(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 November 2012 (29.11.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/162556 A1

(51) International Patent Classification: *D07B 1/16* (2006.01)

(21) International Application Number: PCT/US2012/039460

(22) International Filing Date: 24 May 2012 (24.05.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/489,661 24 May 2011 (24.05.2011) US

(71) Applicant *(for all designated States except US)*: **SAMSON ROPE TECHNOLOGIES** [US/US]; 2090 Thornton Street, Ferndale, WA 98248 (US).

(72) **Inventors; and**
(71) **Applicants** : **CHOU, Chia-te** [US/US]; 905 40th Street, Bellingham, WA 98229 (US). **MOZSGAI, Greg** [US/US]; 8621 Blue Grouse, Blaine, WA 98230 (US). **LIU, Li** [CN/US]; 621 Paloma Lane, Apt 209, Bellingham, WA 98226 (US).

(74) **Agent**: **SCHACHT, Michael, R.**; Schacht Law Office, Inc., 2801 Meridian Street, Suite 202, Bellingham, WA 98225 (US).

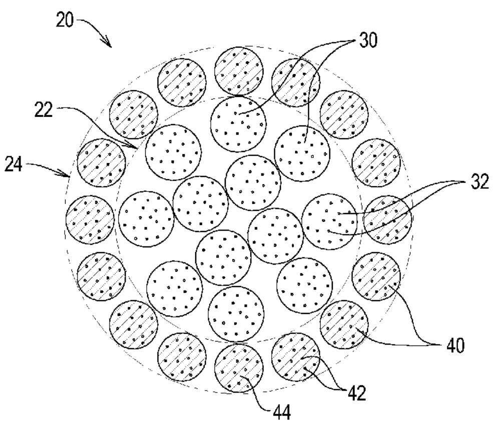
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: ROPE STRUCTURES AND METHODS

FIG. 1B



(57) **Abstract**: A rope structure comprising a core component comprising core fibers combine to form a first rope structure and a first cover component comprising first cover strands comprising first cover fibers within a first matrix material. The first cover strands are arranged around at least a portion of the core component.

WO 2012/162556 A1

ROPE STRUCTURES AND METHODS

RELATED APPLICATIONS

[0001] This application (Attorney's Ref. No. P216949PCT) claims benefit of U.S. Provisional Patent Application Serial No. 61/489,661 filed May 24, 2011, which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to rope systems and methods and, in particular, to rope structures and methods employing a core component and a cover component.

BACKGROUND

[0003] Rope structures must operate in a wide variety of operating environments. Each particular operating environment has its own operating requirements. The operating requirements of a particular operating environment may be defined in terms of rope characteristics such as shape stability, abrasion and/or cut resistance, surface characteristics, weather resistance, and/or weight per unit length.

[0004] The need exists for rope structures that can be designed or engineered for optimum operation in operating environments having particular operating requirements.

SUMMARY

[0005] The present invention may be embodied as a rope structure comprising a core component comprising core fibers combine to form a first rope structure and a first cover component comprising first cover strands comprising first cover fibers within a first matrix material. The first cover strands are arranged around at least a portion of the core component.

[0006] The present invention may also be embodied as a method of forming a rope structure comprising the steps of providing core fibers, combining the core fibers to form a core component comprising a first rope structure, providing first cover fibers, forming at least one cover first cover strand by combining the first cover fibers with a first matrix material, and arranging the at least one first cover strand to form a cover component by arranging the first cover strands around at least a portion of the core component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1A is a schematic side elevation view of a first example rope structure of the present invention;

[0008] Figure 1B is a schematic cross-sectional view of the first example rope structure;

[0009] Figure 2 is a side elevation view of the first example rope structure;

[0010] Figure 3 is a side elevation view of one of the example cover members forming a part of the first example rope structure;

[0011] Figure 4A is a schematic side elevation view of a second example rope structure of the present invention;

[0012] Figure 4B is a schematic cross-sectional view of the second example rope structure;

[0013] Figure 5A is a schematic side elevation view of a third example rope structure of the present invention;

[0014] Figure 5B is a schematic cross-sectional view of the third example rope structure.

[0015] Figure 6A is a schematic side elevation view of a fourth example rope structure of the present invention;

[0016] Figure 6B is a schematic cross-sectional view of the fourth example rope structure;

[0017] Figure 7A is a schematic side elevation view of a fifth example rope structure of the present invention;

[0018] Figure 7B is a highly schematic cross-sectional view of the fifth example rope structure;

[0019] Figure 8A is a schematic side elevation view of a sixth example rope structure of the present invention;

[0020] Figure 8B is a highly schematic cross-sectional view of the sixth example rope structure;

[0021] Figure 9A is a highly schematic cross-sectional view of a seventh example rope structure;

[0022] Figure 9B is a highly schematic cross-sectional view of an eighth example rope structure;

[0023] Figure 9C is a highly schematic cross-sectional view of a ninth example rope structure; and

[0024] Figure 9D is a highly schematic cross-sectional view of a tenth example rope structure.

DETAILED DESCRIPTION

[0025] Referring initially to Figures 1A, 1B, and 2, depicted therein is a first example rope structure 20 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 20 comprises a core component 22 and a cover component 24. The example cover component 24 may be formed along the entire length of the example core component; alternatively, the example cover component may be formed only at one or more particular locations along the length of the example core component 22.

[0026] The example core component 22 is or may be formed by any conventional rope structure, including, but not limited to, a braided rope structure, a twisted strand rope structure, a rope structure formed by a bundle of parallel fibers, a rope structure formed by twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component 22 will typically be made of core strands 30 comprising core fibers 32 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as rope or core strands 30 as depicted in Figure 1B. The rope or core strands 30 are combined to form the rope structure that may be used as the example core component 22.

[0027] An appropriate rope structure for forming the example core component 22 will typically be made of core fibers 32 formed from one or more materials such as Nylon, polyester, olefin (e.g., polyolefin), acrylic, carbon fiber, aramid fiber (e.g., Kolon, Twaron, Kevlar, Technora, and Nomex), high modulus polyethylene fiber (HMPE) (e.g., Dyneema, Spectra, Tensylon, Ocher), high performance polyolefin fiber (e.g., Tyvek, CoolMax, and Innegra S), PBO fiber (e.g., Zylon), TLCP fiber (e.g., Vectran), PIPD fiber (e.g., M-5), PBI fiber (polybenzimidazole fiber), PEN fiber (or Pentex), Acrylonitrile rubber, glass fiber, metallic fiber, Vinyon, Saran, Spandex, Vinalon, Modal, Sulfar, Lyocell, PLA, Orlon, and the like. These types of core fibers 32 are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers 32 is typically referred as a synthetic rope.

[0028] The example cover component 24 may be formed by a plurality cover strands 40 that are arranged to form a cover or jacket for the example core component 22. A plurality of the example cover strands 40 are arranged helically around the example core component 22 such that the entire core component is effectively covered along substantially the entire length of the rope structure 20. The term “covered" in this context may refer to a cover component 24 in which the strands 40 are either tightly adjacent to each such that no gaps exist between adjacent or overlapping strands 40 or to a cover component 24 in which gaps exist between adjacent or overlapping strands 40.

[0029] The example cover strands 40 are formed of cover fibers 42 dispersed or arranged in a resin matrix 44. In the example rope structure 20, the example cover fibers 42 are continuous fibers made of one or more materials such as Nylon, polyester, olefin, HMPE, LCD, acrylic, carbon fiber, aramid fiber (e.g., Twaron, Kevlar, Technora, and Nomex), high performance polyethylene fiber (e.g., Dyneema and Spectra), high performance polyolefin fiber (e.g., Tyvek, CoolMax, and Innegra S), PBO fiber (e.g., Zylon), TLCP fiber (e.g., Vectran), PIPD fiber (e.g., M-5), PBI fiber (polybenzimidazole fiber), PEN fiber (or Pentex), Acrylonitrile rubber, glass fiber, metallic fiber, Vinyon, Saran, Spendex, Vinalon, Modal, Sulfar, Lyocell, PLA, Orlon, and the like. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. The combination of resin and fibers used to form the example cover strands 40 may be referred to as a composite structure.

[0030] To form the example cover strands 40, the individual cover fibers 42 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion, or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 44 by techniques such as solvent removal, solidification from melting, or chemical curing. The example cover stands 40 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. A number of example cross-sectional shapes of the cover strands are depicted in Figures 9A-9D and will be described in further detail below. The example cover strands 40 and components thereof may also be formed of one or more sizes, shapes, and/or materials. The example cover strands 40 are round in cross-section and equal size in the example depicted in Figure 1B, but one or more other shapes and sizes may be used in a given example rope structure 20 of the present invention depending on the desired operating characteristics and operating environment of the given rope structure 20. In addition, one or both of the fibers and the resin may be made of different materials for one or more of the cover strands 40 based on the desired operating characteristics and operating environment of the given rope structure 20.

[0031] Referring now more specifically to Figures 2 and 3, the example cover strands 40 forming a part of the example rope structure 20 will now be described in further detail. Figure 2 illustrates that the rope structure 20 defines a length axis A. Figure 3 illustrates a single one of the example cover strands 40 removed from the rope structure 20 and illustrates that each of the example cover strands 40 is generally helical about a longitudinal axis B. When assembled with other cover strands and the example core component 22 to form the rope structure 20, the longitudinal axes B defined by the substantially helical cover strands 40 will be substantially aligned with the length axis A of the overall rope structure 20.

[0032] The example cover strands 40 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 22. In some situations, the strands 40 maintain the helical shape only when the held at two or more locations by clamps, tape, resin, adhesives, or the like. When held in the helical shape, the strands 40 will return (e.g., spring back) to a straight configuration after the holding force is removed. In other situations, the strands 40 may be allowed to solidify or cure around the core component 22 in the substantially helical shape. In yet another example, the example cover strands 40 may be solidified or cured in the substantially helical shape in advance and then assembled in solidified form to form the rope structure 20.

[0033] Figure 2 also illustrates that the example cover strand 40 defines a pitch associated with repeated angular positions of portions of the substantially helical shape defined by the example cover strand 40. With the example cover strands 40, the pitch is predetermined in relation to the number of cover strands 40 and the thickness of the example cover stands 40 such that the strands 40 form a relatively tight fit (minimal space) between the adjacent cover stands 40 forming the example cover component 24.

[0034] One or more of the strands 40 may contain one or more wires or fibers capable of carrying signals (e.g., electrical signals, optical signals) that can be monitored to determine the state of the rope structure 20 (e.g., non-destructive monitoring or testing). The use of the example cover component 24 in conjunction with the example core component 22 may provide the rope structure 20 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, non-destructive testing capabilities, and/or reduced weight per unit length. The rope structure 20 can thus be engineered for increased performance in a number of specific operating environments.

[0035] Referring now to Figures 4A and 4B, depicted therein is a second example rope structure 120 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 120 comprises a core component 122, a first cover component 124, and a second cover component 126. One or both of the example first and second cover components 124 and 126 may be formed along the entire length of the example core component 122, and one or both of the example cover components 124 and 126 may be formed only at particular locations along the length of the example core component 122.

[0036] The example core component 122 may be formed by a conventional rope structure such as a braided or twisted strand rope, a bundle of parallel fibers or twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component will typically be made of core or rope strands 130 comprising core fibers 132 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the core or rope strands 130 as depicted in Figure 4B. The core or rope strands 130 are combined to form the rope structure that may be used as the example core component 122.

[0037] An appropriate rope structure for forming the example core component 122 will typically be made of core fibers 132 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above . These types of core fibers are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers is typically referred as a synthetic rope.

[0038] The example first cover component 124 may be formed by a plurality of first cover strands 140 comprising first cover fibers 142 dispersed or arranged in a first resin matrix 144. The example second cover component 126 may be formed by a plurality second cover strands 150 comprising second cover fibers 152 dispersed or arranged in a second resin matrix 154. The first and second cover strands 140 and 150 are arranged to form a cover or jacket for the example core component 122.

[0039] A plurality of the example first cover strands 140 and 150 are arranged helically around the example core component 122 such that the entire core component is effectively covered along substantially the entire length of the rope structure 120. As shown in Figure 4A, the example first and second cover strands 140 and 150 are wound in opposite directions around the example core component 122. In other situations, the first and second cover strands 140 and 150 may be wound in the same direction around the example core component 122.

[0040] In the example rope structure 120, the example cover fibers 142 and 152 are continuous fibers made of one or more materials such as the materials used to form the example cover fibers 42 described above. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. Different resin materials may be used to form the matrixes 144 and 154. The example first cover fibers 142 may be made of a different material than the example second cover fibers 152, or both of the example cover fibers 142 and 152 may be made of the same material. The combination of resin and fibers used to form the example cover strands 142 and 152 may, in either or both cases, be referred to as a composite structure.

[0041] To form the example cover strands 140 and 150, the individual cover fibers 142 or 152 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion, or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 144 or 154 by techniques such as solvent removal, solidification from melting, or chemical curing. Like the example cover strands 40 described above, the example cover strands 140 and 150 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 122.

[0042] As described above with respect to the example cover strands 40, the example cover stands 140 and 150 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. The example cover strands 140 and 150 and components thereof may also be formed of one or more sizes, shapes, and/or materials as generally discussed above. The example first cover strands 140 and second cover strands 150 are round in cross-section as depicted in Figure 4B, but one or more other shapes and sizes may be used depending on the desired operating characteristics and operating environment of the rope structure 120.

[0043] The use of the example first and second cover components 124 and 126 in conjunction with the example core component 122 may provide the second example rope structure 120 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, and/or reduced weight per unit length. The second example rope structure 120 can thus be engineered for increased performance in a number of specific operating environments.

[0044] Referring now to Figures 5A and 5B, depicted therein is a third example rope structure 220 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 220 comprises a core component 222, a first cover component 224, and a second cover component 226. One or both of the example first and second cover components 224 and 226 may be formed along the entire length of the example core component 222, and one or both of the example cover components 224 and 226 may be formed only at particular locations along the length of the example core component 222.

[0045] The example core component 222 may be formed by a conventional rope structure such as a braided or twisted strand rope, a bundle of parallel fibers or twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component will typically be made of rope strands 230 comprising core fibers 232 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the rope strands 230 as depicted in Figure 5B. The rope strands 230 are combined to form the rope structure that may be used as the example core component 222.

[0046] An appropriate rope structure for forming the example core component 222 will typically be made of core fibers 232 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above. These types of core fibers are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers is typically referred as a synthetic rope.

[0047] The example first cover component 224 may be formed by a plurality of first cover strands 240 comprising first cover fibers 242 dispersed or arranged in a first resin matrix 244. The example first cover strands 240 are arranged to form an inner cover or an inner jacket for the example core component 222.

[0048] A plurality of the example first cover strands 240 are arranged helically around the example core component 222 such that the entire core component is effectively covered along substantially the entire length of the rope structure 220. As shown in Figure 5A, the example first cover strands are wound in a first direction around the example core component 222.

[0049] In the example rope structure 220, the example cover fibers 242 are continuous fibers made of one or more materials such as the materials used to form the example cover fibers 42 described above. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. The combination of resin and fibers used to form the example cover strands 240 may be referred to as a composite structure.

[0050] To form the example cover strands 240, the individual cover fibers 242 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion, or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 244 by techniques such as solvent removal, solidification from melting, or chemical curing. Like the example cover strands 40 described above, the example cover strands 240 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 222.

[0051] As described above with respect to the example cover strands 40, the example cover stands 240 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. The example cover strands 240 and components thereof may also be formed of one or more sizes, shapes, and/or materials as generally discussed above. The example first cover strands 240 are round in cross-section as depicted in Figure 5B, but one or more other shapes and sizes may be used depending on the desired operating characteristics and operating environment of the rope structure 220.

[0052] The example second cover component 226 may be formed by a conventional rope jacket structure such as a braided jacket. An appropriate conventional rope jacket structure for forming the example core component will typically be made of jacket strands 250 comprising jacket fibers 252 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the jacket strands 250 as depicted in Figure 5B. The jacket strands 250 are combined to form the rope jacket structure that may be used as the example second cover component 226.

[0053] An appropriate rope structure for forming the example second cover component 226 will typically be made of jacket fibers 252 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above. These types of jacket fibers are commonly referred to as synthetic fibers.

[0054] The use of the first and second cover components 224 and 226 in conjunction with the example core component 222 may provide the rope structure 220 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, and/or reduced weight per unit length. The rope structure 220 can thus be engineered for increased performance in a number of specific operating environments.

[0055] Referring now to Figures 6A and 6B, depicted therein is a fourth example rope structure 320 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 320 comprises a core component 322, an intermediate component 324, and a cover component 326. One or both of the intermediate component 324 and the example cover component 326 may be formed along the entire length of the example core component 322, and one or both of the intermediate component 324 and the example cover component 326 may be formed only at particular locations along the length of the example core component 322.

[0056] The example core component 322 may be formed by a conventional rope structure such as a braided or twisted strand rope, a bundle of parallel fibers or twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component will typically be made of rope or core strands 330 comprising core fibers 332 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the rope strands 330 as depicted in Figure 6B. The rope strands 330 are combined to form the rope structure that may be used as the example core component 322.

[0057] An appropriate rope structure for forming the example core component 322 will typically be made of core fibers 332 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above. These types of core fibers are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers is typically referred as a synthetic rope.

[0058] The intermediate component 324 is formed by a film sheet or strip that is wrapped or wound around the example core component 322. The example intermediate component 324 is a thin strip of plastic film that is wrapped (with overlapping edges) in a first direction around the example core component 322 before the example cover component 326 is formed over the example core component 322. The example intermediate component 324 may reduce the friction between the example core component 322 and the example cover component 326 and/or act as a barrier or filter to prevent fluids, particles, or other contaminants from reaching the core component 322.

[0059] The example cover component 326 may be formed by a plurality of cover strands 350 comprising cover fibers 352 dispersed or arranged in a resin matrix 354. The example first cover strands 350 are arranged to form a cover or jacket for the example core component 322. A plurality of the example cover strands 350 are arranged helically around the intermediate component 324 and the example core component 322 such that the entire core component 322 is effectively covered by the example cover component 326 along substantially the entire length of the rope structure 320. As shown in Figure 6A, the example cover strands 350 are wound in a second direction around the example intermediate component 324. However, the cover strands 350 may be wound in the same direction as a film strip forming the example intermediate component 324.

[0060] In the example rope structure 320, the example cover fibers 352 are continuous fibers made of one or more materials such as the materials used to form the example cover fibers 42 described above. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. The combination of resin and fibers used to form the example cover strands 350 may be referred to as a composite structure.

[0061] To form the example cover strands 350, the individual cover fibers 352 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 354 by techniques such as solvent removal, solidification from melting, or chemical curing. Like the example cover strands 40 described above, the example cover strands 350 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 322

[0062] As described above with respect to the example cover strands 40, the example cover stands 350 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. The example cover strands 350 and components thereof may also be formed of one or more sizes, shapes, and/or materials as generally discussed above. The example first cover strands 350 are round in cross-section as depicted in Figure 6B, but one or more other shapes and sizes may be used depending on the desired operating characteristics and operating environment of the rope structure 320.

[0063] The use of the intermediate component 324 and/or cover component 326 in conjunction with the example core component 322 may provide the rope structure 320 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, and/or reduced weight per unit length. The rope structure 320 can thus be engineered for increased performance in a number of specific operating environments.

[0064] Referring now to Figures 7A and 7B, depicted therein is a fifth example rope structure 420 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 420 comprises a core component 422, an intermediate component 424, and a cover component 426. One or both of the intermediate component 424 and the example cover component 426 may be formed along the entire length of the example core component 422, and one or both of the intermediate component 424 and the example cover component 426 may be formed only at particular locations along the length of the example core component 422.

[0065] The example core component 422 may be formed by a conventional rope structure such as a braided or twisted strand rope, a bundle of parallel fibers or twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component will typically be made of rope or core strands 430 comprising core fibers 432 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the example core or rope strands 430 as depicted in Figure 7B. The example core or rope strands 430 are combined to form the rope structure that may be used as the example core component 422.

[0066] An appropriate rope structure for forming the example core component 422 will typically be made of core fibers 432 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above. These types of core fibers are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers is typically referred as a synthetic rope.

[0067] The intermediate component 424 is formed by a coating material on the example core fibers 432 forming the example core component 422. The example intermediate component 424 is formed by one or more layers of coating material that is sprayed onto or soaked into the example core component 422 in liquid form and allowed to dry or set before or after the example cover component 426 is formed over the example core component 422. If the coating material is sprayed onto the example core component 422, the intermediate component 424 will typically take the form of a thin layer that covers most if not all of the outer surfaces of the example core strands 430. If the example core component 422 is soaked in the coating material, the coating material may fill at least a part of the volume defined by the interstitial spaces between the fibers 432 forming the example core strands 430. A vacuum applied to these interstitial spaces may encourage flow of liquid coating material into the interstitial spaces. In any case, the example intermediate component 424 may reduce the friction between the example core component 422 and the example cover component 426.

[0068] The example cover component 426 may be formed by a plurality of cover strands 450 comprising cover fibers 452 dispersed or arranged in a resin matrix 454. The example first cover strands 450 are arranged to form a cover or jacket for the example core component 422. A plurality of the example cover strands 450 are arranged helically around the intermediate component 424 and the example core component 422 such that the entire core component 422 is effectively covered by the example cover component 426 along substantially the entire length of the rope structure 420. As shown in Figure 7A, the example cover strands 450 are wound in a second direction around the example core component 422.

[0069] In the example rope structure 420, the example cover fibers 452 are continuous fibers made of one or more materials such as the materials used to form the example cover fibers 42 described above. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. The combination of resin and fibers used to form the example cover strands 250 may be referred to as a composite structure.

[0070] To form the example cover strands 450, the individual cover fibers 452 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion, or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 454 by techniques such as solvent removal, solidification from melting, or chemical curing. Like the example cover strands 40 described above, the example cover strands 450 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 422.

[0071] As described above with respect to the example cover strands 40, the example cover stands 450 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. The example cover strands 450 may also be formed of one or more sizes, shapes, and/or materials as generally discussed above. The example first cover strands 450 are round in cross-section as depicted in Figure 7B, but one or more other shapes and sizes may be used depending on the desired operating characteristics and operating environment of the rope structure 420.

[0072] The use of the intermediate component 424 and/or cover component 426 in conjunction with the example core component 422 may provide the rope structure 420 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, and/or reduced weight per unit length. The rope structure 420 can thus be engineered for increased performance in a number of specific operating environments.

[0073] Referring now to Figures 8A and 8B, depicted therein is a sixth example rope structure 520 constructed in accordance with, and embodying, the principles of the present invention. The example rope structure 520 comprises a core component 522, an intermediate component 524, a cover component 526, and an outer component 528. One or more of the intermediate component 524, the example cover component 526, and the outer component 528 may be formed along the entire length of the example core component 522. In addition, one or more of the intermediate component 524, the example cover component 526, and the outer component 528 may be formed only at particular locations along the length of the example core component 522.

[0074] The example core component 522 may be formed by a conventional rope structure such as a braided or twisted strand rope, a bundle of parallel fibers or twisted yarns, and/or a bundle of parallel ropes (e.g., core ropes or sub-ropes). An appropriate conventional rope structure for forming the example core component will typically be made of rope or core strands 530 comprising core fibers 532 that are combined into rope sub-components such as yarns. In turn, the yarns are combined into rope sub-components such as the rope strands 530 as depicted in Figure 8B. The rope strands 530 are combined to form the rope structure that may be used as the example core component 522.

[0075] An appropriate rope structure for forming the example core component 522 will typically be made of core fibers 532 formed from one or more materials such as any of the materials that may be used to form the core fibers 32 described above. These types of core fibers are commonly referred to as synthetic fibers, and a conventional rope structure made from such core fibers is typically referred as a synthetic rope.

[0076] The intermediate component 524 is formed by a coating material on or film material wrapped or wound around the example core fibers 532 forming the example core component 522. The example intermediate component 524 is formed by a strip of film material wrapped around the example core component 522. In any form, the example intermediate component 524 may reduce the friction between the example core component 522 and the example cover component 526.

[0077] The example cover component 526 may be formed by a plurality of cover strands 550 comprising cover fibers 552 dispersed or arranged in a resin matrix 554. The example first cover strands 550 are arranged to form a cover or jacket for the example core component 522. A plurality of the example cover strands 550 are arranged helically around the intermediate component 524 and the example core component 522 such that the entire core component 522 is effectively covered by the example cover component 526 along substantially the entire length of the rope structure 520. As shown in Figure 8A, the example cover strands 550 are wound in a second direction around the example core component 522.

[0078] In the example rope structure 520, the example cover fibers 552 are continuous fibers made of one or more materials such as the materials used to form the example cover fibers 42 described above. The resin material is or may be a conventional polymeric resin, such as a thermoplastic or thermosetting resin. The combination of resin and fibers used to form the example cover strands 550 may be referred to as a composite structure.

[0079] To form the example cover strands 550, the individual cover fibers 552 are arranged in bundles, and the resin material is applied to the bundles by wet coating, powder coating, pultrusion, extrusion, or other means such that the resin coats or penetrates the bundles. For example, the resin may be applied in a fluid (e.g., liquid) or fluidized (e.g., powder) form to facilitate penetration of the fiber bundles and then solidified into the matrix 554 by techniques such as solvent removal, solidification from melting, or chemical curing. Like the example cover strands 40 described above, the example cover strands 550 may be twisted, wound, braided, or otherwise arranged in a solidified form or in an un-solidified or un-cured form around the example core component 522.

[0080] As described above with respect to the example cover strands 40, the example cover stands 550 may be formed in one or more of a number of cross-sectional shapes such as round, dogbone, square or rectangular, A-shape, or trapezoidal. The example cover strands 550 may also be formed of one or more sizes, shapes, and/or materials as generally discussed above. The example first cover strands 550 are round in cross-section as depicted in Figure 8B, but one or more other shapes and sizes may be used depending on the desired operating characteristics and operating environment of the rope structure 520.

[0081] The outer component 528 is formed by a coating material on or film material wrapped or wound around the example cover strands 550 or cover fibers 552 forming the example cover component 526. The example outer component 528 is formed by a strip of film material wrapped around the example cover component 526. In any form, the example outer component 528 may be formed such that the whole rope 520 can be protected, and its surface can be filled/shaped to define a smooth outside.

[0082] The use of the intermediate component 524, cover component 526, and/or outer component 528 in conjunction with the example core component 522 may provide the rope structure 520 with improved shape stability, increased abrasion and cut resistance, better surface characteristics, improved weather resistance, and/or reduced weight per unit length. The rope structure 520 can thus be engineered for increased performance in a number of specific operating environments.

[0083] Turning now to Figures 9A-9D of the drawing, several examples of cover strand configurations will be described.

[0084] Figure 9A depicts a rope structure 620 comprising a core component 622 and a cover component 624. The cover component 624 comprises a set of first cover strands 626 and a set of second cover strands 628. The cover strands may be composite structures like any of the cover strands described above. In the example cover component 624, one of the second cover strands 628 is arranged between each of the first cover strands 628, and the adjacent surfaces of the first and second cover strands 626 and 628 are complementary. In particular, the cross-sectional area of the example first cover strands 626 is round, while the cross-sectional area of the second cover strands 628 defines inner and outer surfaces 628a and 628b and side surfaces 628c and 628d. The example inner and outer surfaces 628a and 628b are flat, while the example side surfaces 628c and 628d are inwardly curved (concave). Outwardly curved outer surfaces 626a of the round first cover strands 626 substantial conform to or are complementary with the inwardly curved side surfaces 628c and 628d of the second cover strands 628. The outer surfaces 626a and side surfaces 628c and 628d need not be curved or circular but should be complementary. The inner and outer surfaces 628a and 628b need not be flat. The inner surfaces 628a may be shaped or contoured for better engagement with the core component 622, and the outer surfaces 628b may be shaped, contoured, or textured to provide enhanced surface characteristics to the overall rope structure 620.

[0085] Figure 9B depicts a rope structure 630 comprising a core component 632 and a cover component 634. The cover component 634 comprises a set of first cover strands 636 and a set of second cover strands 638. The cover strands may be composite structures like any of the cover strands described above. In the example cover component 634, one of the second cover strands 638 is arranged between each of the first cover strands 638, and a cross-sectional area of the first cover strands 636 is larger than a cross-sectional area of second cover strands 638. In particular, the cross-sectional areas of the example first and second cover strands 636 and 638 are both round, but the cross-sectional area of the second cover strands 638 defines a smaller radius than the radius of the first cover strands 636. In addition, the centers of the example second cover strands 638 are arranged radially inwardly towards the core component 632 relative to the centers of the example first cover strands 636.

[0086] Figure 9C depicts a rope structure 640 comprising a core component 642 and a cover component 644. The cover component 644 comprises a set of cover strands 646. The example cover strands 646 may be composite structures like any of the cover strands described above. In the example cover component 644, the cover strands 646 define a primary lateral dimension W1 and a primary radial dimension T1, where the radial dimension T1 is smaller than the lateral dimension W1. In addition, the example cover strands 646 further define a secondary lateral dimension W2 and a secondary radial dimension T2. The secondary lateral dimension W2 is smaller than the primary lateral dimension W1, and the secondary radial dimension T2 is smaller than the primary radial dimension T1. Corners 646a, 646b, 646c, and 646d of the example cover strands 646 are rounded, and the second radial dimension T2 corresponds to flat surfaces 646e and 646f. The example cover strands 646 may be described as dogbone-shaped in cross-sectional area. This dogbone shape provides desirable performance characteristics for a given size and weight per unit length of the example cover strands 646.

[0087] Figure 9D depicts a rope structure 650 comprising a core component 652 and a cover component 654. The cover component 654 comprises a set of cover strands 656. The example cover strands 656 may be composite structures like any of the cover strands described above. In the example cover component 654, the cover strands 656 are quadrilaterals and thus define flat inner and outer surfaces 656a and 656b and flat side surfaces 656c and 656d. The example cover strands 656 may define trapezoid shapes (or possibly complementary trapezium shapes) in cross-sectional area. The example cover strands 656 are trapezoidal, and the angled side surfaces 656c and 656d of adjacent cover strands 656 overlap over a substantial surface area to minimize gaps between adjacent cover strands 656. The side surfaces 656c and 656d need not be flat but should be complementary. The inner surfaces 656a need not be flat, but may instead be shaped or contoured for better engagement with the core component 652. The outer surfaces 656b also need not be flat and instead may be shaped, contoured, or textured to provide enhanced surface characteristics to the overall rope structure 650.

[0088] It should be understood that the various components of the rope structures 20, 120, 220, 320, 420, 520, 620, 630, 640, and 650 may be used in combinations other than the specific combinations disclosed herein. For example, the example rope structure 520 employs an intermediate component 524 and an outer component 528 formed by a film wrapped around the core component 522 and cover component 526. Either or both of the intermediate component 524 and the outer component 528 may be replaced by a coating such as the coating forming the example intermediate component 424 of the example rope structure 420. As another example, a coating or film may be applied to the core component 122, first cover component 124, and/or second cover component 126 of the second example rope structure 120. Similarly, a coating or film may be applied to the core component 222, first cover component 224, and/or second cover component 226 of the third example rope structure 220. As yet another example, a second cover component such as the second cover component 226 of the third example rope structure 220 may be applied to any other rope structure (e.g., the rope structures 20, 120, 320, 420, 520, 620, 630, 640, and 650) embodying the principles of the present invention.

[0089] In addition, any one or more of the various components used to form rope structures of the present invention may be made of the same material (homogenous) or of different materials (non homogenous). Even a given component may be homogenous or non-homogenous depending upon the nature of the operating characteristics and environment.

[0090] Any one of the structures 20, 120, 220, 320, 420, 520, 620, 630, 640, and 650 could be terminated with swaging with end fittings, pot fitting using resin matrix, or simply by terminating only the core component using conventional techniques for splicing ropes. Before terminating, the structure 20, 120, 220, 320, 420, 520, 620, 630, 640, and 650 will typically held together temporarily. The temporary holding method could be, for example, by covering the section with tape, and then using holes clamps at both ends to keep the construction together. Then the structure will be terminated using the swaging method or the pot fitting method. After the construction is fixed permanently (e.g. after certain resin curing time), then the holes clamps and tape can be removed.

[0091] For the method of swaging with end fittings, resin could also be added into the end fittings to fill the gaps before clamping. The swaging force would typically be justified depending on the materials.

[0092] If the rope is terminated using the method of pot fitting with resin matrix the cone shape of the end of structure 20, 120, 220, 320, 420, 520, 620, 630, 640, and 650 is maintained, and the end of the structure is put it into the pot. In this case, the fitting pot will also typically be cone shaped. The bottom of the pot is then sealed to avoid resin flow out. Resin is added on top of the pot to avoid or minimize the formation of bubbles. The entire construction will typically be kept hanging vertical to the ground until the resin is fully cured.

[0093] If conventional splicing techniques are used to form a termination using only the core component, the spliced area may be covered using a separate splice cover component, structure, coating, and/or the like.

What is claimed is:

1. A rope structure comprising:

a core component comprising core fibers combine to form a first rope structure; and

a first cover component comprising first cover strands comprising first cover fibers within a first matrix material; wherein

the first cover strands are arranged around at least a portion of the core component.

2. A rope structure as recited in claim 1, in which the first matrix material is solidified such that the first cover strands hold a generally helical form.

3. A rope structure as recited in claim 1, in which the first matrix material comprises polymeric resin.

4. A rope structure as recited in claim 1, further comprising a second cover component comprising second cover strands comprising second cover fibers within a second matrix material, where the second cover strands are arranged around at least a portion of the first cover component.

5. A rope structure as recited in claim 4, in which the second matrix material is solidified such that the second cover strands hold a generally helical form.

6. A rope structure as recited in claim 5, in which the second matrix material is formed of polymeric resin.

7. A rope structure as recited in claim 1, further comprising a second cover component comprising second cover fibers combine to form a second rope

structure, where the second cover component is arranged around at least a portion of the first cover component.

8. A rope structure as recited in claim 1, further comprising an intermediate component arranged between the core component and the cover component.

9. A rope structure as recited in claim 8, in which the intermediate component comprises a coating.

10. A rope structure as recited in claim 9, in which the intermediate component comprises a film.

11. A rope structure as recited in claim 1, further comprising an outer component arranged substantially around at least a portion of the cover component.

12. A rope structure as recited in claim 11, in which the outer component comprises a coating.

13. A rope structure as recited in claim 11, in which the outer component comprises a film.

14. A method of forming a rope structure comprising the steps of:
providing core fibers;
combining the core fibers to form a core component comprising a first rope structure;
providing first cover fibers;
forming at least one cover first cover strand by combining the first cover fibers with a first matrix material;

arranging the at least one first cover strand to form a cover component by arranging the first cover strands around at least a portion of the core component.

15. A method of forming rope structure as recited in claim 14, in which the first matrix material solidifies prior to formation of the cover component.

16. A method of forming a rope structure as recited in claim 14, in which the first matrix material solidifies after formation of the cover component.

17. A method of forming a rope structure as recited in claim 14, further comprising the steps of:

providing second cover fibers;

forming at least one cover strand by combining the second cover fibers with a second matrix material;

arranging the at least one second cover strand to form a second cover component by arranging the second cover strands around at least a portion of the first cover component.

18. A method of forming a rope structure as recited in claim 14, further comprising the step of forming an intermediate component between the core component and the first cover component.

19. A method of forming a rope structure as recited in claim 18, in which the step of forming the intermediate component comprises the step of applying a coating to the core component.

20. A method of forming a rope structure as recited in claim 18, in which the step of forming the intermediate component comprises the step of arranging a film around at least a portion of the core component.

21. A method of forming a rope structure as recited in claim 14, further comprising the step of forming an outer component around at least a portion of the first cover component.

22. A method of forming a rope structure as recited in claim 21, in which the step of forming the outer component comprises the step of applying a coating to the first cover component.

23. A method of forming a rope structure as recited in claim 21, in which the step of forming the outer component comprises the step of arranging a film around at least a portion of the first cover component.

FIG. 1A

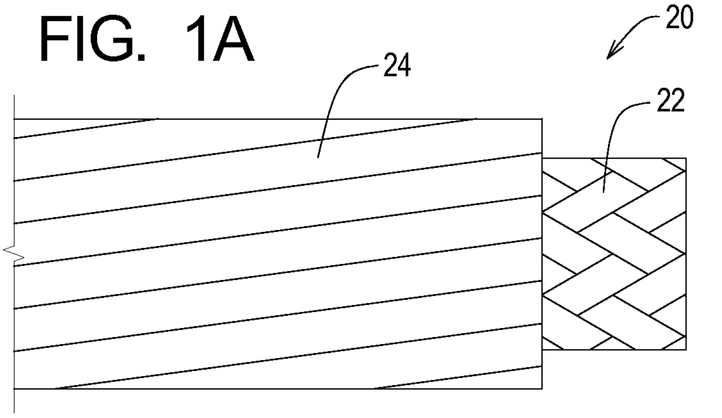


FIG. 1B

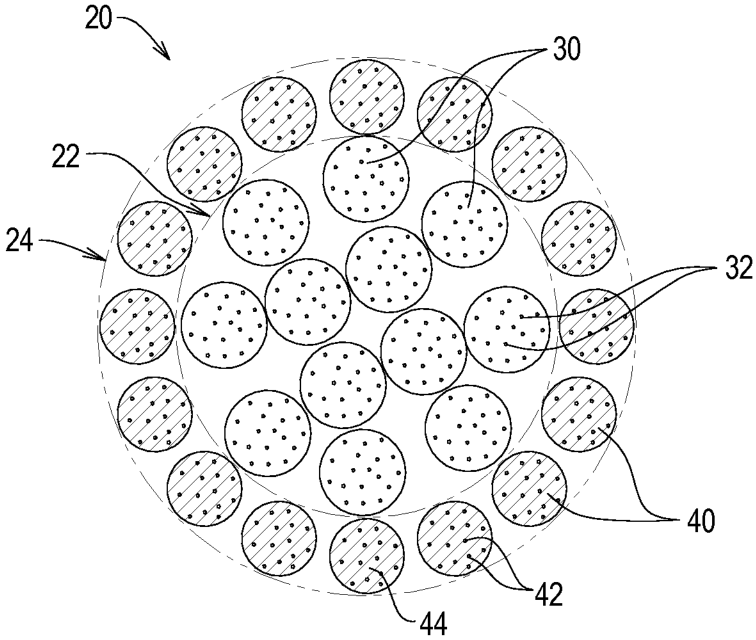


FIG. 2

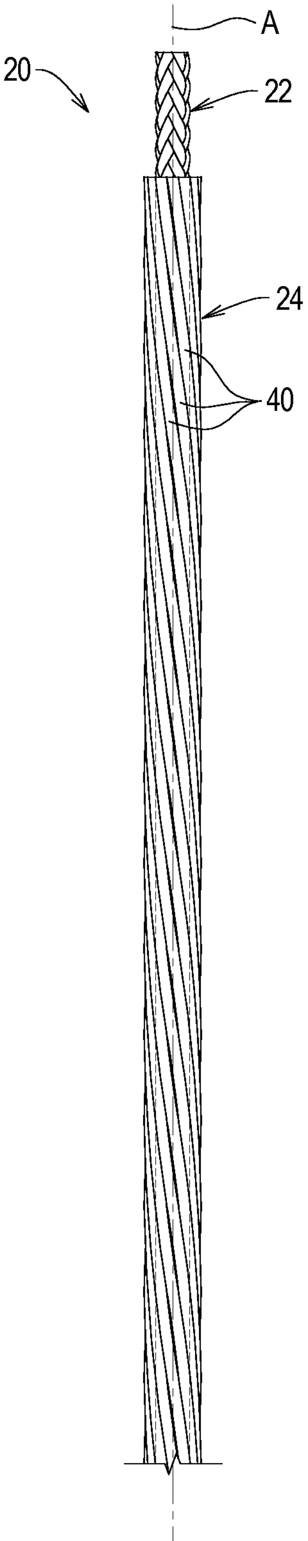


FIG. 3

FIG. 4A

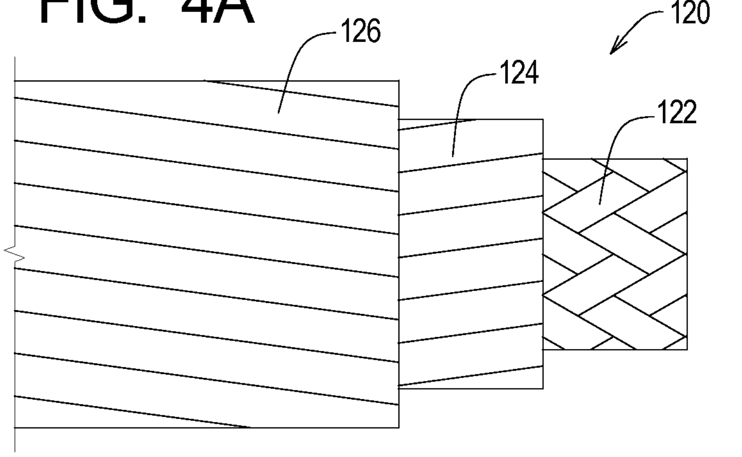


FIG. 4B

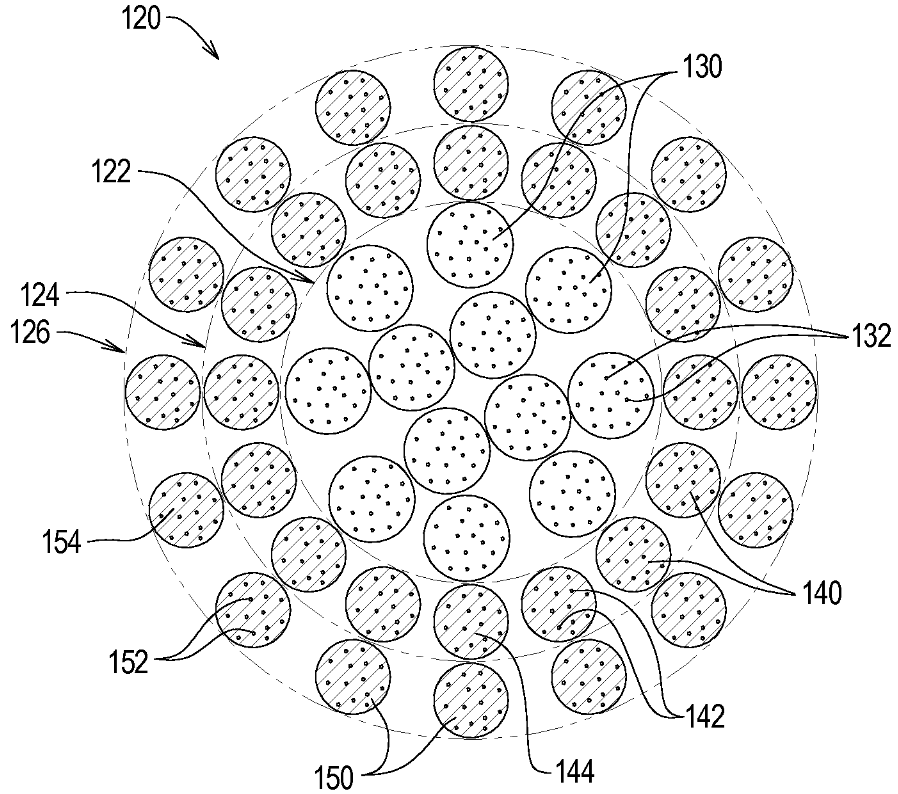


FIG. 5A

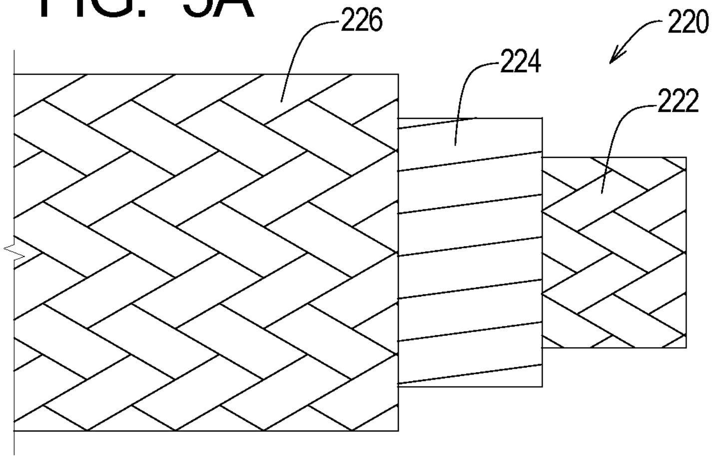


FIG. 5B

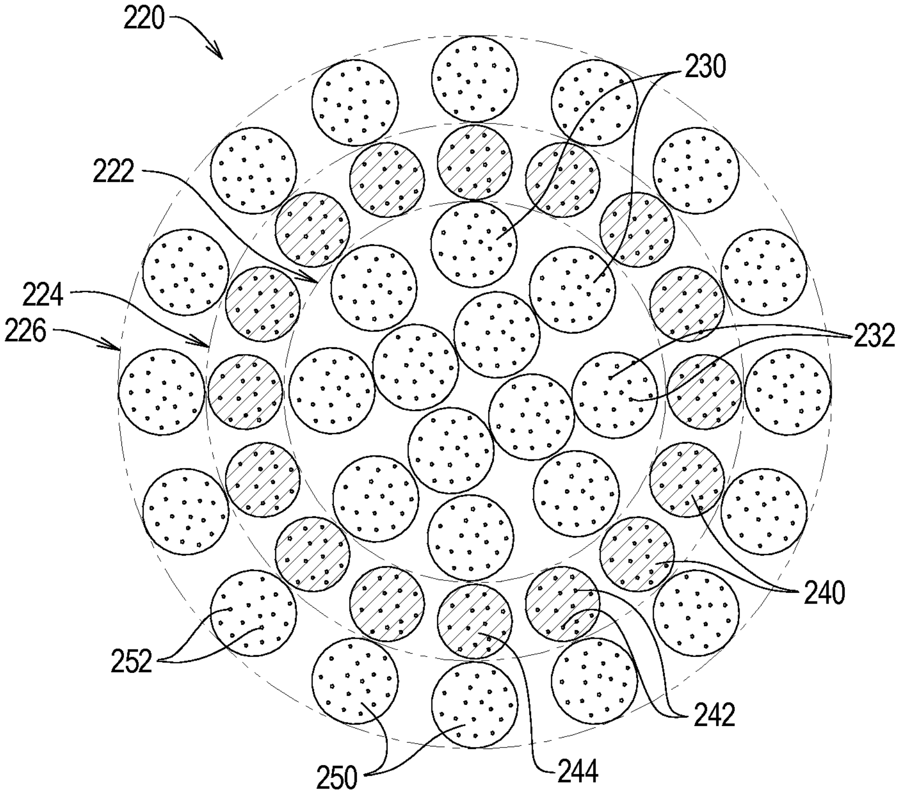


FIG. 6A

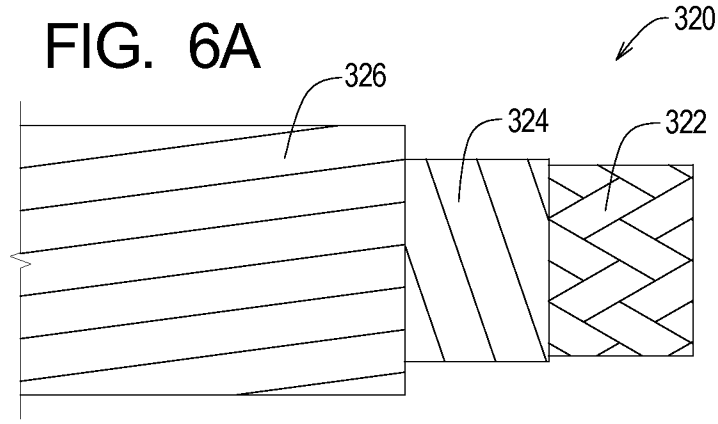


FIG. 6B

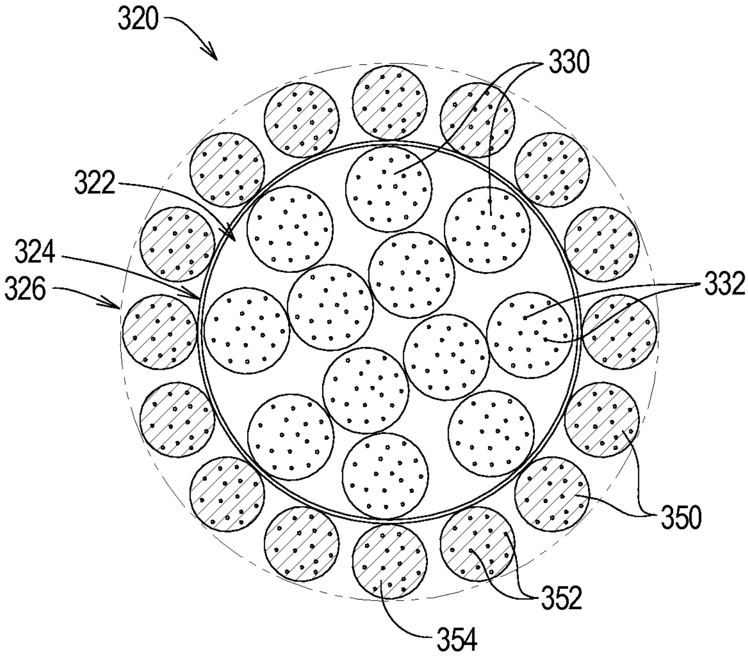


FIG. 7A

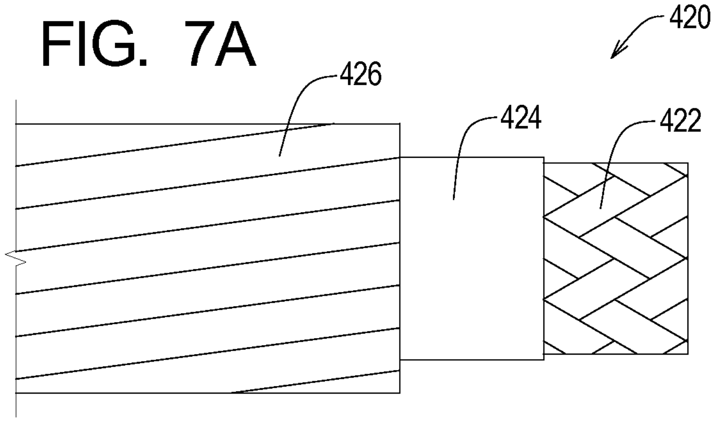


FIG. 7B

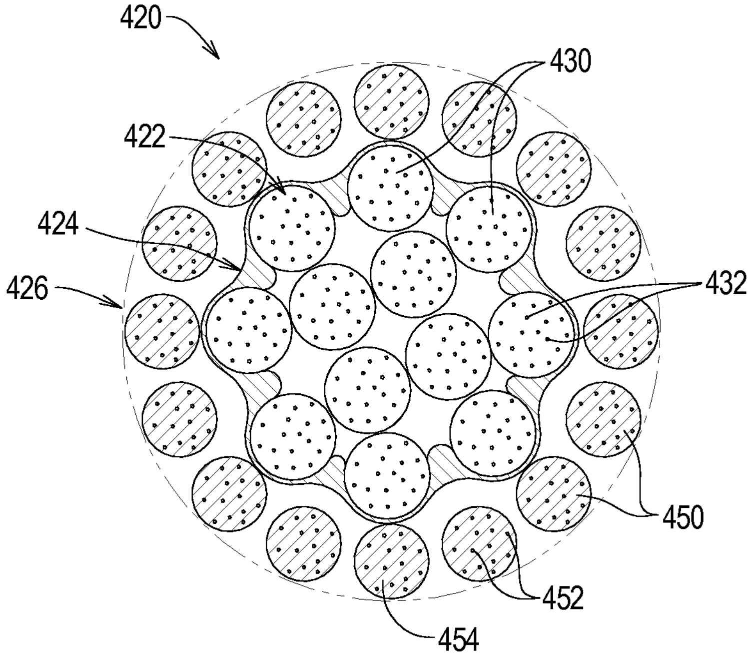


FIG. 8A

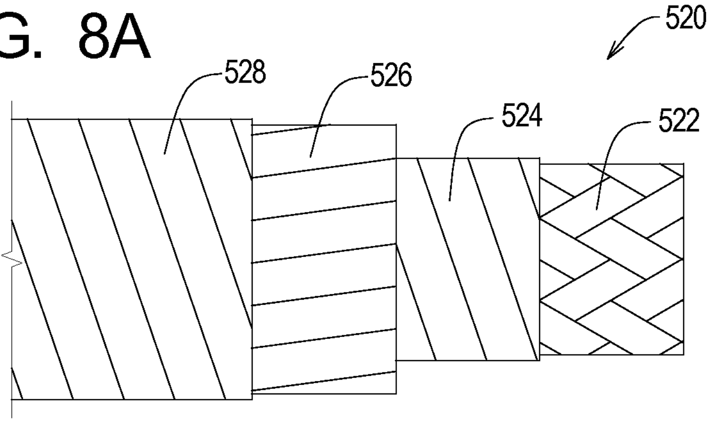


FIG. 8B

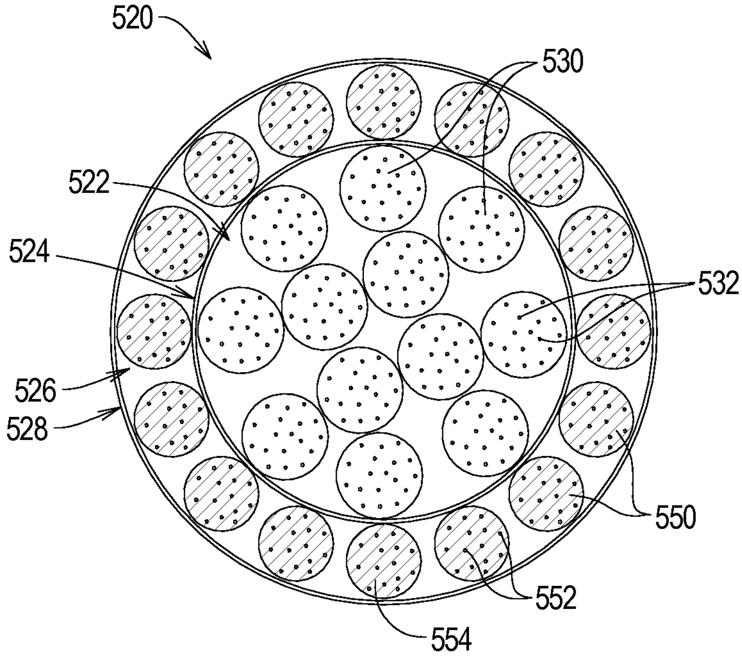


FIG. 9A

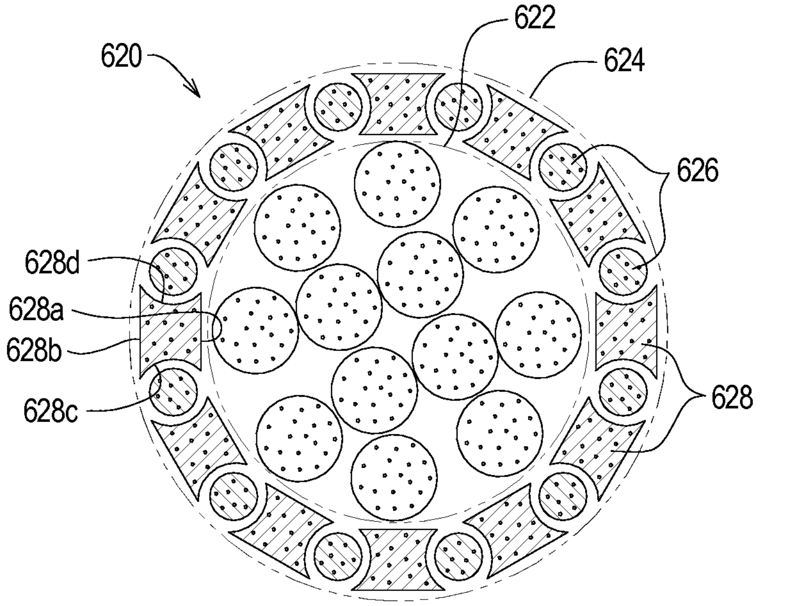


FIG. 9B

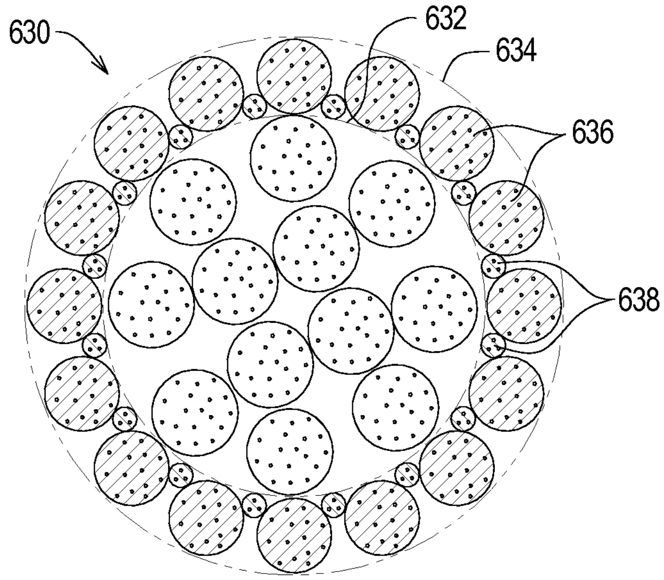


FIG. 9C

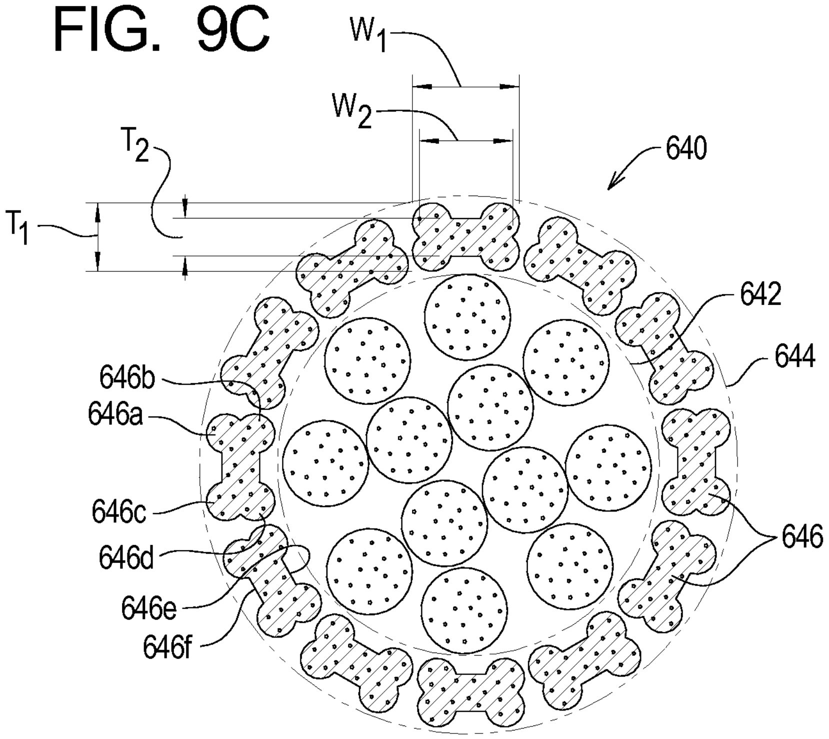
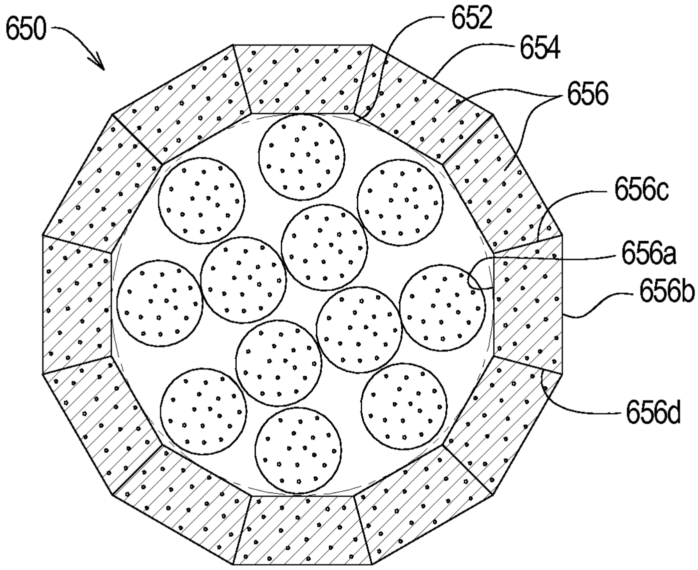

W1
W2
T2
T1
640
642
644
646b
646a
646c
646d
646e
646f
646

FIG. 9D


650
652
654
656
656c
656a
656b
656d

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2012/039460

A. CLASSIFICATION OF SUBJECT MATTER *D07B 1/16 (2006.01)*

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)

D07B 1/16, 5/00, 1/00, D02G 3/36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Esp@cenet, PatSearch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0282801 A1 (SAMSON ROPE TECHNOLOGIES) 19.11.2009, paragraph [0021], fig. 4	1-23
Y	US 2007/0137163 A1 (MAMUTEC AG) 21.06.2007, paragraphs [0034], [0057], fig. 1	1-23
Y	US 2005/0279074 A1 (DOUGLAS E. JOHNSON et al.) 22.12.2005, paragraphs [0001], [0003], [0006], [0050]	1-23
Y	US 2007/0266693 A1 (ASAHI INTECC CO., LTD) 22.11.2007, abstract, fig. 9-12	2, 5
Y	RU 2295144 C2 (PIRELLI EHND K. SPA) 10.03.2007, p. 9, lines 23-52, example 1	11-13, 21-23

☐ Further documents are listed in the continuation of Box C.

☐ 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 document 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
07 August 2012 (07.08.2012)	13 September 2012 (13.09.2012)

Name and mailing address of the ISA/ FIPS
Russia, 123995, Moscow, G-59, GSP-5,
Berezhkovskaya nab., 30-1

Facsimile No. +7 (499) 243-33-37

Authorized officer

I. Doroshenko

Telephone No. (495)531-64-81