US 20150337490A1

(19) **United States**

(12) **Patent Application Publication**

Burdette, III et al.

(10) **Pub. No.: US 2015/0337490 A1**

(43) **Pub. Date: Nov. 26, 2015**

(54) **ROPE PRODUCTS, SYSTEMS, METHODS AND APPLICATIONS**

(71) Applicant: **Southern Weaving Company**, Greenville, SC (US)

(72) Inventors: **Cecil Curtiss Burdette, III**, Easley, SC (US); **David Andrew Broadway**, Anderson, SC (US)

(73) Assignee: **SOUTHERN WEAVING COMPANY**, Greenville, SC (US)

(21) Appl. No.: **14/713,967**

(22) Filed: **May 15, 2015**

Related U.S. Application Data

(60) Provisional application No. 61/993,703, filed on May 15, 2014.

Publication Classification

(51) **Int. Cl.**

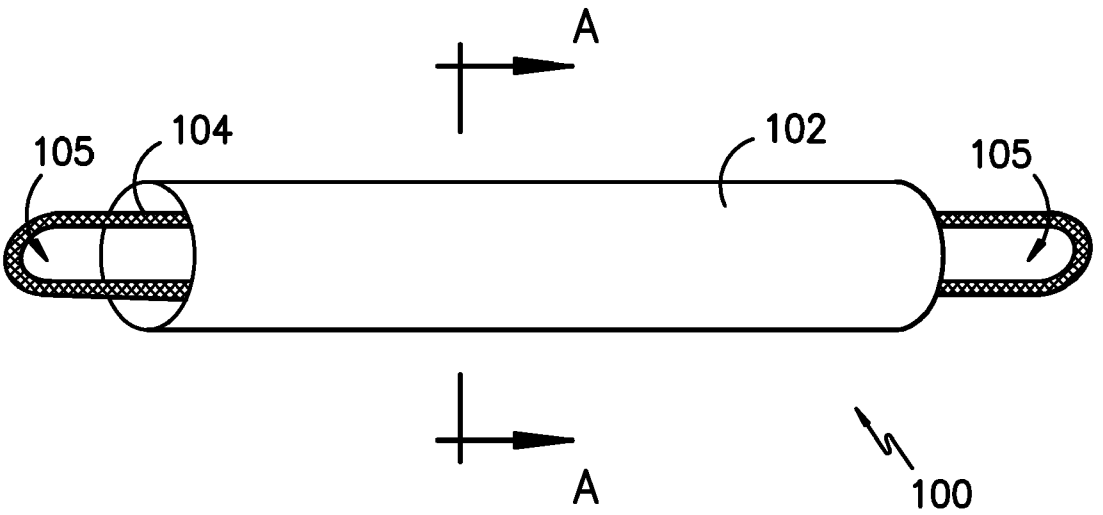
D07B 1/12	(2006.01)
D07B 1/02	(2006.01)
D03D 3/02	(2006.01)

(52) **U.S. Cl.**

CPC .. ***D07B 1/12*** (2013.01); ***D03D 3/02*** (2013.01); ***D07B 1/02*** (2013.01)

(57) **ABSTRACT**

Embodiments of the present invention include rope products, systems, processes, and related applications as disclosed herein.



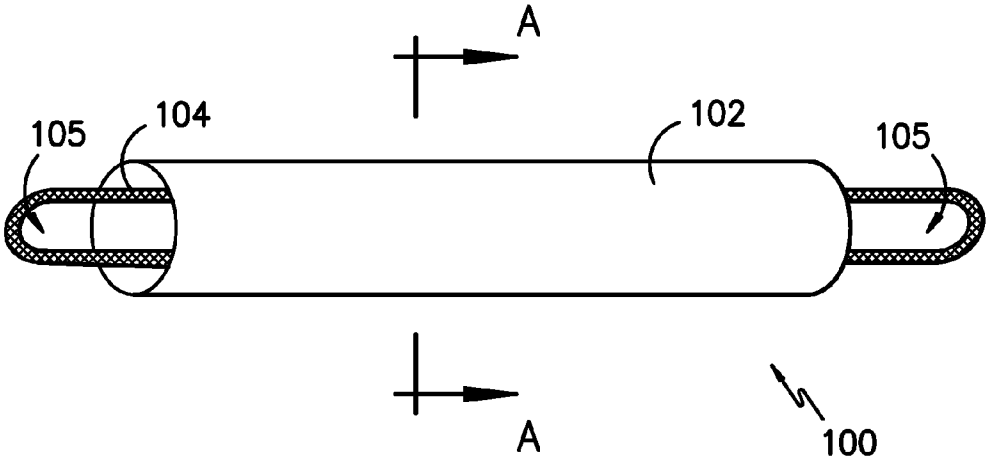


FIG. -1-

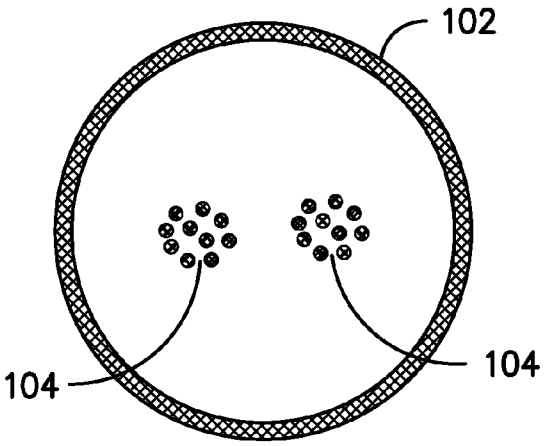


FIG. -1A-

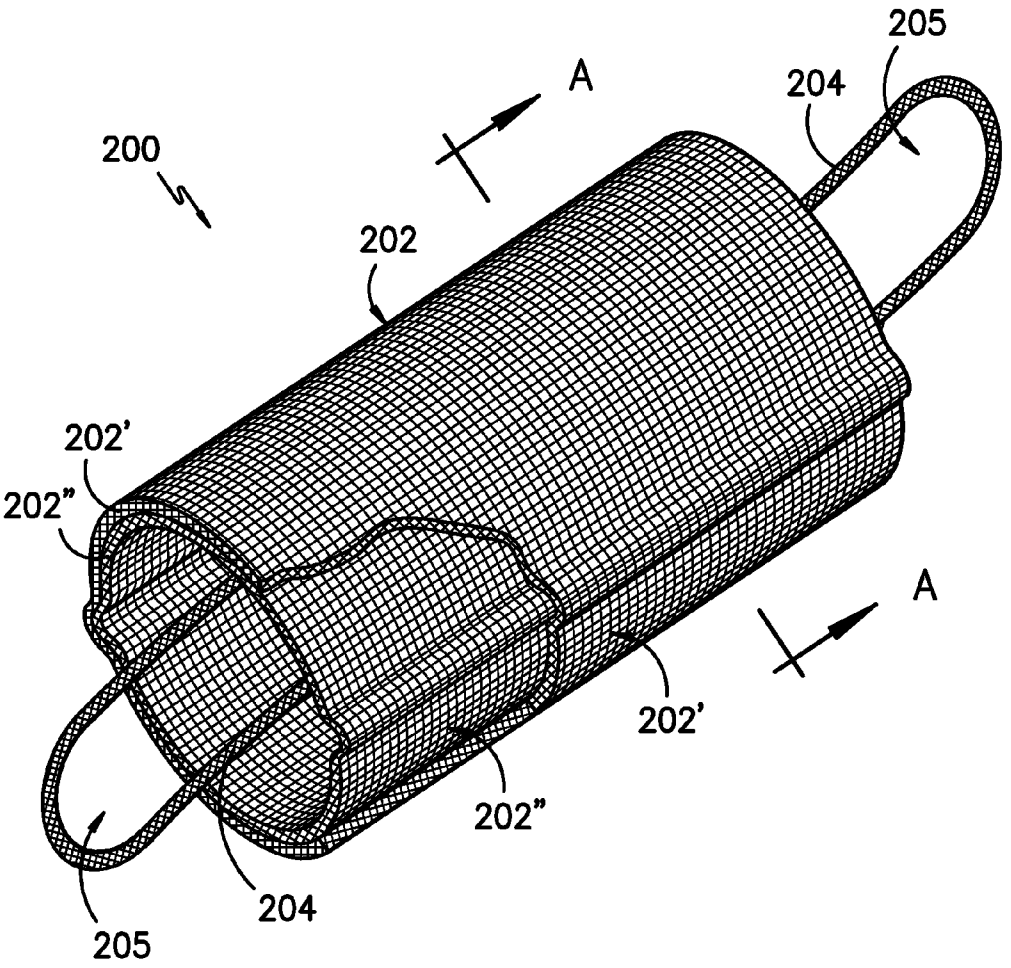


FIG. -2-

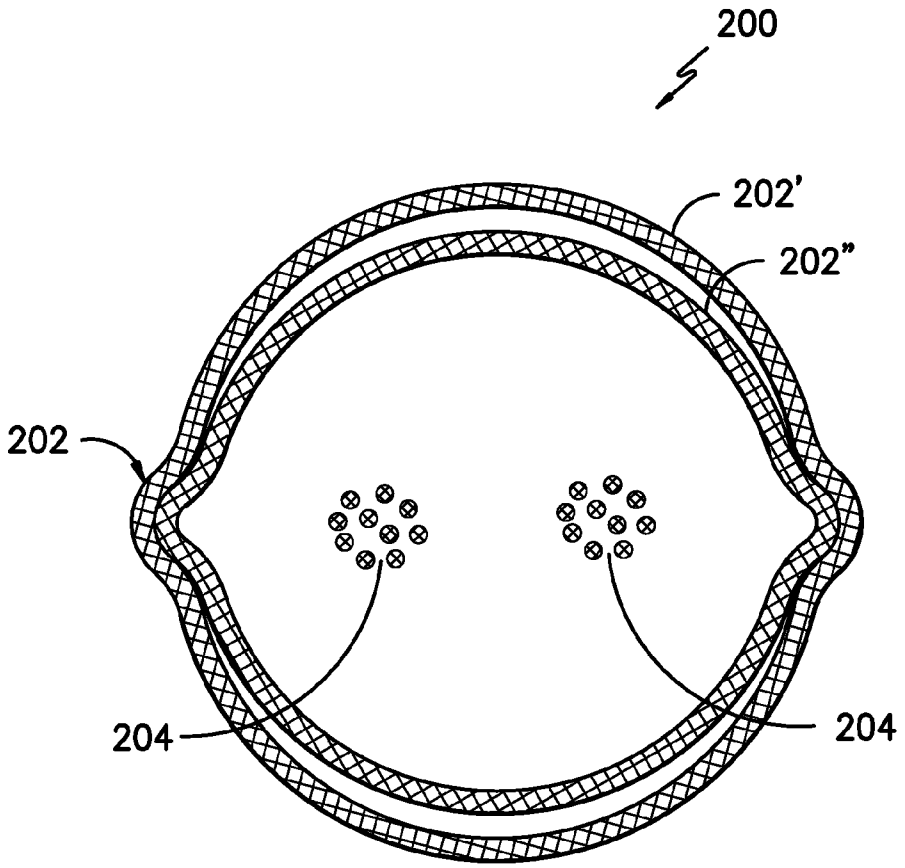


FIG. -2A-

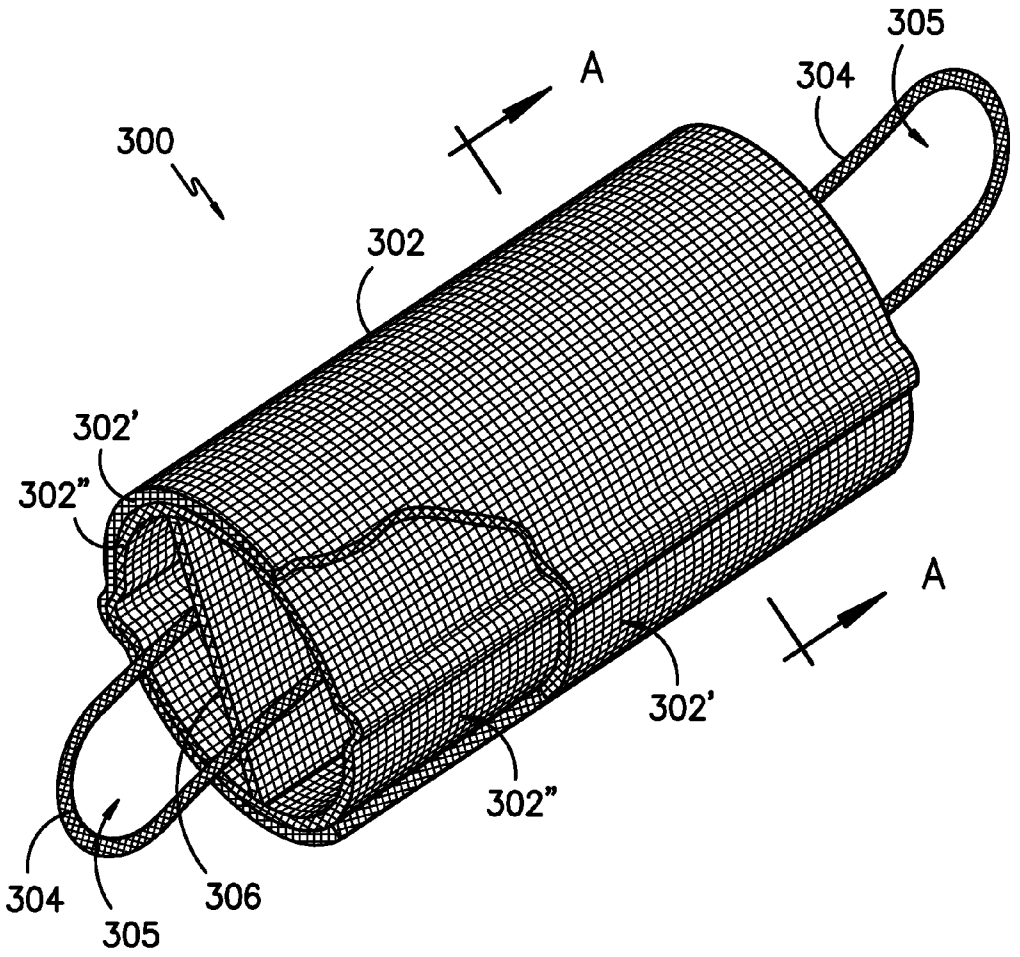


FIG. -3-

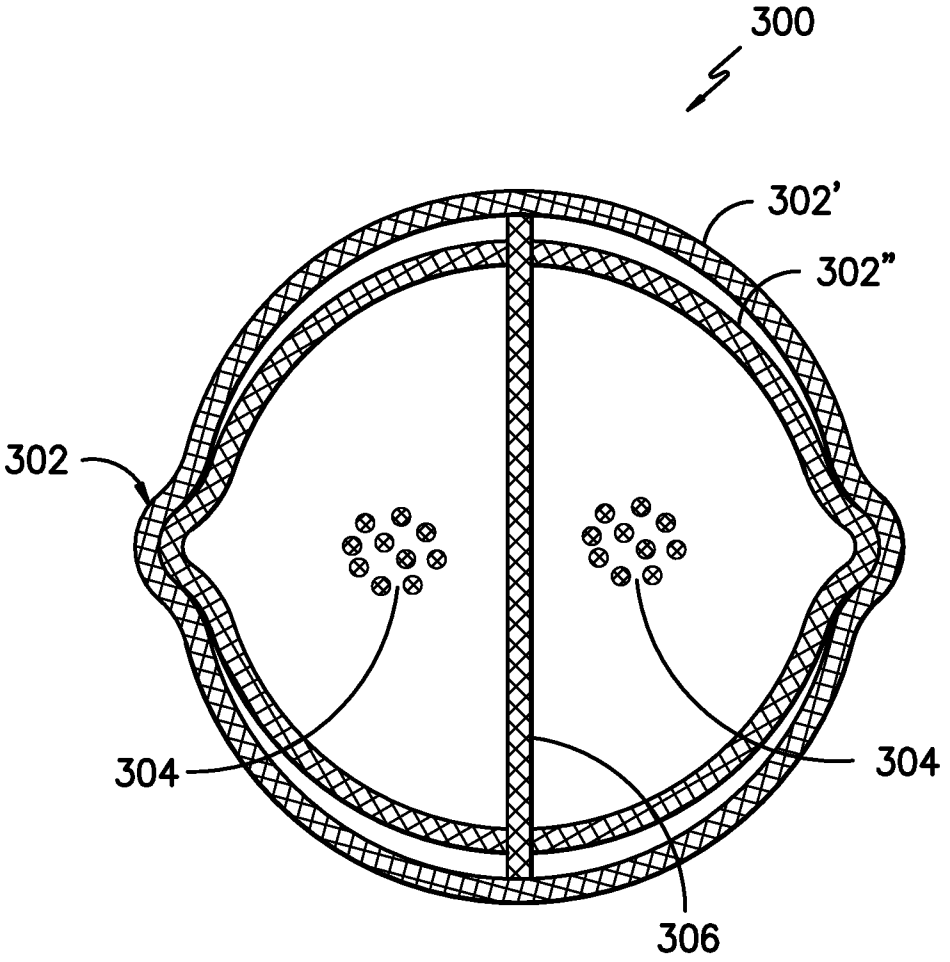


FIG. -3A-

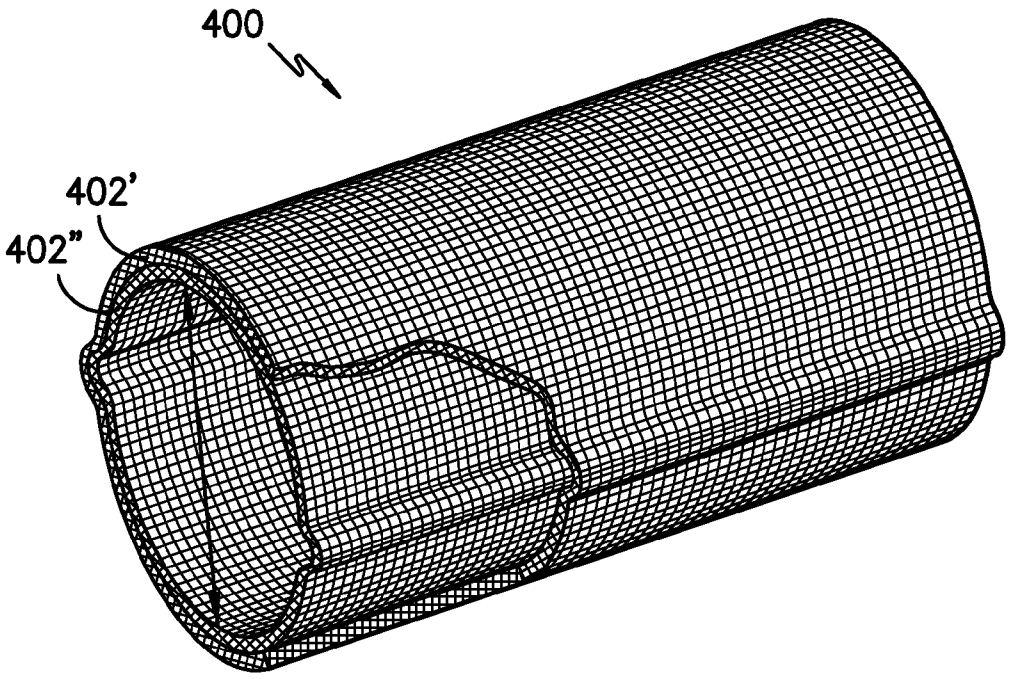


FIG. -4-

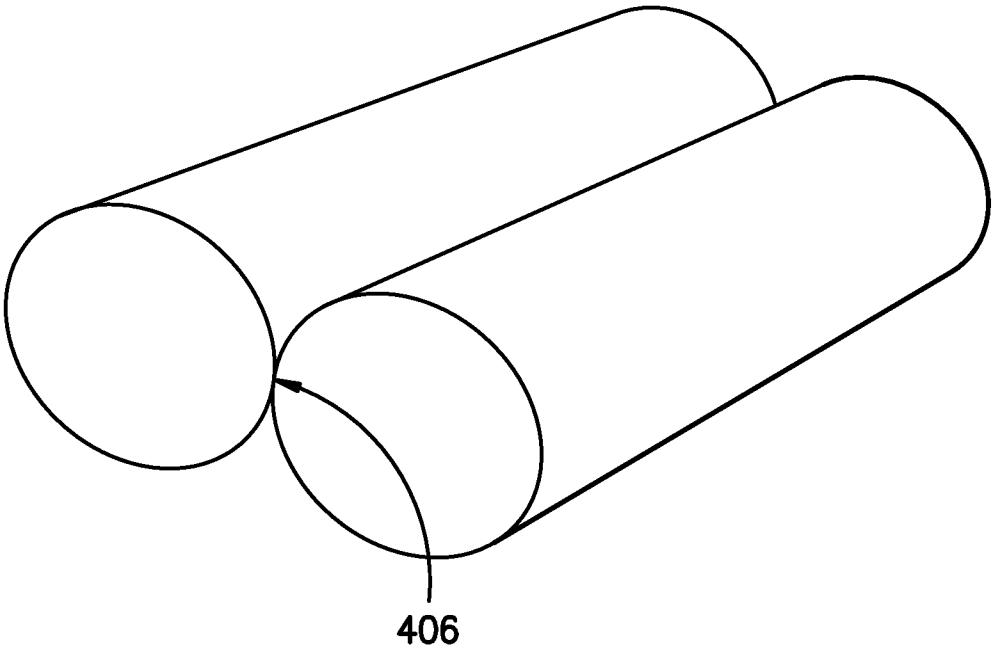


FIG. -4A-

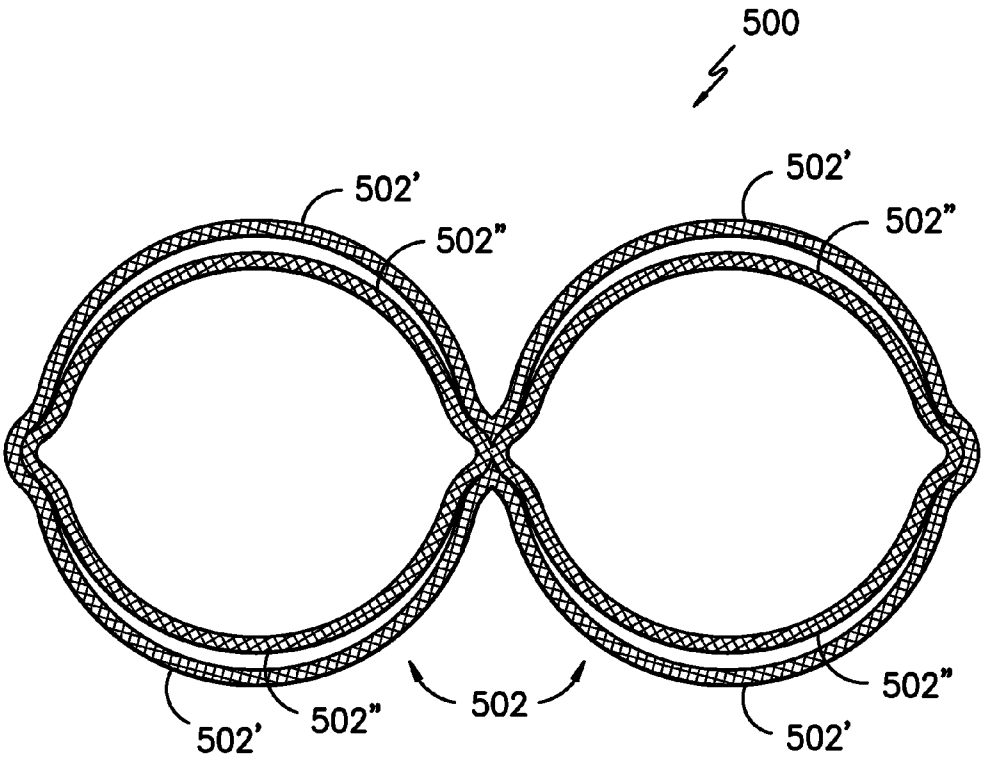


FIG. -5-

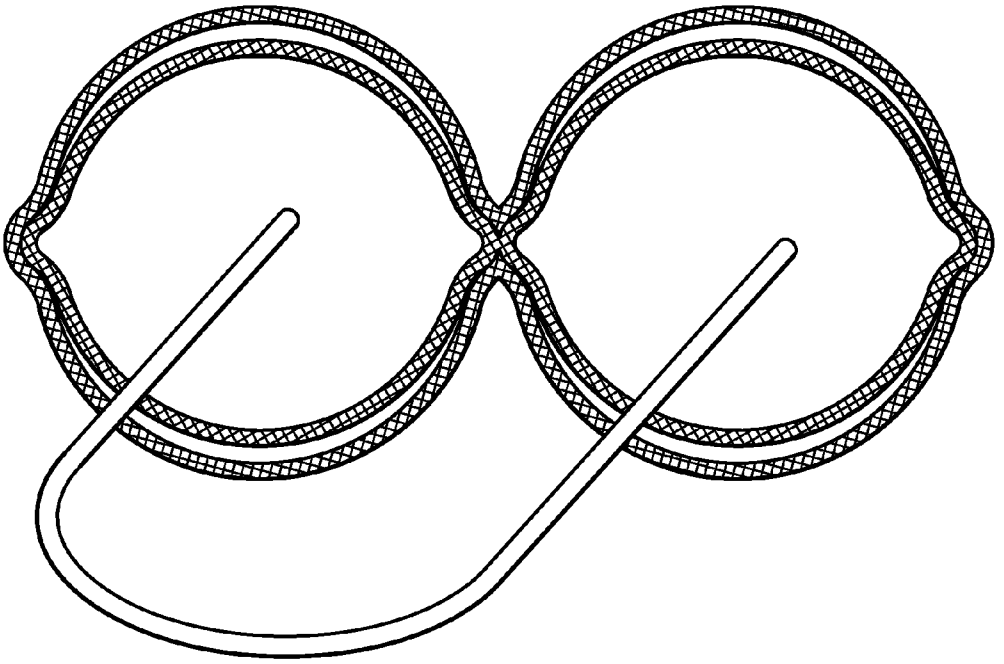


FIG. -5A-

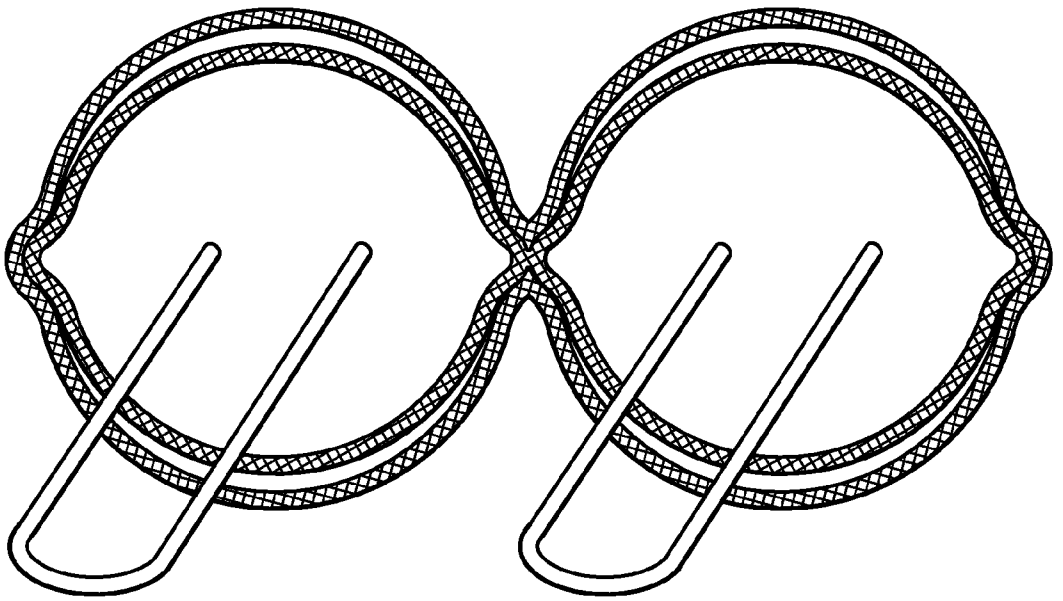


FIG. -5B-

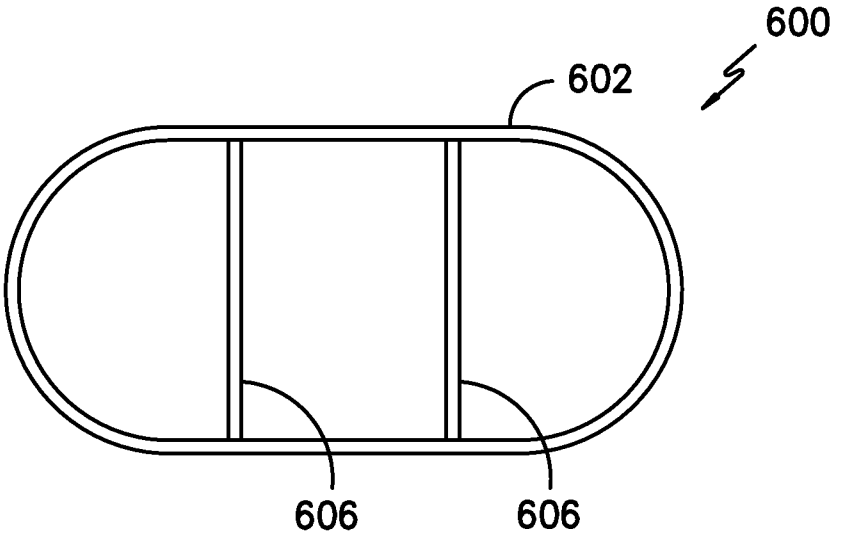


FIG. -6-

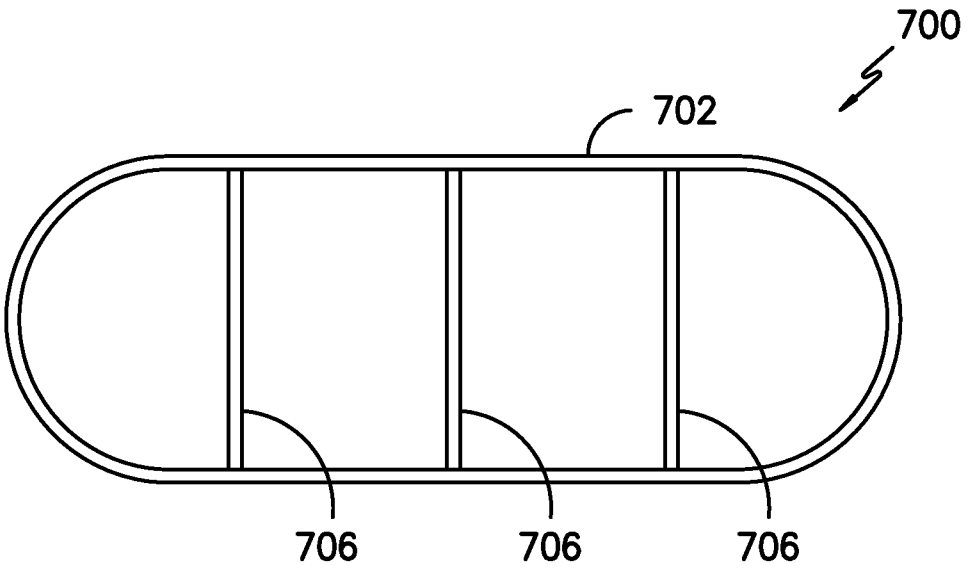


FIG. -7-

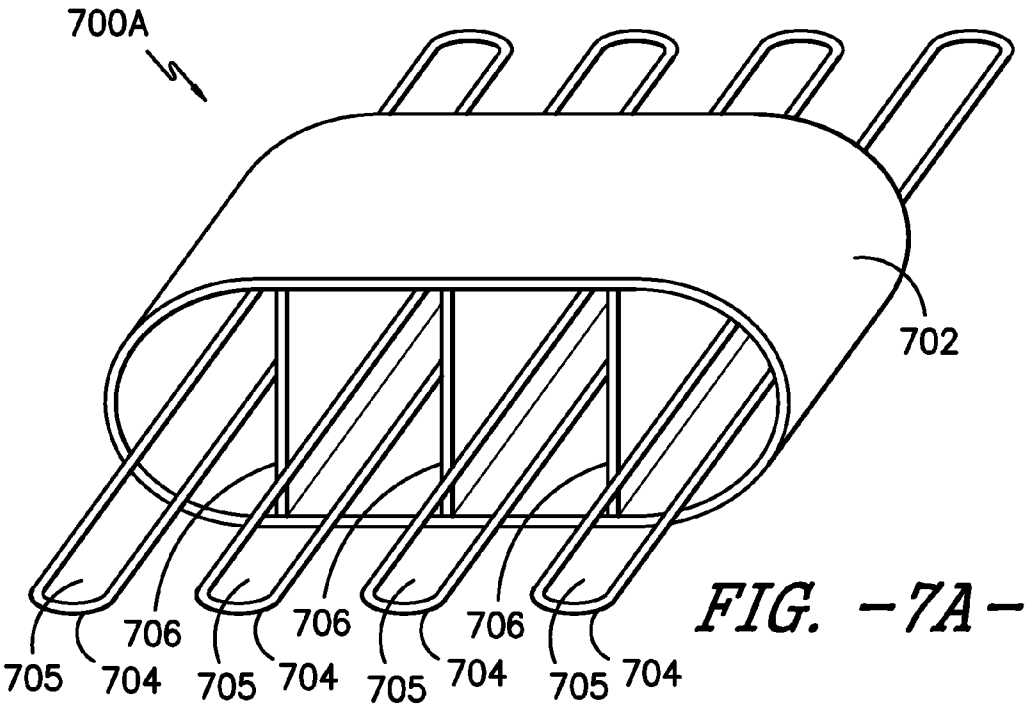

700A
702
705
704
706
705
704
706
705
704
706
705
704

FIG. -7A-

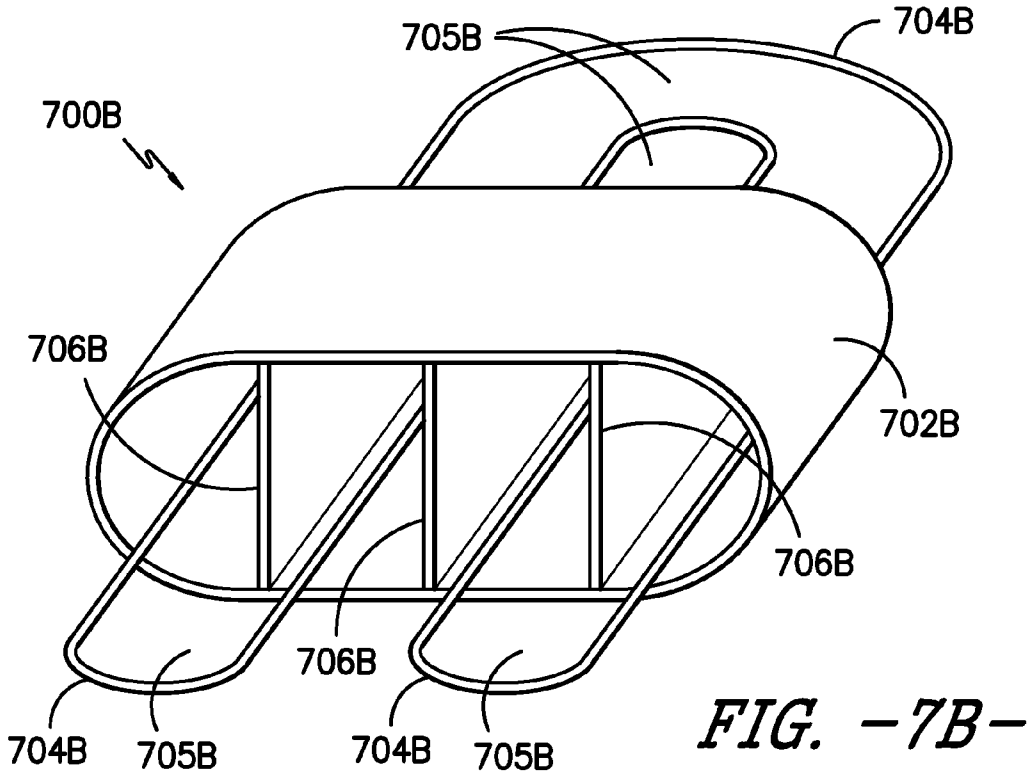

705B
704B
700B
706B
702B
706B
706B
704B
705B
704B
705B

FIG. -7B-

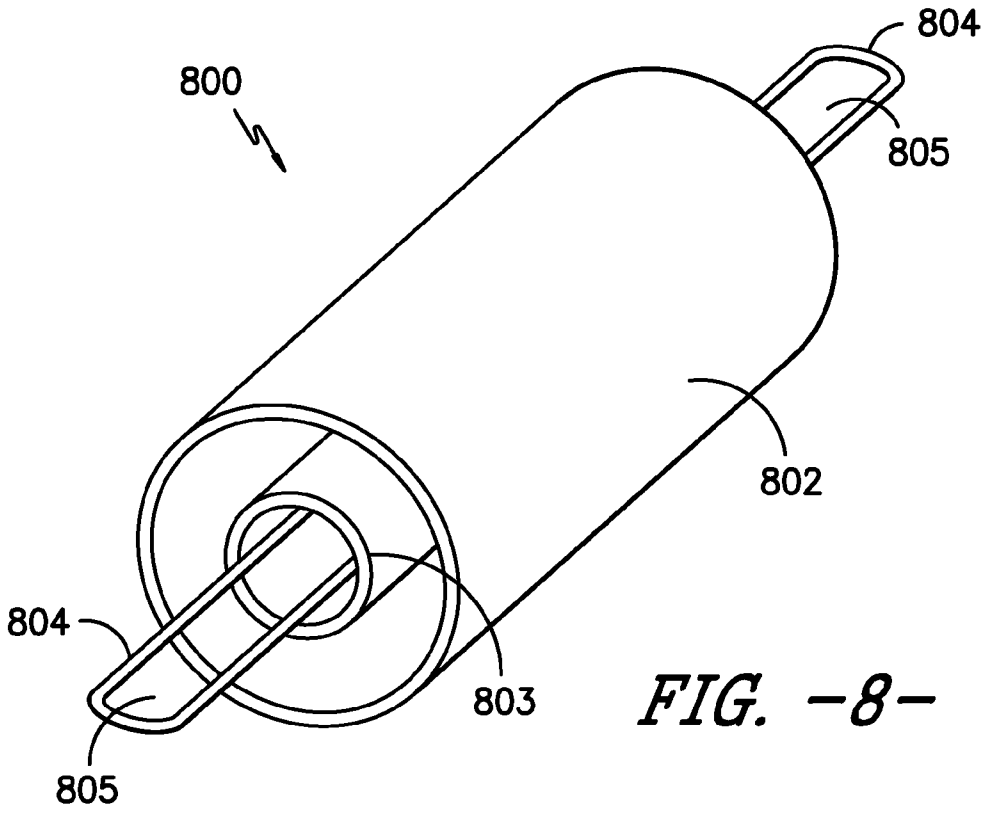


FIG. -8-

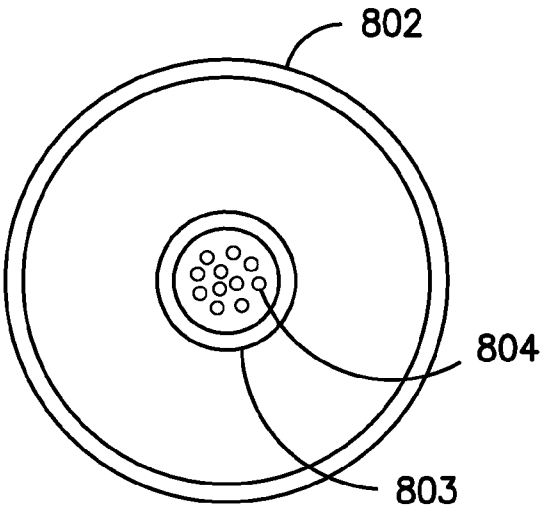


FIG. -8A-

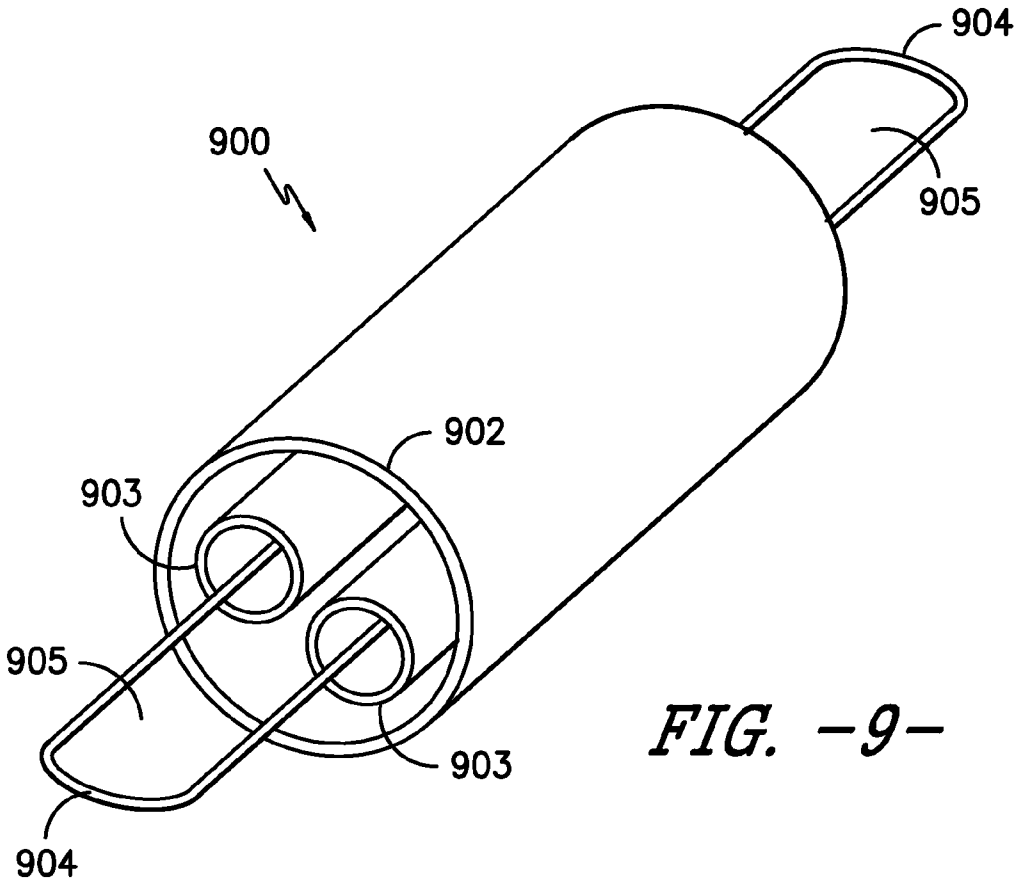


FIG. -9-

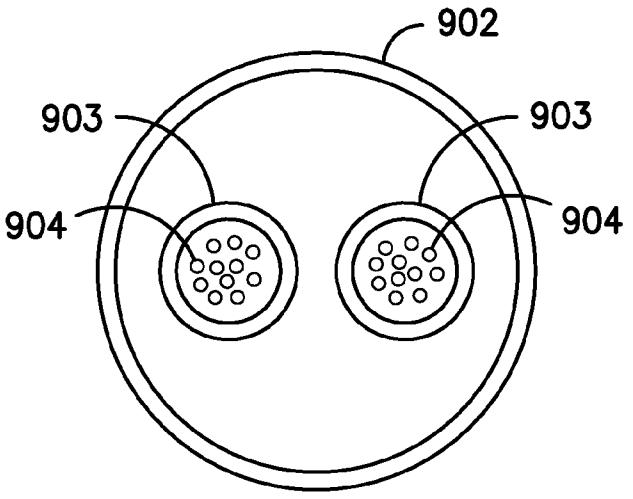


FIG. -9A-

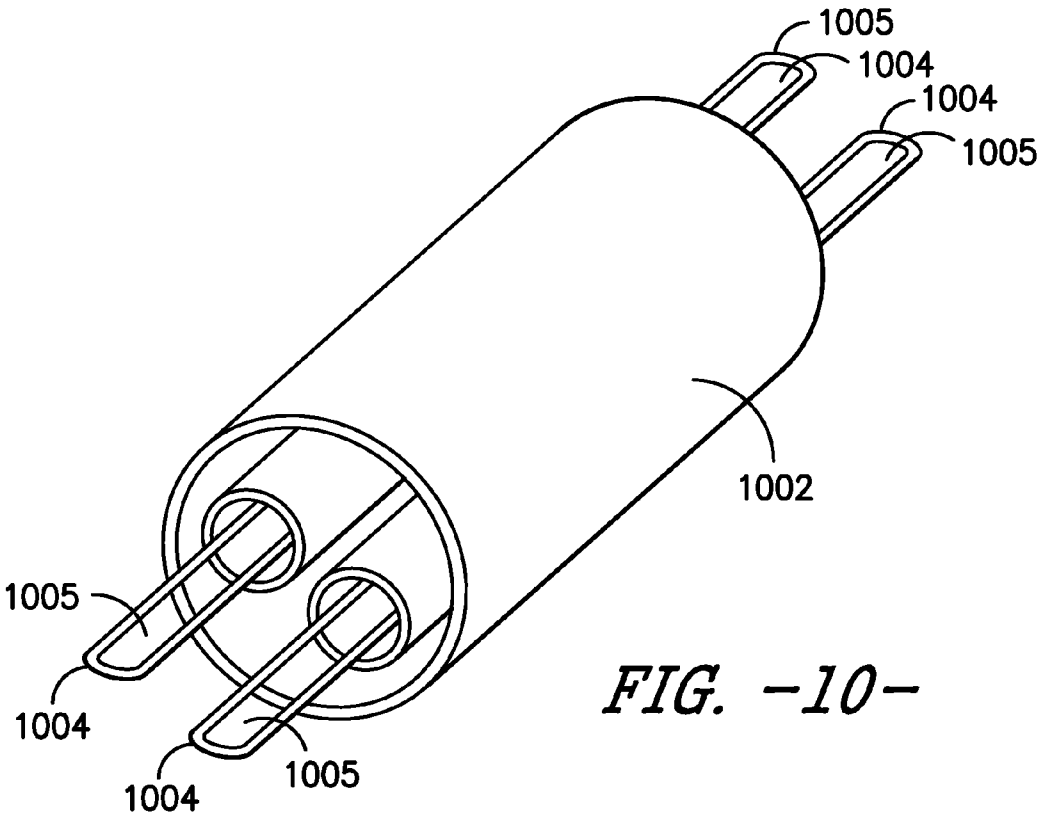


FIG. -10-

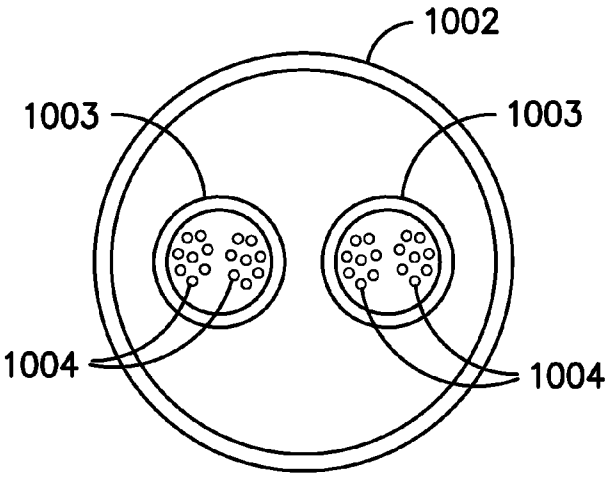


FIG. -10A-

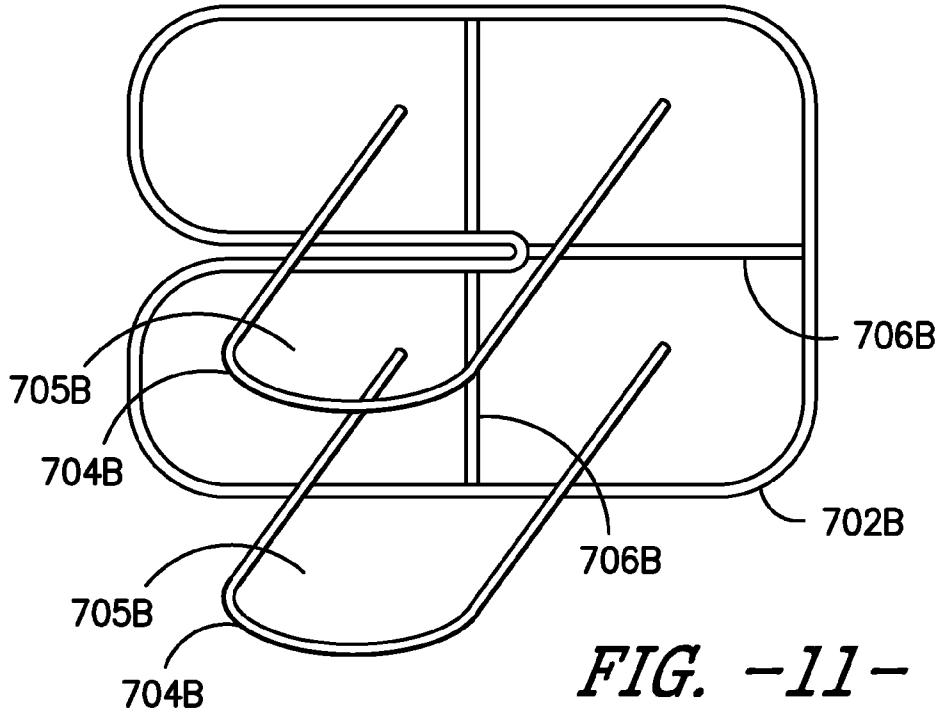

706B
705B
704B
702B
706B
705B
704B

FIG. -11-

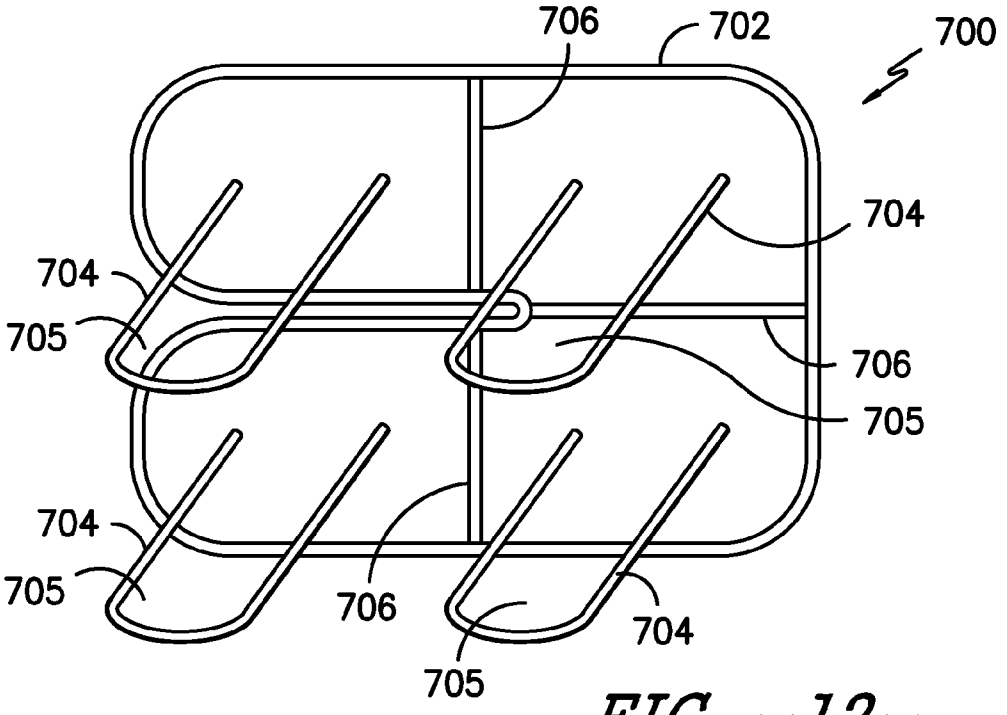

706
702
700
704
704
705
706
705
704
705
706
704
705

FIG. -12-

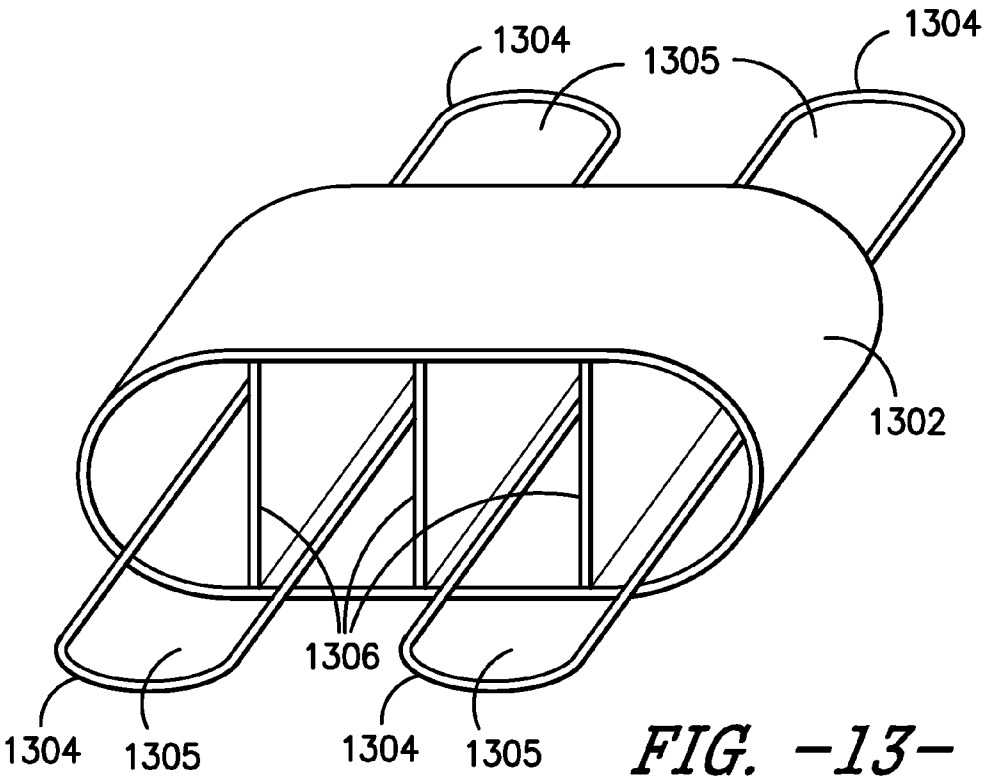


FIG. -13-

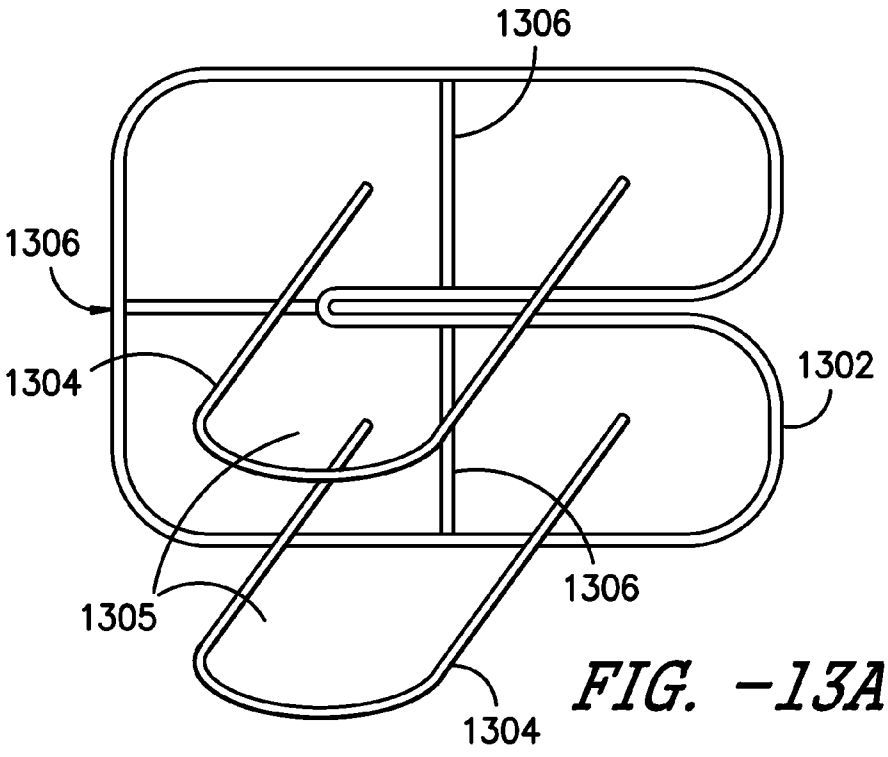


FIG. -13A-

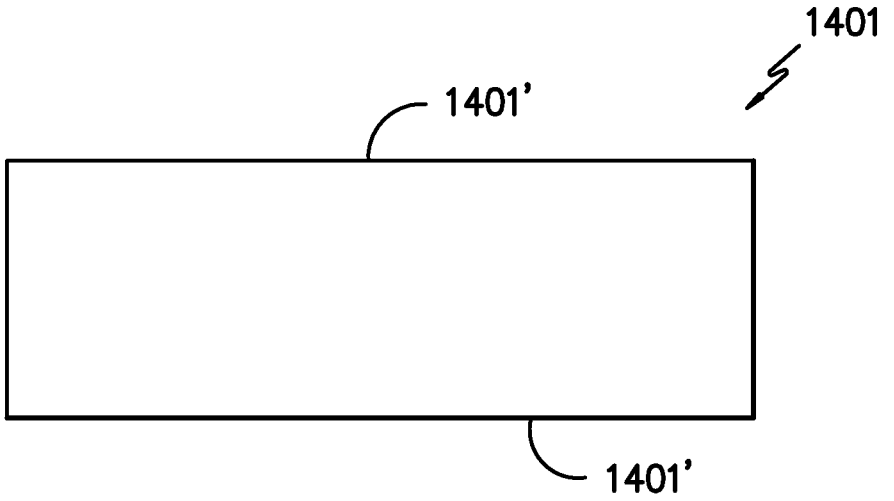


FIG. -14-

FIG. -14A-

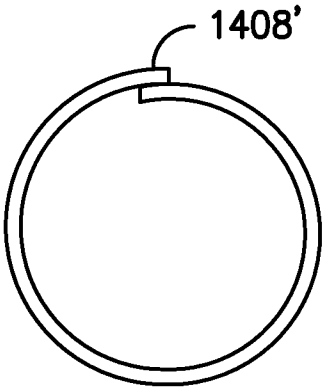


FIG. -14B-

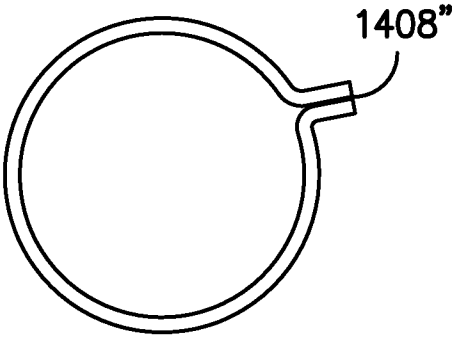


FIG. -14C-

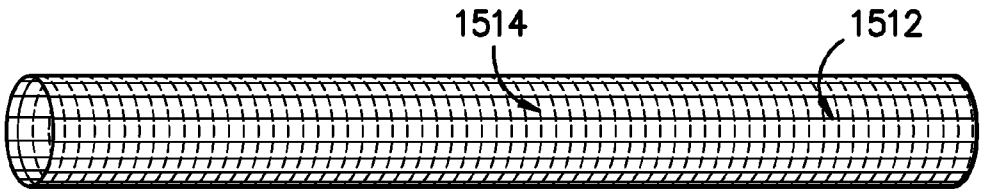


FIG. -15A-

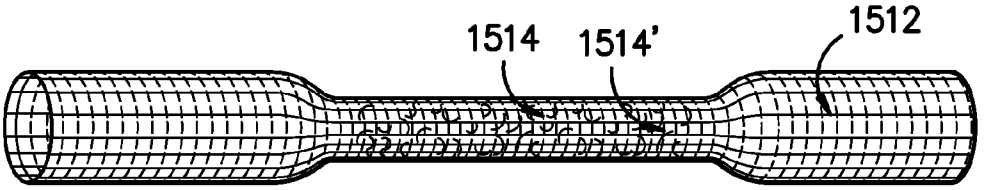


FIG. -15B-

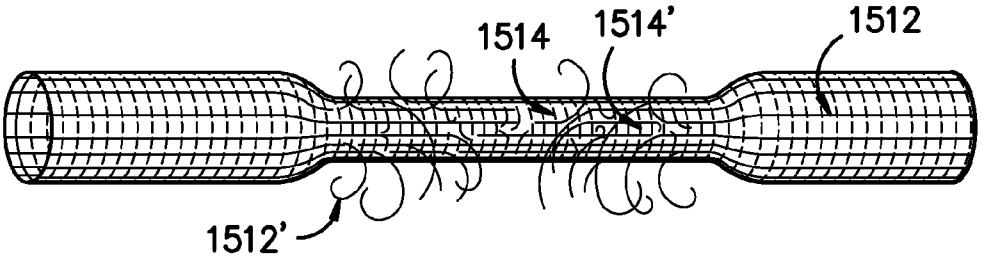


FIG. -15C-

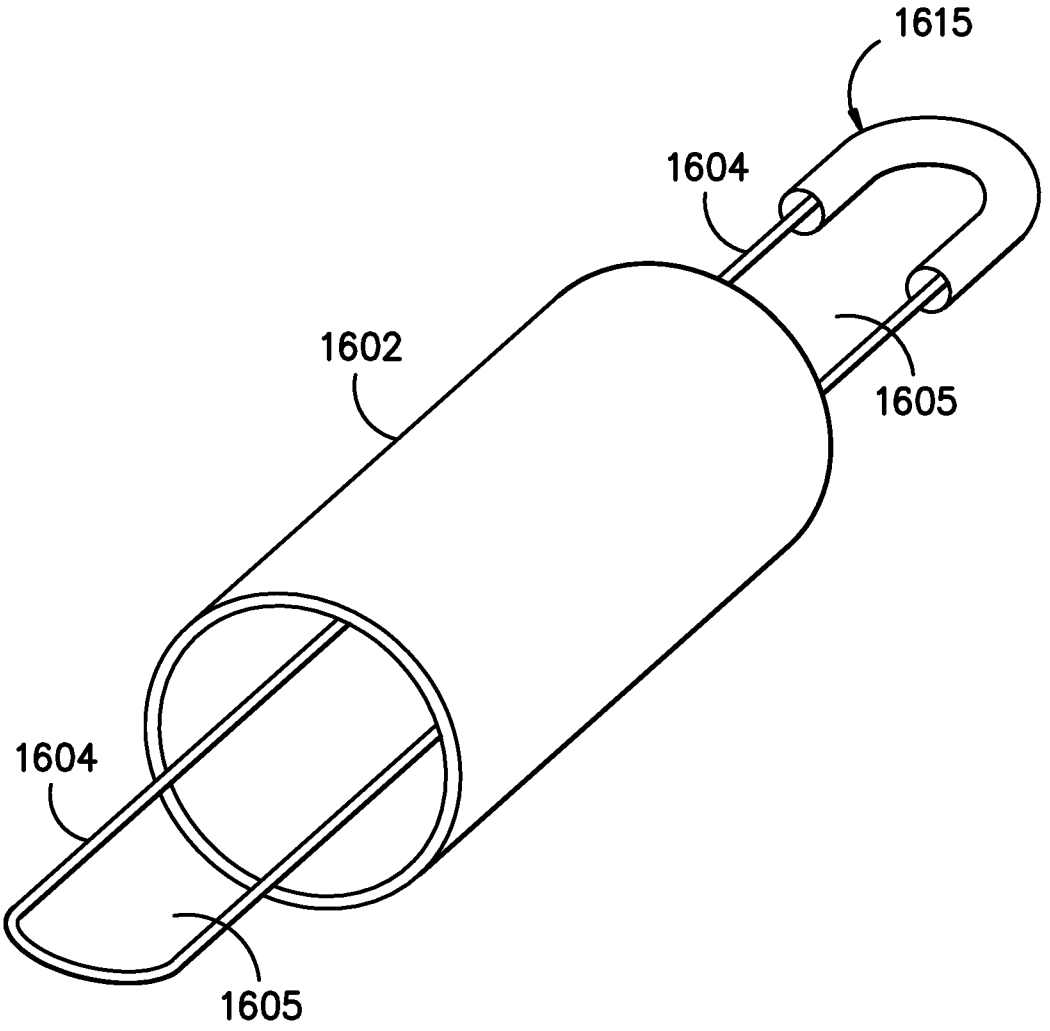


FIG. -16-

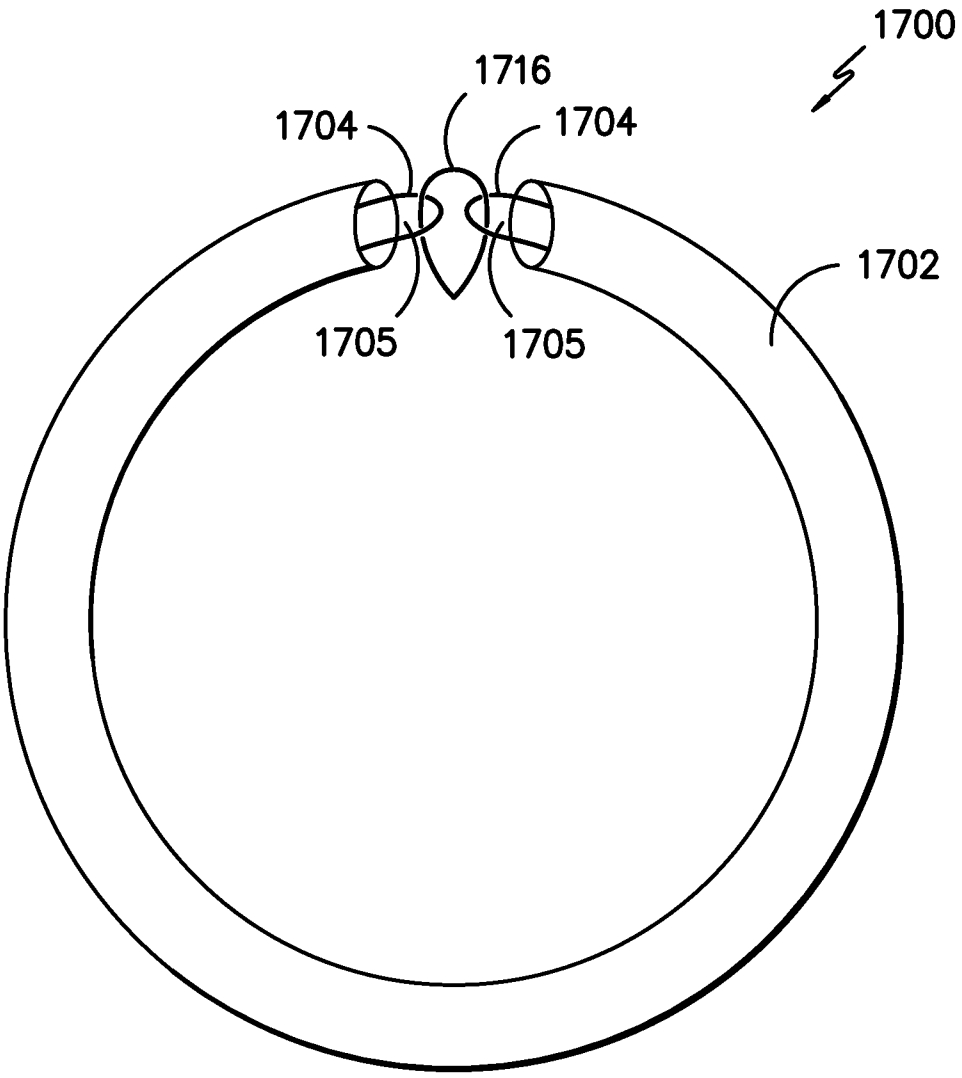


FIG. -17-

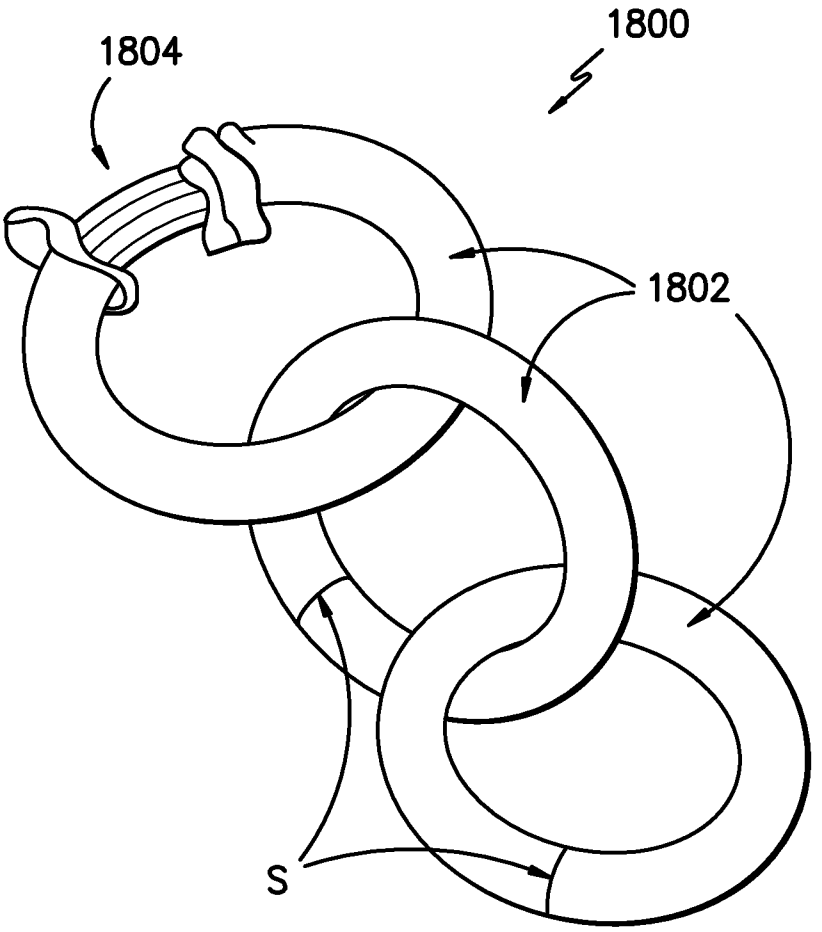


FIG. -18-

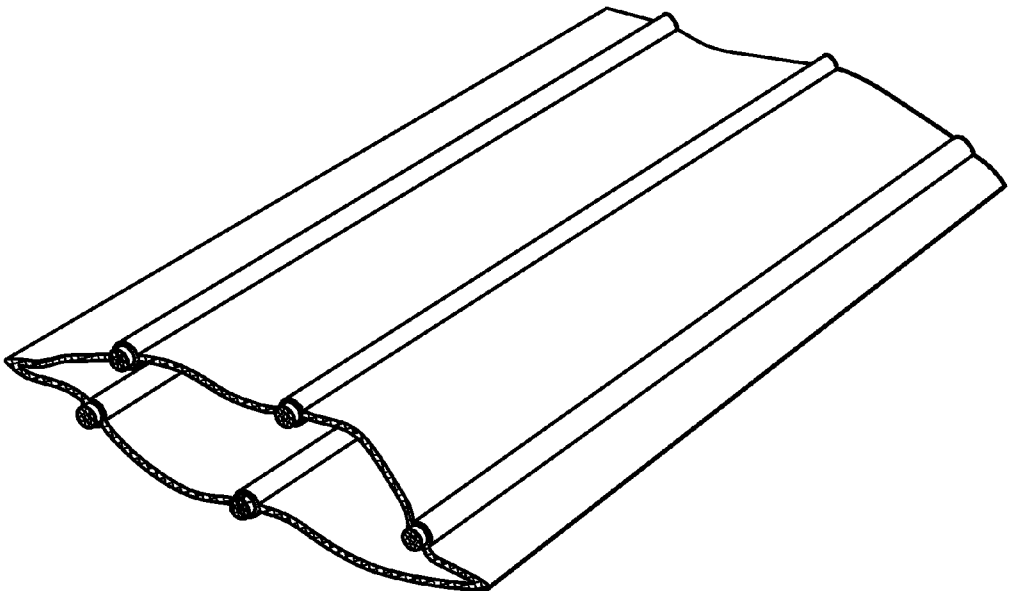


FIG. -19-

ROPE PRODUCTS, SYSTEMS, METHODS AND APPLICATIONS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a non-provisional application of U.S. Provisional Application No. 61/993,703, filed May 15, 2014, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Rope products, such as winches and slings, may have numerous applications, and previous types of rope products are known in the art. The present invention relates generally to novel rope products, systems, processes, and related applications.

SUMMARY OF THE INVENTION

[0003] In an embodiment, the invention includes novel rope products, systems, processes, and related applications as disclosed herein. Generally, in one embodiment, the invention includes a rope system. The rope system includes a woven cover having at least one channel and two terminal ends, and the woven cover also includes a plurality of warp threads and a plurality of weft threads and wherein the warp thread and weft threads are interwoven together. The rope system also includes a bundle of fibers that form a continuous loop, and the bundle of fibers is at least partially disposed within the woven cover such that a portion of the bundle of fibers extends beyond the two terminal ends of the woven cover and are exposed as loops.

[0004] In another embodiment, the invention includes a linked rope system. The linked rope system includes (1) a fiber material configured in a loop with joined ends to form a first bundle of fiber in a continuous loop, wherein the first bundle of fiber is at least partially encased within a first cover and (2) a second fiber material in a loop with joined ends to form a second bundle of fiber in a continuous loop, wherein the second bundle of fiber is at least partially encased within a second cover. In addition, the first bundle of fiber and the second bundle of fiber are interlinked.

[0005] In yet another embodiment, the present invention includes a method of making a linked rope system. The method includes the steps of looping a first fiber material and joining two terminal ends of the first fiber material to form a first bundle of fiber in a continuous loop, and at least partially enclosing the first bundle of fiber is at least partially encased within a first cover. The method also includes the steps of looping a second fiber material and joining two terminal ends of the first fiber material to form a second bundle of fiber in a continuous loop, and at least partially enclosing the second bundle of fiber is at least partially encased within a second cover. Furthermore, the method includes interlinking the first bundle of fiber that is at least partially encased within a first cover and the second bundle of fiber that is at least partially encased within a second cover.

[0006] The present invention may be better understood by reference to the description and figures that follow. It is to be understood that the invention is not limited in its application to the specific details as set forth in the following description and figures. The invention is capable of other embodiments and of being practiced or carried out in various ways

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A full and enabling disclosure of the present invention is set forth in the specification, which refers to the appended figures.

[0008] FIG. **1** depicts a rope system pursuant to one embodiment of the present invention;

[0009] FIG. **1**A shows a cross-sectional view of the embodiment of FIG. **1** along the line A-A;

[0010] FIG. **2** depicts a rope system pursuant to one embodiment of the present invention;

[0011] FIG. **2**A shows a cross-sectional view of the embodiment of FIG. **2** along the line A-A;

[0012] FIG. **3** depicts a rope system pursuant to one embodiment of the present invention;

[0013] FIG. **3**A shows an end view of the embodiment of FIG. **3**;

[0014] FIG. **4** depicts a rope system pursuant to one embodiment of the present invention with a partial cutaway view and with a dashed line representing how a divider may be formed in some embodiments;

[0015] FIG. **4**A depicts a further embodiment of the embodiment in FIG. **4** wherein an embodiment of a divider is formed; a rope system pursuant to one embodiment of the present invention;

[0016] FIG. **5** depicts a cover pursuant to one embodiment of the present invention;

[0017] FIGS. **5**B, and **5**C depicts rope systems pursuant to various embodiments of the present invention using the cover embodiment of FIG. **5**;

[0018] FIGS. **6** and **7** depict covers pursuant to certain embodiments of the present invention;

[0019] FIGS. **7**A, and **7**B depict rope systems pursuant to embodiments of the present invention;

[0020] FIG. **8** depicts a rope system pursuant to one embodiment of the present invention;

[0021] FIG. **8**A depicts an end view of the embodiment of FIG. **8**;

[0022] FIG. **9** depicts a rope system pursuant to one embodiment of the present invention;

[0023] FIG. **9**A depicts an end view of the embodiment of FIG. **9**;

[0024] FIG. **10** depicts a rope system pursuant to one embodiment of the present invention;

[0025] FIG. **10**A depicts an end view of the embodiment of FIG. **10**

[0026] FIGS. **11** depicts an end view of the rope system embodiment of FIG. **7**B in a folded configuration;

[0027] FIG. **12** depicts an end view of the rope system embodiment of FIG. **7**A in a folded configuration;

[0028] FIG. **13** depicts a rope system pursuant to one embodiment of the present invention;

[0029] FIG. **13**A depicts an end view of the rope system embodiment of FIG. **13** in a folded configuration;

[0030] FIGS. **14**, **14**A, **14**B, and **14**C depict embodiments of a weldable or seamed cover pursuant to embodiments of the present invention;

[0031] FIGS. **15**A, **15**B, and **15**C depict embodiments of covers of the present invention having auditory and/or visual indicators of breakage;

[0032] FIG. **16** depicts a rope system pursuant to one embodiment of the present invention;

[0033] FIG. **17** depicts the rope system of FIG. **16** in an additional configuration;

[0034] FIG. **18** depicts a rope system pursuant to one embodiment of the present invention; and

[0035] FIG. **19** depicts a cover having ribs pursuant to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0036] Reference now will be made in detail to the embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation of the invention, not a limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment, can be used on another embodiment to yield a still further embodiment.

[0037] Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents. In addition, the use of reference characters with the same two ending digits as other reference characters in the present specification and drawings, without a specific discussion of such structure, is intended to represent the same or analogous structure in different embodiments. Other objects, features and aspects of the present invention are disclosed in or are obvious from the following detailed description. It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention.

[0038] The present invention includes rope systems. In some embodiments, such rope systems may include a bundle of fibers displaced, partially or fully, within a cover. By way of example and with reference to an illustrative embodiment, FIG. **1** shows rope system **100**. Rope system **100** includes a cover **102**, which is shown as a woven tubular cover having two open longitudinal ends, and fiber bundle **104**. As shown, fiber bundle **104** is comprised of fibers that are continuously wrapped in a loop and then each end of the fibers are joined by a knot (not shown). In this regard, the fibers are a single length and the knot serves as the only connection point. FIG. **1**A shows a cross-section of the embodiment of FIG. **1** along the line A-A. As shown, fiber bundle **104** extends beyond each longitudinal end of cover **102** to form loops **105**. In this depicted embodiment, fiber bundle **104** may be formed and then inserted into cover **102**. In other embodiments, cover **102** may be woven around fiber bundle **104** or, prior to being formed in a tubular shape, cover **102** may be wrapped around fiber bundle **104** and then sealed to form a tubular shape around cover **102**. In other embodiments, fiber bundle **104** may be formed by looping fiber bundle **104** within an already-formed cover **102**. In still other embodiments, cover **102** may have an alternative shape, such as a flat shape or a square shape.

[0039] In another exemplary embodiment, as shown in FIG. **2** (with a partial cutaway view), rope system **200** includes cover **202**, wherein cover **202** is a tube-in-a-tube design having an outer cover **202'** and an inner cover **202"**. FIG. **2**A shows a cross-section of the embodiment of FIG. **2** along the lines A-A. As shown, fiber bundle **204** form loops **204'** and **204"**.

[0040] In still another embodiment, as shown in FIG. **3**, rope system **300** includes divider **306** disposed within inner cover **302"**, such that two channels are formed within inner cover **302"**. As shown, divider is centrally located within inner cover **302**, but in other embodiments it may be placed at alternative locations within inner cover **302"**. Fiber bundle **304** is disposed around divider **306**. FIG. **3**A shows a cross-section of the embodiment of FIG. **3** along the lines A-A. In this embodiment, fiber bundle may be formed by looping fibers inside inner cover **302"** and around divider **306**, and then tying the ends of the fibers with a knot. As shown in FIGS. **3** and **3**A, divider **306** is a separate piece of material joined into **302** to form divider **306**. In alternative embodiments, a divider may be formed by joining portions of the inside cover **402"** together, such as by weaving, sewing, or otherwise. For example, as shown in FIGS. **4** and **4**A, cover **400** may have portions of its inner cover **402"** joined together (such as joining the points indicated by the dashed line in FIG. **4**A) to form a divider.

[0041] By further way of example, in still other embodiments, a divider may be formed by joining separate covers together, such as by weaving or sewing, such that the two joined covers join to form a single cover having two channels separated by a divider, such as shown in FIG. **5**, which is an end view of such an illustrative embodiment. In such embodiments, a fiber bundle may be looped continuously through each channel (such as shown schematically in FIG. **5**B) or each channel may contain its own continuously-looped fiber bundle (such as shown schematically in FIG. **5**C). In similar fashion, any suitable form of divider discussed herein may also be present in the embodiment shown in FIG. **1** or in other embodiments.

[0042] In some embodiments, multiple dividers may be present. By way of example, as shown in FIG. **6**, which is an end view of an illustrative cover that may be used in connections with rope system embodiments of the present invention, two dividers may be present such that three channels are formed. As noted above with regard to FIGS. **5**B and **5**C, a fiber bundle may continuously loop in one channel or may continuously extend through two channels or all three channels in the embodiment shown in FIG. **6**. Although cover **600** is shown as a single-layer cover, alternative covers may be employed using multiple dividers, including tube-in-tube cover configurations. Similarly, the dividers in the embodiment of FIG. **6** are exemplary and any type of divider may be employed. In other embodiments, more three or more dividers may be included. As shown in FIG. **7**, which is an end view of an exemplary cover, three dividers may be employed, which forms four channels. In some such embodiments, as with any embodiments described herein, each divided section may contain a fiber bundle as shown in FIG. **7**A or, alternatively, a fiber bundle may be looped around a divider as shown in FIG. **7**B (wherein the B suffix added to the reference numerals is merely to differentiate FIG. **7**A).

[0043] In some embodiments, such as shown in FIGS. **8** and **8**A, fiber bundle **804** may be surrounded by a separate cover **803** that is displaced within, but not adjoined to, cover **802**. In still other embodiments, multiple separate covers may be used as shown in FIG. **9**. In such embodiments, a fiber bundle may be contained within a single separate cover as shown in FIGS. **9** and **9**A or may be looped between two or more separate covers as shown in FIGS. **10** and **10**A. In still other embodiments, separate covers **803** and **903** may optionally have a divider therein, wherein a fiber bundle may be continuously looped in a single channel therein or between one or more channels therein. In some embodiments, the separate

cover, such as separate cover **803**, may be waterproof or water resistant, and another cover, such as cover **802**, may be abrasion resistant.

[0044] In some embodiments, a rope system may be folded into a more compact form. By way of example, FIG. **11** shows rope system **700**B of FIG. **7**B, which illustrated a cover **702**B having three dividers **706**B such that there were four channels. As shown in FIG. **11**, folding rope system **700**B over in the latitudinal direction results in the embodiment shown in the end view of FIG. **11**. In similar fashion, the embodiment of FIG. **7**A may be folded to form the folded embodiment shown in the end view depiction of FIG. **12**. Finally, in another exemplary embodiment, a rope system may have the configuration shown in FIG. **13** and may be folded as shown in the end view of FIG. **13**A. In other embodiments, additional dividers and channels may be present, and folding may be accomplished to form an accordion-like folded rope system.

[0045] In some embodiments, a cover may extend along the entire length or substantially the entire length of a winch or rope system. In other embodiments, a cover may extend to or slightly beyond any hardware at an end of the rope system. As shown in the foregoing illustrative embodiments, a cover may extend over an entire fiber bundle except for the loops of the fiber bundle that extend from each longitudinal end of a cover. In some embodiments, the cover may alternatively extend substantially over the entire fiber bundle except the loops. In other embodiments, a cover may also extend over the loops. In still other embodiments, a cover may surround the loops and have an open portion on the interior of the loop, in which case hardware may still be readily attached within the open portion.

[0046] In the embodiments discussed above, each fiber bundle is formed by continuously wrapping one or more continuous fibers and then joining the free ends. In some embodiments, such free ends of the fiber bundle may be joined by a knot. In other embodiments of the illustrative embodiments herein, such free ends of a fiber bundle may be taped, glued, or joined using any other suitable methods. In some embodiments, the free ends of a fiber bundle ends are not sewn, spliced, clipped, or clamped. Furthermore, a space or gap may exist between the inside of a cover and the fiber bundle, such as shown, by example, in FIG. **1**A.

[0047] Covers used in the present invention may be comprised of any suitable material for a particular embodiment. For example, in some embodiments, the fibers of a woven cover may comprise any suitable natural or synthetic material known in the art or combinations thereof. In some embodiments, the fibers comprise meta-, para-aramid fibers, para-aramid fibers, meta-aramid fibers, cotton, rayon, Teflon®-coated fibers, shaped fibers, glass fibers, basalt fibers, carbon fibers, high modulus polyethylene fibers, liquid crystal polymer fibers, hollow fibers, nylon, polyesters, polypropylene, polyethylene, polyphenylene sulfide, polyetheretherketone, polyolefins, high modulus polyethylene (HMPE), amide polymers or copolymers, other aramids, metal yarns, other suitable materials, and combinations thereof. According to some embodiments, such fibers may be heat-shrinkable or have elasticity. By way of example, and without limitation, in some embodiments a cover may include nylon and polyester fibers. In some embodiments, any materials noted herein for a cover may be used for a fiber bundle and any materials noted for a fiber bundle may be used for a cover and vice versa. In addition, any materials used for a cover or a bundle of fibers may be treated or coated to improve the properties of the material for a particular application.

[0048] In some embodiments, materials included in a cover may have one or more of high tensile strength, high thermal resistance, high abrasion resistance, low shrinkage at high temperatures, high fatigue resistance, ultraviolet radiation resistance, high chemical and heat stability, and low moisture regain. In some embodiments, spun or texturized fibers or yarns may be used to limit abrasion. Also, the fibers may be coated with polymers, paraffin waxes, non-paraffin waxes, and/or other substances to improve abrasion, ultraviolet resistance, water and chemical resistance, improve moisture wicking, provide improved heat transfer, fire resistance, and other desirable properties for a particular embodiment.

[0049] In some embodiments, a cover used in embodiments of the present invention may be a woven webbing. The term "woven", as used herein, means interlacing individual fibers in a regular order. Any method of weaving known in the art may be utilized in this invention. Similarly, any weave pattern known in the art may be utilized in the webbing including, but not limited to, a plain weave, a twill weave, a satin weave, a tabby weave, a taffeta weave, a matt weave, a basket weave, a rib weave, computer-generated interlacings, and combinations thereof. The fibers of a cover may have any configuration known in the art. For example, the configuration of the fibers may be circular, ovular, elliptical, or flat. Additional configurations of woven material are included in U.S. patent application Ser. No. 14/078,211, which is published as U.S. Published Patent Application No. 2014/178,615 and which is incorporated herein in its entirety by reference. In some embodiments, covers may have a construction and/or composition other than a woven construction, such as a film cover, coated fabrics, or combinations of different constructions.

[0050] In addition, in some embodiments, covers of the present invention may include one or more spaced longitudinal ribs, such as shown, by way of example, in FIG. **19**. Such ribs, which may have increased longitudinal stiffness, may be spaced equidistantly from one another or may be spaced intermittently. In some embodiments, the ribs may comprise a woven rope. The ribs may be formed from any suitable material, including materials disclosed to form a cover or a bundle of fibers herein. In some embodiments, ribs may be woven into a cover, whereas in other embodiments they may be attached by any conventional manner. The projection height of the ribs can vary, but may be, in an embodiment, greater than the thickness of the cover. In some embodiments, the projection height may be 5% to 200% greater than the thickness of the cover, including each intermittent value therein. In some embodiments, the projection height may be at least 5% greater than the thickness of the cover. In another embodiment, the projection height **56** for the ribs may be at least 10% greater than the thickness of the cover. In another embodiment, the projection height of the ribs may be at least 20% greater than the thickness of the cover. In yet another embodiment, the projection height may be up to 50% greater than the thickness of the cover and, in still another embodiment, the projection height may be 100% greater than the thickness of the cover. Additional configurations of ribbed covers are disclosed in U.S. patent application Ser. No. 14/204,758, which is published as U.S. Published Patent Application No. 2014/311,611 and which is incorporated herein in its entirety by reference.

[0051] By way of example, and without limitation, covers in some embodiments of the present invention may include

warp yarns and weft yarns having any suitable denier for a particular application. For example, in some embodiments, warp yarns in the range of about 840 denier to about 2,700 denier may be used. In some embodiments, warp yarns having greater than 2700 denier may be employed, such as in the range of about 2,700 denier to about 5,000 denier. In some embodiments, warp yarns having less than 3,000 denier may be used. In some embodiments fill (or weft) yarn having a denier in the range of about 500 denier to about 1,000 denier may be used. With the foregoing exemplary ranges each intermittent value is specifically included.

[0052] For embodiments employing a woven cover, any suitable weaving parameters may be employed. By way of example, a cover may have a tight plain weave, such as in the range of about 4.75 picks per inch to about 50 picks per inch, including each intermittent value therein. In some embodiments, a woven cover may have a pick count of at least about 17.5 picks per inch. In some embodiments, a woven cover may have a plain weave of about 2.5 to about 7.5 picks per inch, including each intermittent value therein. In other embodiments, an outer sleeve may have a pick count of at least about 12.5 picks per inch. In some embodiments, a cover may include an inner cover and an outer cover as previously described, wherein an inner and outer cover may have the same woven configuration or differing woven configurations. For example, in some embodiments an inner cover may have a plain weave configuration and an outer cover may have either a twill weave or a plain weave configuration. For reference, a plain weave may also be referred to as a basket weave.

[0053] In still other embodiments, covers may include nonwoven material that is sewn or otherwise connected in a tubular shape. For example, in some embodiments, covers may be sewn, bonded, or otherwise prepared using the same materials as discussed for woven constructions or alternative materials. By way of example, in some embodiments, a cover may be formed using weldable materials, By way of example, a cover of some embodiments may be formed by coating a webbing material, film, fabric, or other material (which may be, by way of example, woven, spun bond nonwoven, nonwoven laminates, films, perforated films, or combinations thereof) with a weldable plastic, such as, for example, polyvinyl chloride or polyurethane. In such weldable embodiments, any suitable weldable materials may be employed, such as films, fibers, or nonwovens coated or uncoated so long as the material can be joined by heat, ultrasonic, radio frequency, welding, or the like.

[0054] By way of example, a rope system with a weldable cover may be formed as shown in the illustrative embodiment of FIG. **14**. As shown, material **1401**, which has longitudinal edges **1401'**, may be laid flat, as shown in FIG. **14**, and then it may be folded by joining longitudinal edges **1401'** to form a tubular shape, such as that shown in FIG. **14**A. Longitudinal edges **1401'** may be welded to form a seam. Any suitable seam may be used, such as those shown in FIGS. **14**B and **14**C, which illustrate exemplary alternative welded seams **1408'** and **1408"** from an end view of a tubular cover. In some embodiments, a hook and loop fastener or similar means may be used to join longitudinal edges of a cover. Such welded covers may be used in the manner described herein for any embodiment as a cover for one or more fiber bundles. In addition, such covers with fibers bundle may be used, for example, as a winch rope or, after joining the ends of the tubular cover by any suitable joinder, such as by welding, sewing, heat, ultrasonic, radio frequency, or in any other suitable manner.

[0055] In some embodiments, and as illustrated in FIGS. **15**A, **15**B, and **15**C, embodiments of the present invention may include auditory and/or visual indicators of breakage prior to a complete break of the rope system. By way of example, covers made of woven material may be used in certain embodiments of the present invention as described above. Such woven covers may include both warp yarns and weft yarns. As provided in some embodiments of the present invention, these materials may provide the warnings necessary for use in embodiments of the present invention. For example, although most ropes are given maximum load requirements, the warp yarns and/or weft yarns may include maximum load weights that are less than the total breaking weight of the entire cover or fiber bundle of a rope system or that are less than the maximum load weight of the entire rope system. For example, in some embodiments, some or all warp yarns and/or weft yarns in a rope may have maximum load weights that are between about 20 and about 80% of the total breaking weight of the entire rope system. In other embodiments, warp yarns and/or weft yarns may include maximum load weights of between about 40 and 60% of the total breaking weight of the entire rope system. In such instances, as the maximum weight is approached, the warp yarns and/or weft yarns will start to break, thereby providing a user with visual and auditory warnings of approaching breakage.

[0056] As shown in FIG. **15**A, an exemplary woven rope includes warp yarns **1502** and weft yarns **1504**. As shown, FIG. **15**B, the rope is subjected to strain, and some of the weft yarns **1504** begin to break as shown by broken weft yarns **1504'**. in this manner, broken weft yarns **104'** may provide an iodination that the total breaking weight of the entire rope is being neared or that a certain threshold of strain or stress has been met. As shown in FIG. **15**C, the exemplary rope has undergone additional stress and some of the warp yarns **1502** have broken as shown by broken warp yarns **1502'**. These broken warp yarns **1502'** may provide an additional indication of a certain threshold being met or neared for the entire rope.

[0057] In some embodiments, additional materials, such as a distinct weft strand or a distinct warp strand of a different material than the other weft and/or warp strands, may be incorporated into a rope to provide an indication of a threshold being met or neared. For example, in one embodiment, such distinct weft strands or a distinct warp strands may be of a weaker material than the remaining weft or warp strands of the rope, such that when the weaker distinct weft strand and/or distinct warp strands are broken an indication is provided. In still other embodiments, an additional material, such as a yarn that does not otherwise serve as a weft strand or warp strand, may be incorporated into a rope to provide an indication of a threshold being met or neared.

[0058] In addition, to provide even greater indications of breakage, some or all weft yarns and warp yarns may be of various colors such that a user may determine when a particular breaking point is reached or is being reached. For example, in some embodiments, some weft yarns may be of a different color, for example red, than the other materials, such as white, utilized in the rope construction. As load conditions are being reached, those red weft yarns, optionally selected to break before the entire rope system reaches a maximum breaking

weight, will start to break and will thereby provide the user with a clear indication of possible breakage.

[0059] With regard to fiber bundles employed in embodiments of the present invention, such fiber bundles may include any suitable fibers or any other material suitable for a particular embodiment. By way of example, such fibers and materials may include, without limitation, polyester, nylon, meta- para-aramid fibers, para-aramid fibers, meta-aramid fibers, cotton, rayon, Teflon®-coated fibers, shaped fibers, glass fibers, basalt fibers, carbon fibers, high modulus polyethylene fibers, liquid crystal polymer fibers (such as, by way of example, those available from Vectran Fiber, Inc.), hollow fibers, polypropylene, polyethylene, polyphenylene sulfide, polyetheretherketone, polyolefins, high modulus polypropylene, amide polymers or copolymers, other polyolefins, other aramids, metal yarns, other suitable materials, and combinations thereof. In addition, by way of example, the fiber bundle may have any suitable structure, such as, without limitation, twisted or untwisted continuous filaments, parallel strands, filament bundles comprised of mono-filament yarns, filament bundles comprised of films, twisted rope, braided rope (including, without limitation, solid braided rope and hollow braided rope), liquid crystal polymer rope, woven rope, kern-mantle rope, woven ropes with components that may be twisted or braided, braided or twisted ropes using components that are woven or of another format, and combinations thereof. By way of example, and without limitation, such fibers in some embodiments may include twisted, cabled, braided, or woven yarns, or combinations thereof. In some embodiments, spun or texturized fibers or yarns may be used to limit abrasion. According to some embodiments, such fibers may be heat-shrinkable or have elasticity. Also, the fibers may be coated with or otherwise include, such as by using nano-coatings through vapor deposition or other suitable means, with polymers, paraffin waxes, non-paraffin waxes, and/or other substances to improve abrasion, ultraviolet resistance, water and chemical resistance, improve moisture wicking, provide improved heat transfer, fire resistance, and other desirable properties for a particular embodiment. In addition, such materials and/or alternative materials may be used in other non-woven covers that are also within the scope of the present invention.

[0060] Any size of fibers may be used as is suitable for a particular embodiment. Furthermore, any fibers employed may be monofilament, multifilament, or tapes. In addition, the size of the bundles shown in the figures herein are exemplary and are not limiting. The fiber within a bundle may also be more tightly packed within a bundle than shown in the depicted embodiment, as well as bound, joined, braided twisted, or otherwise connected if desired. In other embodiments, smaller or larger bundles may be employed. In addition, in some embodiments, multiple bundles may be employed within a single cover and, in some embodiments, even within a single channel within a cover.

[0061] Any suitable denier of fiber may be used. In one embodiment, the fibers of the woven rope may be in the range of about 10,000 denier to about 100,000 denier, including each intermittent value therein. In some embodiments, fibers may have a denier of or greater than about 10,000 denier. In still other embodiments, fibers of or less than about 100,000 denier may be employed.

[0062] Fiber bundles may be wrapped as many times as suitable for any particular embodiment or application. A predetermined length of fiber may be selected based on the ultimate number of wrappings desired and the desired length of the rope system. In some embodiments, an increased number of wrappings may reduce the impact on the connection of the ends of the fiber bundle, such as any impact (such as from tension) at a knot joining the free ends of a fiber bundle. In addition, although ends of a fiber bundle are joined as a knot in the embodiments described above, other suitable connections may be used such as taping, gluing, air splicing, and other suitable connections. In some embodiments, the knot or other connection may be disposed within a cover of a rope system.

[0063] In some embodiments, a fiber bundle may include a fiber optic cable, a sensor wire, and/or other materials, such as for load or temperature sensing. Such materials may be included within a fiber bundle as described above or may be included as a separate fiber bundle.

[0064] In some particular embodiments, rope systems of the present invention may be used as a winch rope. In such embodiments, such as shown in FIG. **16**, fiber bundle **1604** is surrounded by cover **1602** except for loops **1605** that extend from cover **1602**. Thimble **1615** may be included on one loop **1605** for use in winch applications or other applications. The depicted thimble is exemplary for one embodiment, but any suitable thimble or other hardware may be used, In some embodiments, each loop of that embodiment may include a thimble or other suitable hardware. A metal hook may optionally be attached to one or both ends, either to the fiber bundle loop directly or to a thimble thereon. In some embodiments, one loop at a longitudinal end of the rope system may be attached directly to a winch drum. Winch rope system embodiments may be prepared from any of the embodiments discussed herein.

[0065] In other embodiments, rope systems of the present invention may be used to form or function as a round sling. Round sling embodiments may be prepared from any of the embodiments discussed herein. Such slings may be used to harness or support heavy objects in applications such as, for example, aircraft, rigging, engine, shipbuilding, or other industrial or construction-related tools and parts. In some embodiments, a bundle of fibers may be continuously wound and then partially or wholly encased within a cover, such as by forming or joining a cover around the bundle of fibers. By way of example, and with reference to FIG. **17**, loops **1705** of rope system **1700** may be joined together such that the rope system forms a round sling. Any suitable hardware may be used to join loops together to form a round sling, such as metal shackle **1716** shown for exemplary purposes in FIG. **17**. In addition, cover **1702** may surround all or a portion of fiber bundles **1704**. In some embodiments, cover **1702** may surround all of fiber bundles **1705** except for loops **1705**. In still other embodiments, cover **1702** may not cover loops **1705**, but after joining loops **1705** together to form a round sling, then cover **1702** may be extended to cover a portion or all of the loops, including or excluding any hardware. In such embodiments, a terminal end at each end of cover **1702** may be connected or joined together to form a continuous cover. Such connection may be done by any suitable means, including fasteners. In some embodiments, such round slings may be joined and connected to create a chain or linked rope system as described below.

[0066] In other embodiments, the present invention further includes a chain or linked rope system. Such linked rope systems may include a plurality of a bundle of fibers in a continuous loop, optionally encased wholly or partially

within a cover, interlinked with other bundles of fiber formed in a continuous loop and also optionally encased wholly or partially within a cover. By way of example, FIG. **18** shows a linked rope system **1800**. As shown, a bundle fibers **1804** (shown in a partial cutaway view) is encased within a cover **1802**, and such a fiber bundle is present (although not shown) within each depicted cover **1802**, which has two ends joined by seam S to form a continuous circular cover. The cover and encased bundle of fibers are interlinked with one or more other covers and encased bundle of fibers as depicted.

[0067] Linked rope systems of the present invention may be formed using any suitable procedure for a particular application. For example, as shown with reference to FIG. **18**, the bundle of fibers are formed into a continuous loop of fibers by looping a fiber material through an open cover, such as a cover having to open ends (as shown in FIG. **18** for one cover **1804**), and then joining two free ends of the fiber material to form a bundle of fibers in a continuous loop. A seam, such as seam S in FIG. **18**, may then be formed to join the ends of a cover together to form a circular cover that fully encases the bundle of fibers within that cover. In other embodiments, a bundle of fibers comprising a continuous loop of fibers may be formed and then a cover may be formed or wrapped around that already-formed bundle of fibers, such as by wrapping material to form a cover around the already-formed continuous loop of a bundle of fibers and then sewing a seam to form the cover in a manner similar to that shown in FIGS. **14**-**14**C. In still other embodiments, round sling embodiments of the type previously described above with respect to FIG. **17**, may be used, wherein loops of a bundle of fibers may be joined, such as by using any suitable hardware, including pins, shackles, thimbles, hooks, and the like made from appropriate materials for a particular application, such as stainless steel, steel, plastic, or composites, to form a link. A plurality of such links may be joined to form a linked rope system. In addition, in some embodiments, links may be connected to other links using hardware or by tying or sewing, as opposed to interlinking. As noted, in some such embodiments, a cover may be extended to cover the entire underlying bundle of fibers after connecting the loops of the bundle of fibers. Although the foregoing embodiments are illustrative, in other embodiments a linked rope system may include a plurality of bundles of fibers are interlinked and wherein some or all of the bundle of fibers do not include a cover.

[0068] Rope systems of the present invention may be used for any other suitable purpose, such as other types of slings, harnesses, and ropes. Although particular embodiments of the invention have been described using specific terms, devices, and methods, such description is for illustrative purposes only. The words used are words of description rather than of limitation. It is to be understood that changes and variations may be made by those of ordinary skill in the art without departing from the spirit or the scope of the present invention, which is set forth in the following claims. In addition, it should be understood that aspects of the various embodiments may be interchanged in whole or in part. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained therein.

What is claimed is:

1. A rope system comprising:

a cover having at least one channel and two terminal ends; and

a bundle of fibers that form a continuous loop, wherein the bundle of fibers is at least partially disposed within the cover and wherein a portion of the bundle of fibers extends beyond the two terminal ends of the cover and are exposed as loops.

2. The rope system of claim **1** wherein the bundle of fiber comprise a length of material formed in a loop and having two terminal ends of the material joined together to form the continuous loop.

3. The rope system of claim **1** wherein the cover is a woven cover comprising a plurality of warp threads and a plurality of weft threads and wherein the warp thread and weft threads are interwoven together.

4. The rope system of claim **1** wherein the cover is comprised of meta-, para-aramid fibers, para-aramid fibers, meta-aramid fibers, cotton, rayon, Teflon®-coated fibers, shaped fibers, glass fibers, basalt fibers, carbon fibers, high modulus polyethylene fibers, liquid crystal polymer fibers, hollow fibers, nylon, polyesters, polypropylene, polyethylene, polyphenylene sulfide, polyetheretherketone, polyolefins, high modulus polyethylene (HMPE), amide polymers or copolymers, other aramids, other suitable materials, and combinations thereof.

5. The rope system of claim **4** wherein one or more of the warp threads and weft threads comprise polymers, paraffin waxes, non-paraffin waxes, or combinations thereof.

6. The rope system of claim **1** wherein the bundle of fibers are comprised of polyester, nylon, meta- para-aramid fibers, para-aramid fibers, meta-aramid fibers, cotton, rayon, Teflon®-coated fibers, shaped fibers, glass fibers, basalt fibers, carbon fibers, high modulus polyethylene fibers, liquid crystal polymer fibers, hollow fibers, polypropylene, polyethylene, polyphenylene sulfide, polyetheretherketone, polyolefins, high modulus polypropylene, amide polymers or copolymers, other polyolefins, other aramids, and combinations thereof.

7. The rope system of claim **1** wherein the bundle of fibers comprises one or more of the structures selected from the group comprising twisted continuous filaments, untwisted continuous filaments, parallel strands, filament bundles comprised of mono-filament yarns, filament bundles comprised of films, twisted rope, braided rope, woven rope, kernmantle rope, woven ropes with twisted or braided components, braided or twisted ropes with woven components, and combinations thereof.

8. The rope system of claim **6** wherein at least a portion of the bundle of fibers is coated with polymers, paraffin waxes, non-paraffin waxes, or combinations thereof.

9. The rope system of claim **1** wherein the cover comprises and inner cover and an outer cover.

10. The rope system of claim **1** wherein the cover comprises a divider.

11. The rope system of claim **10** wherein the bundle of fibers that form a continuous loop are disposed around the divider.

12. The rope system of claim **10** wherein a bundle of fibers is disposed on each side of the divider.

13. The rope system of claim **1** wherein the cover comprises a plurality of dividers and a plurality of channels.

14. The rope system of claim **13** wherein the cover comprises three or more channels and a bundle of fibers is at least partially disposed in at least three channels of the cover.

15. The rope system of claim **10** wherein the cover encases at least a portion of a plurality of bundles of fibers.

16. The rope system of claim **15** wherein at least more than one of the bundle of fibers is at least partially disposed within

the cover and extends beyond the two terminal ends of the cover and are exposed as loops.

17. The rope system of claim **1** further comprising a joining component configured to connect the loops of the bundle of fibers that are exposed.

18. The rope system of claim **17** wherein a plurality of rope systems are interlaced to form a linked rope system.

19. The rope system of claim **17** wherein the terminal ends of the cover are adjoined to entirely encase the bundle of fibers.

20. The rope system of claim **1** wherein the cover is at least partially disposed within a second cover and wherein the cover and the second cover are unattached.

21. The rope system of claim **1** wherein the cover is configured to have one or more properties selected from the group consisting of high tensile strength, high thermal resistance, high abrasion resistance, low shrinkage at high temperatures, high fatigue resistance, ultraviolet radiation resistance, high chemical and heat stability, and low moisture regain.

22. The rope system of claim **1** wherein the cover is configured to provide an alert as a total breaking weight of t is approached, wherein the cover comprises indicator yarns displaced within the cover, wherein the indicator yarns have maximum load weights that are less than the total breaking weight of the entire rope.

23. A linked rope system comprising:

a fiber material configured in a loop with joined ends to form a first bundle of fiber in a continuous loop, wherein the first bundle of fiber is at least partially encased within a first cover;

a second fiber material in a loop with joined ends to form a second bundle of fiber in a continuous loop, wherein the second bundle of fiber is at least partially encased within a second cover;

wherein the first bundle of fiber and the second bundle of fiber are interlinked.

24. The linked rope system of claim **23** wherein the second fiber material is selected from the group consisting of a fiber material having the same composition as the first fiber material and a fiber material having a distinct composition from the first fiber material.

25. The linked rope system of claim **23** wherein the first bundle of fiber is entirely encased within a first cove and the second bundle of fiber is entirely encased within a second cover.

26. A method of making a linked rope system, the method comprising:

looping a first fiber material and joining two terminal ends of the first fiber material to form a first bundle of fiber in a continuous loop,

at least partially enclosing the first bundle of fiber is at least partially encased within a first cover;

looping a second fiber material and joining two terminal ends of the first fiber material to form a second bundle of fiber in a continuous loop,

at least partially enclosing the second bundle of fiber is at least partially encased within a second cover;

interlinking the first bundle of fiber that is at least partially encased within a first cover and the second bundle of fiber that is at least partially encased within a second cover.

27. The method of claim **26** wherein the first fiber material is looped through the first cover wherein the first cover has two open terminal ends, and joining the two terminal ends of the first cover together after the two terminal ends of the first fiber material are joined, and wherein the second fiber material is looped through the second cover wherein the second cover has two open terminal ends and wherein the second fiber material is also looped through the interior of the loop formed by the first bundle of fiber that is at least partially encased within a first cover, and joining the two terminal ends of the second cover together after the two terminal ends of the second fiber material are joined.

* * * * *