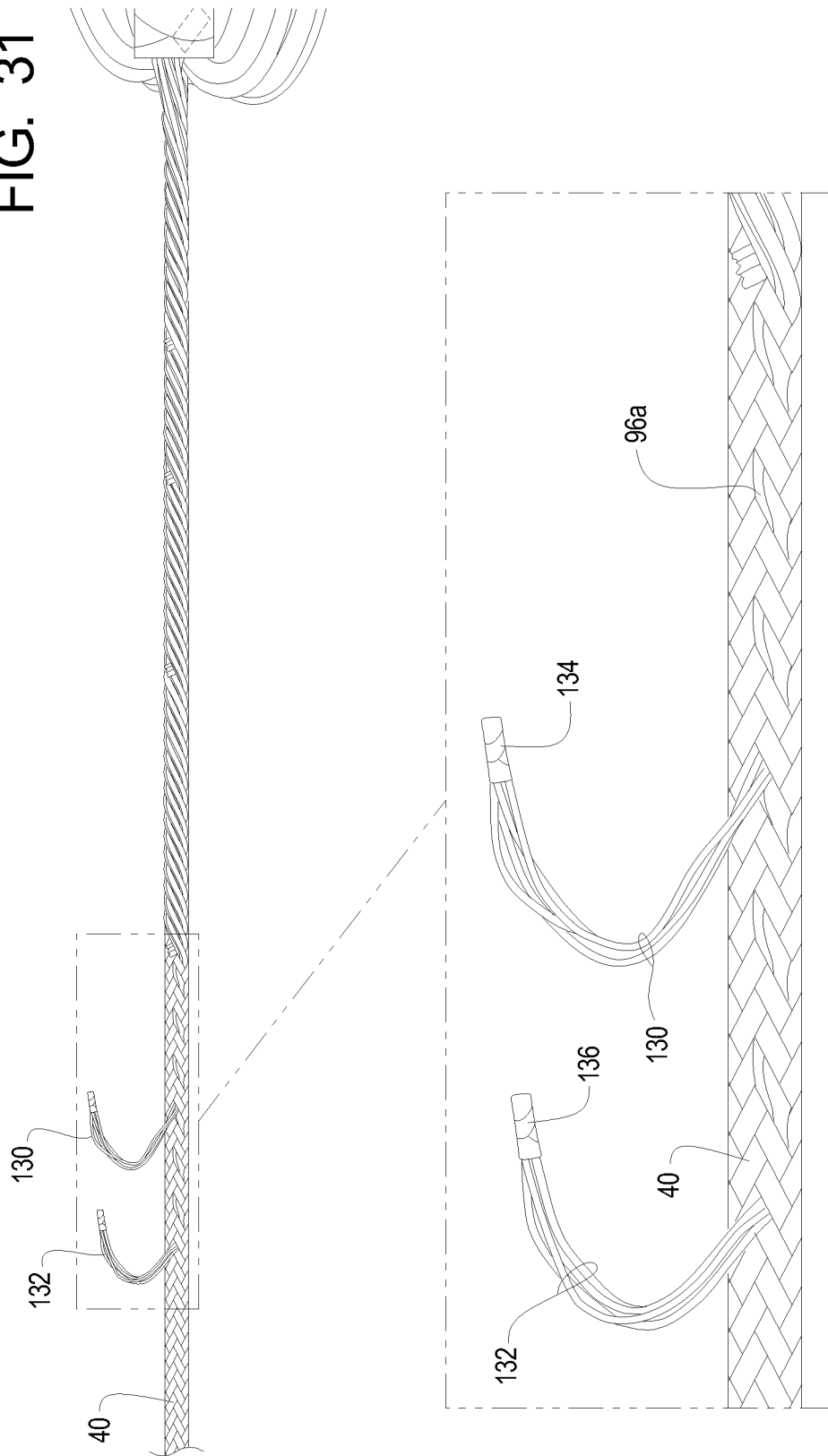


FIG. 32

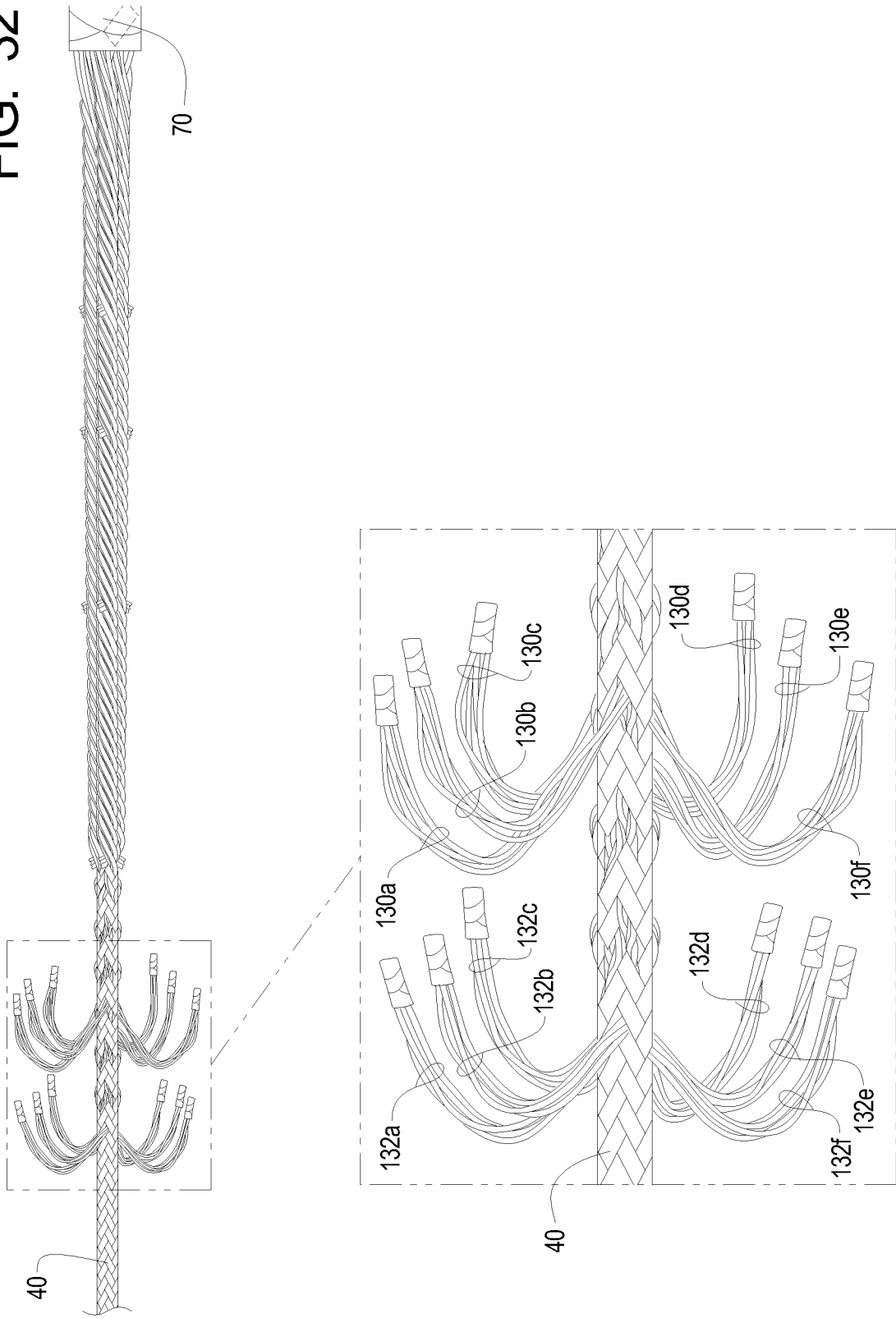


FIG. 33

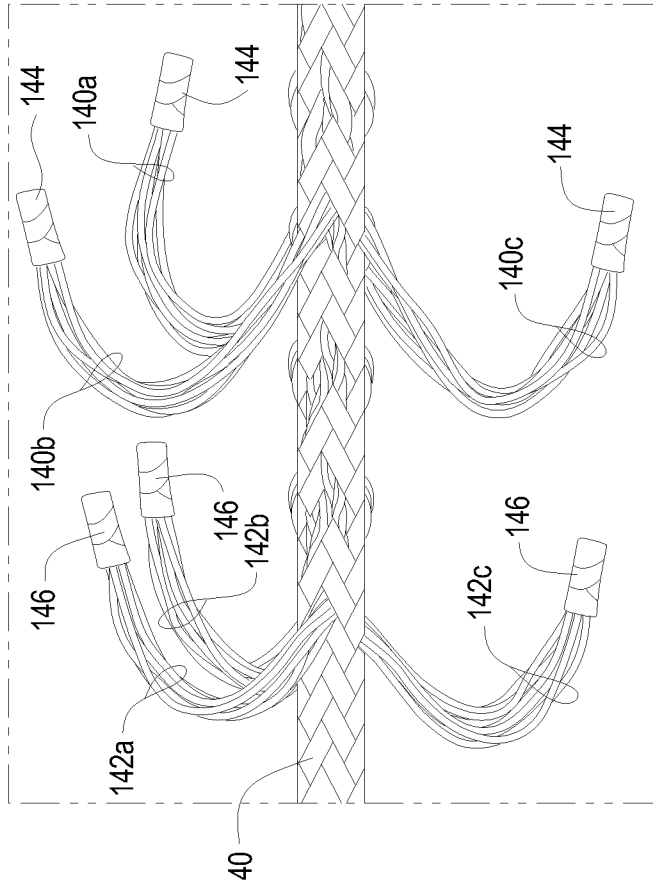


FIG. 34

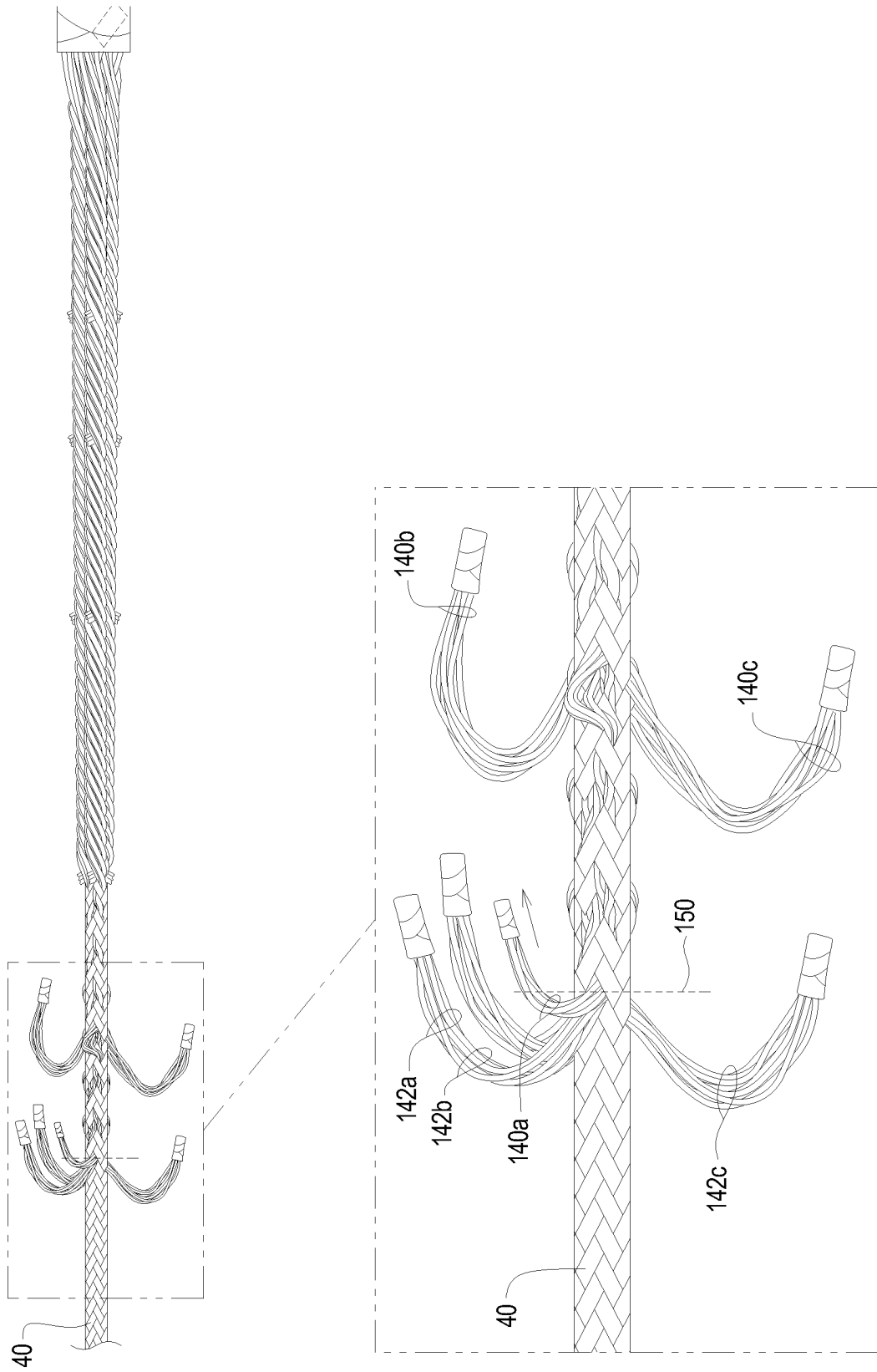


FIG. 36

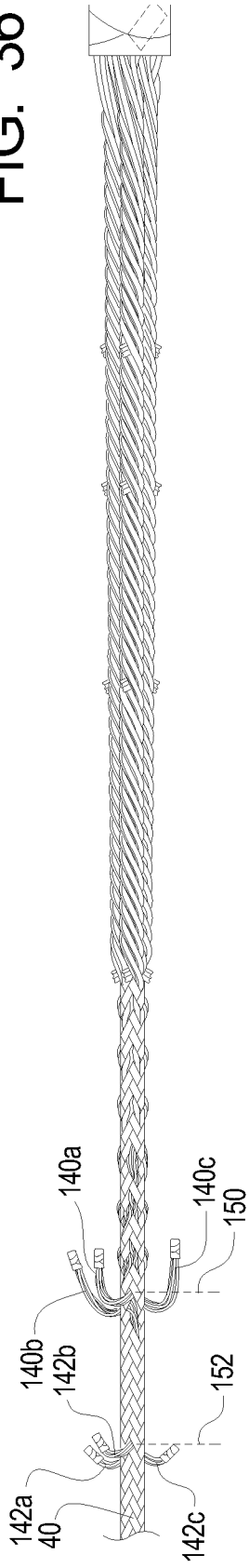


FIG. 37

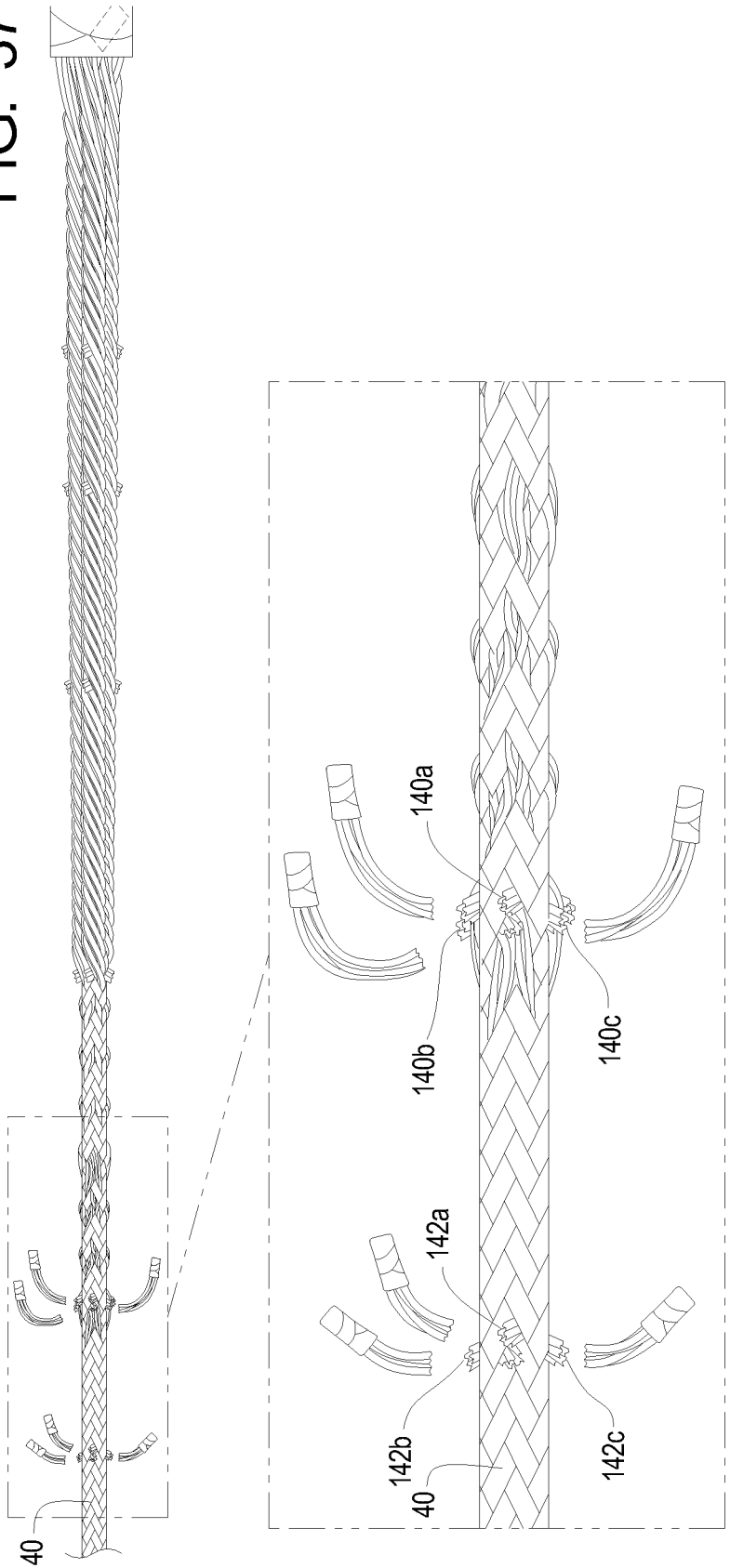
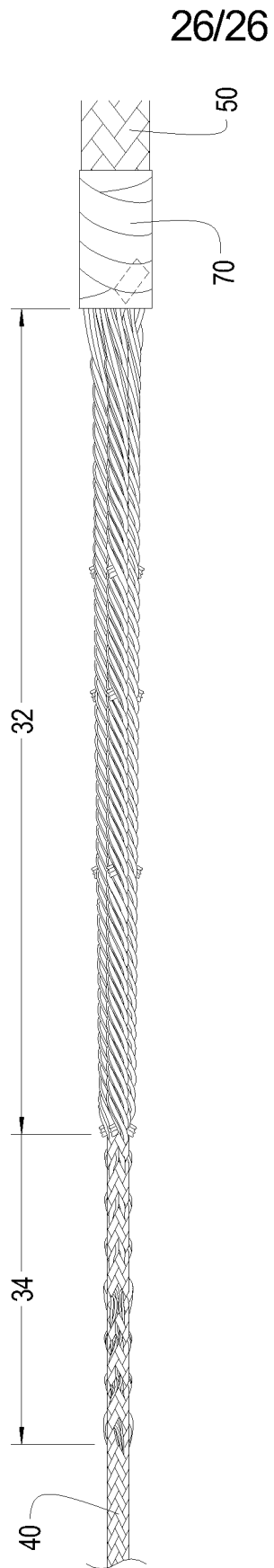


FIG. 38



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/065892

A. CLASSIFICATION OF SUBJECT MATTER		
Int.Cl. D07B9/00(2006.01) i, B65H69/06(2006.01) i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
Int.Cl. D07B1/00-9/00, B65H69/06		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2016 Registered utility model specifications of Japan 1996-2016 Published registered utility model applications of Japan 1994-2016		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3120734 A (AMERICAN CHAIN & CABLE CO. INC.) 1964.02.11, column 4, lines 15-26, figs. 7-9	1
A	(Family: none)	2-21
A	WO 2013/134033 A1 (ACTUANT CORPORATION) 2013.09.12, Best Mode for Carrying Out the Invention & US 2015/0128553 A1 & EP 2822887 A1 & AU 2013230564 A & KR 10-2014-0132000 A	1-21
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
25.03.2016		05.04.2016
Name and mailing address of the ISA/JP		Authorized officer
Japan Patent Office		SAITO, Katsuya
3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan		4S 9344
		Telephone No. +81-3-3581-1101 Ext. 3474

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/065892

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/039715 A1 (DSM IP ASSETS B. V.) 2004.05.13, CLAIMS & JP 2006-504879 A & US 2006/0048494 A1 & EP 1575860 A1 & DE 60308552 D & BR 315873 A & AU 2003279607 A & AT 340145 T & KR 10-2005-0074522 A & CN 1708446 A	1-21
A	WO 2000/005162 A2 (TEUFELBERGER GESELLSCHAFT MBH) 2000.02.03, Abstract & EP 1040070 A2 & AT 3431 U	1-21