US 20110047900A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2011/0047900 A1**

(43) **Pub. Date: Mar. 3, 2011**

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(54) **MODULAR COMPOSITE UTILITY POLE**

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(21) Appl. No.: **12/846,135**

(22) Filed: **Jul. 29, 2010**

Related U.S. Application Data

(60) Provisional application No. 61/236,474, filed on Aug. 24, 2009.

Publication Classification

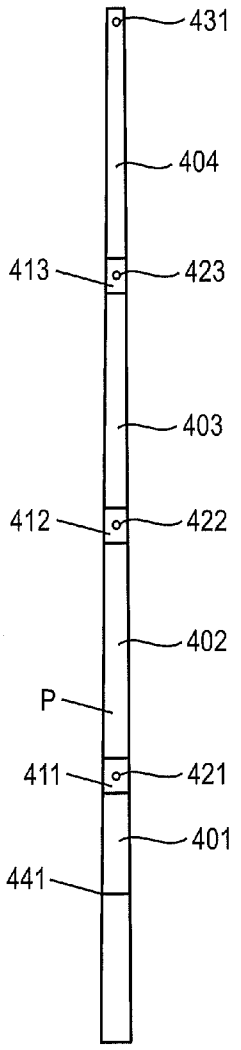
(51) **Int. Cl.**

E04C 3/00	(2006.01)
E04C 2/22	(2006.01)
E04H 14/00	(2006.01)
E04H 12/00	(2006.01)

(52) **U.S. Cl.** **52/173.1**; 52/848; 52/309.1; 52/651.02; 156/175

(57) **ABSTRACT**

A modular composite utility pole has a plurality of sections, each with a tapered hollow tube having a plurality of plies, wherein a first end has a larger diameter than a second end, wherein each section is adapted to join at least one adjoining section at a joint wherein the first end of an upper section overlaps the second end of a lower section, the lower section having a ledge proximate to the second end of the lower section, with a fastener passing through the joint via apertures in the sections, and wherein, when the modular composite utility pole is erected, the joint is self-located by the joint features, and wherein substantially all vertical load is transferred between sections via the a surface of the second end of the upper section resting upon the ledge of the lower section. Also disclosed are individual sections and methods of making them.



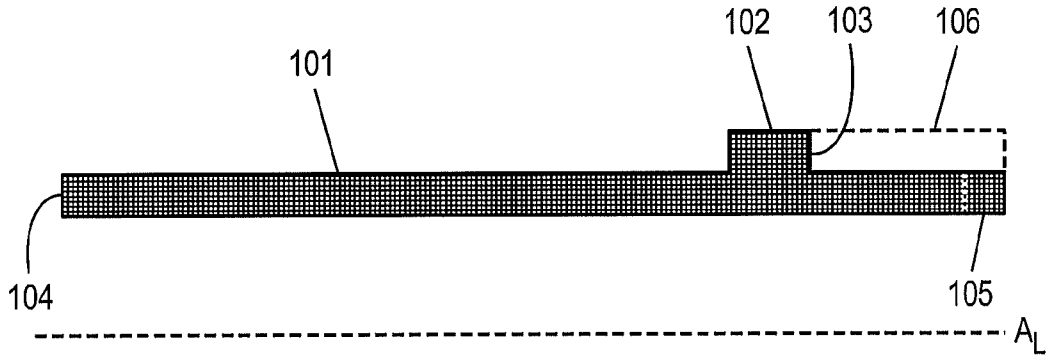


FIG. 1

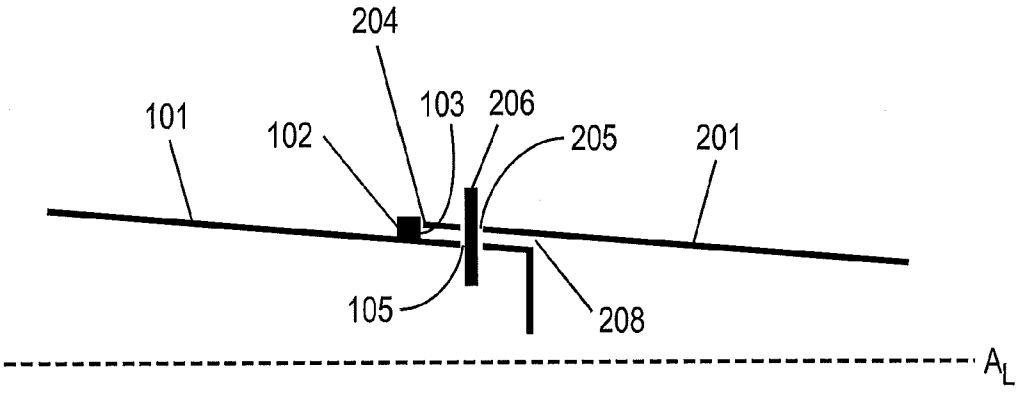


FIG. 2

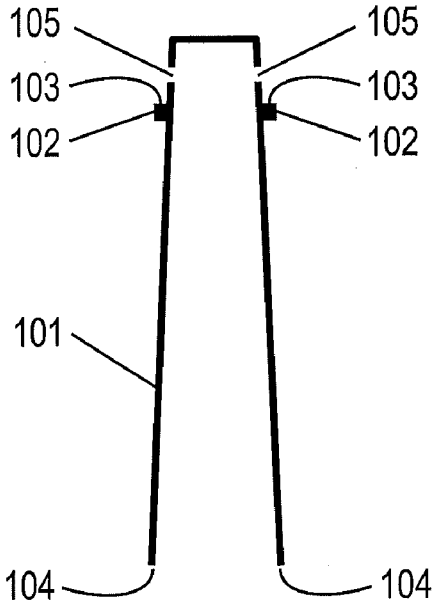


FIG. 3A

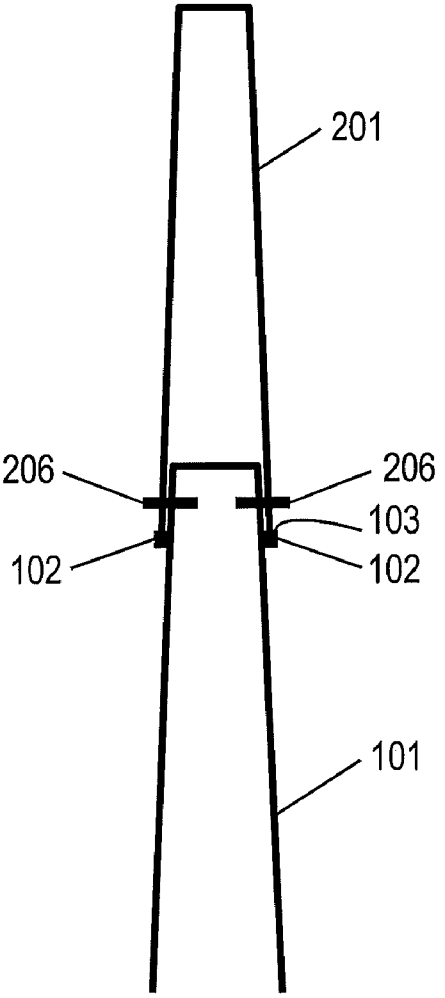


FIG. 3B

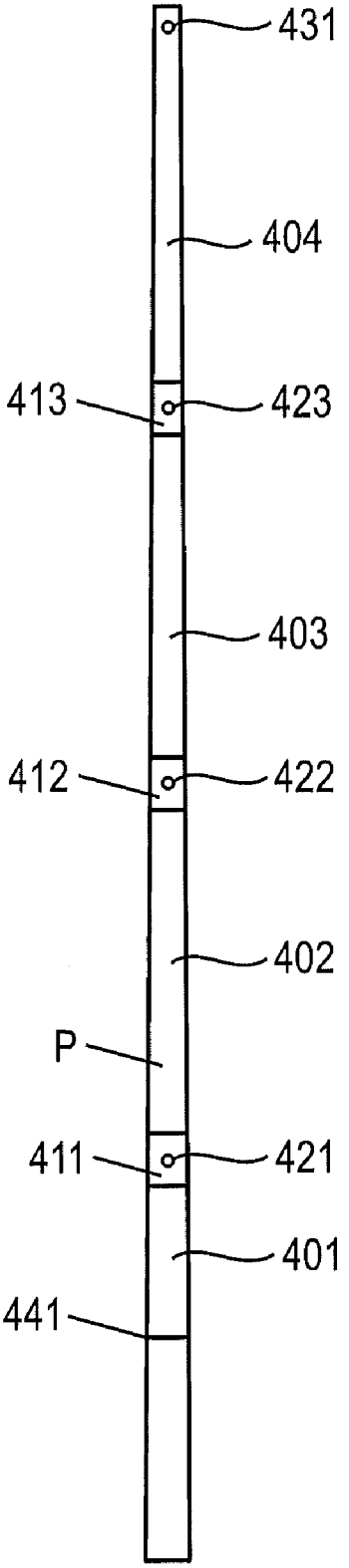


FIG. 4

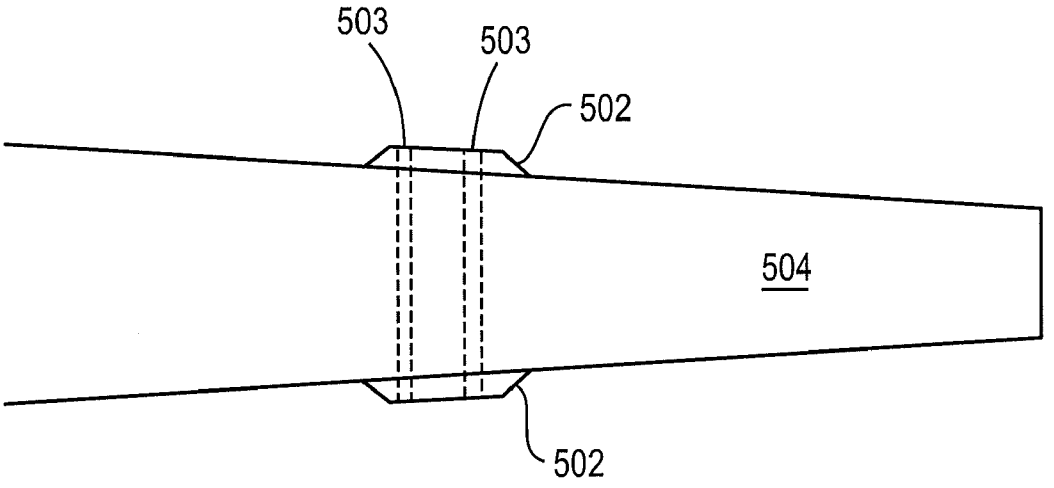


FIG. 5

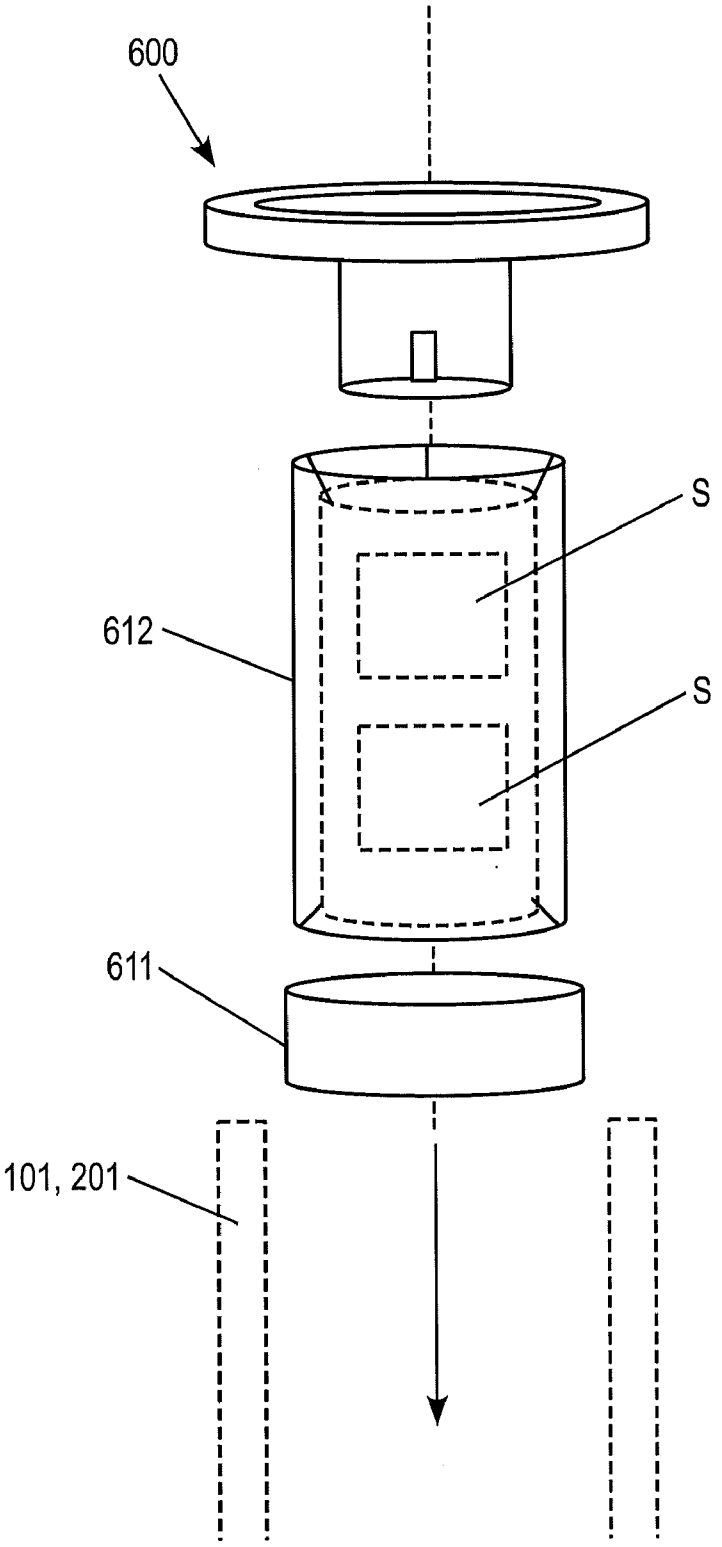


FIG. 6A

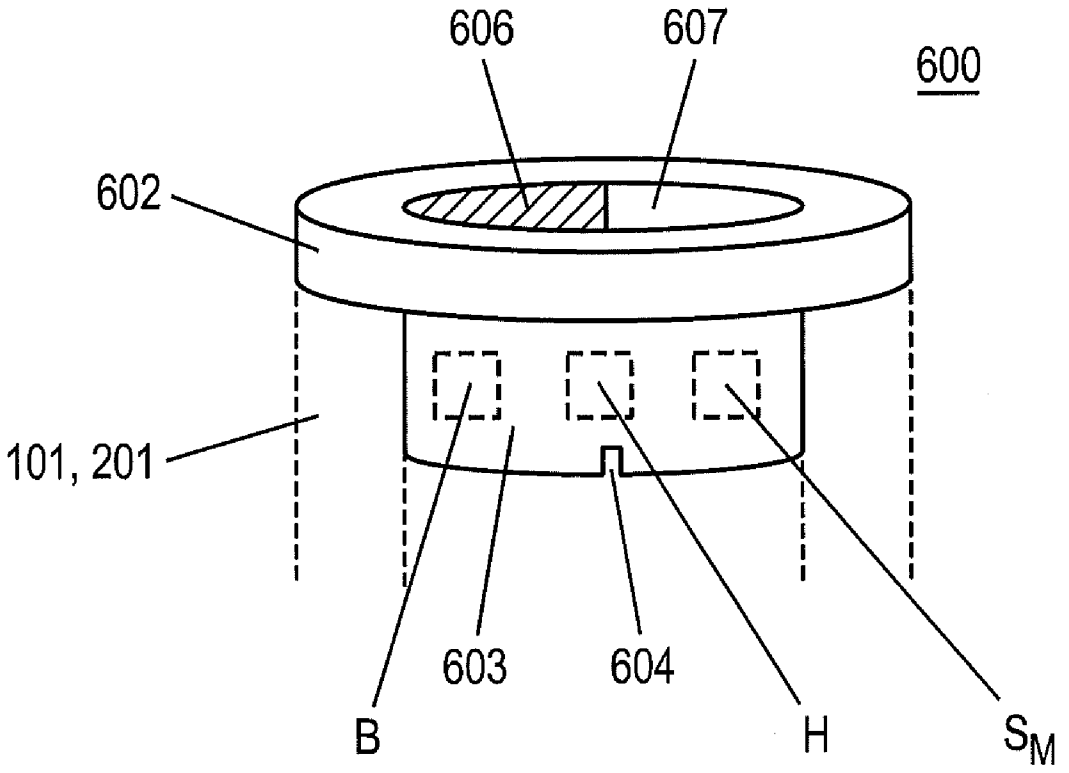


FIG. 6B

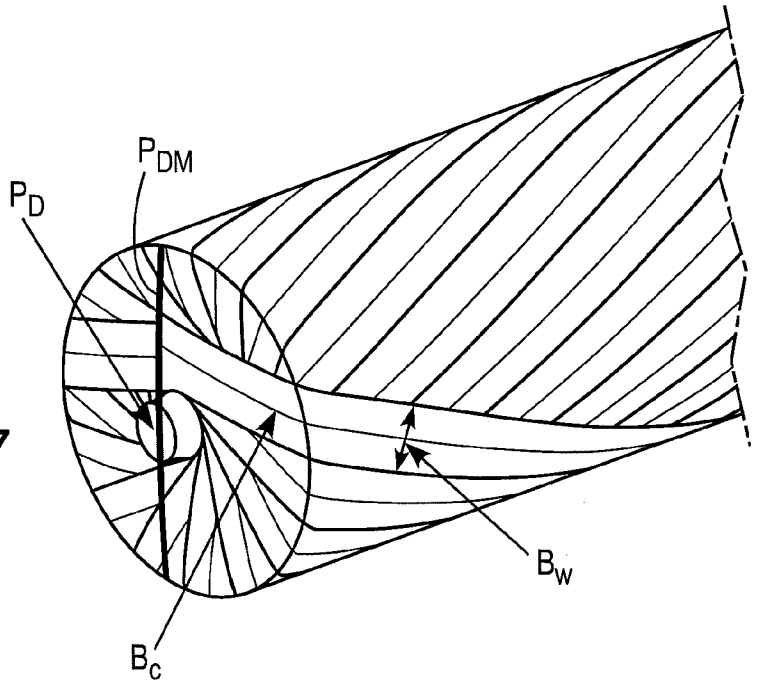


FIG. 7

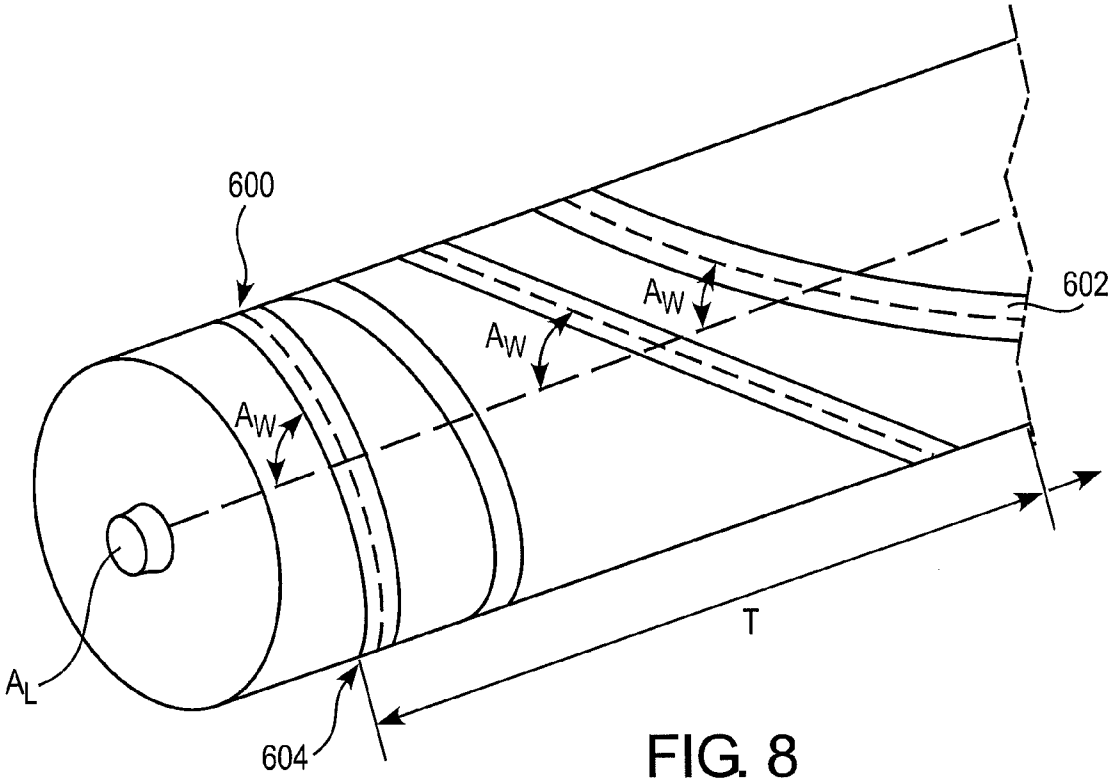


FIG. 8

MODULAR COMPOSITE UTILITY POLE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. §119(e) to U.S. provisional Application No. 61/236,474, filed on Aug. 24, 2009, the entire content of which is incorporated herein by reference.

FIELD

[0002] The present invention is in the technical field of utility poles, such as for power distribution and communications. The present invention is also in the technical field of composites.

BACKGROUND

[0003] In this specification where a document, act or item of knowledge is referred to or discussed, this reference or discussion is not an admission that the document, act or item of knowledge or any combination thereof was at the priority date, publicly available, known to the public, part of common general knowledge, or otherwise constitutes prior art under the applicable statutory provisions; or is known to be relevant to an attempt to solve any problem with which this specification is concerned.

[0004] Wood is the predominant material used for utility poles sized for distribution ("distribution poles"). The wood is harvested from forests and prepared and treated with chemicals to help prolong its useful life. Nonetheless, wood may be subject to infestation, rot, and/or decay due to environmental conditions. Thus, wood requires maintenance, creating an operational burden. Wood poles are also heavy, making handling, installation, and replacement difficult.

[0005] Furthermore, wood poles are solid and do not yield on impact, thus creating a hazard to motor vehicles and their occupants. This problem is exacerbated by the fact that distribution poles tend to be located along roadways.

[0006] A need exists for utility poles exhibiting long service life as well as the ability to be easily installed and/or repaired in the field.

[0007] While certain aspects of conventional technologies have been discussed to facilitate disclosure of the invention, Applicants in no way disclaim these technical aspects, and it is contemplated that the claimed invention may encompass one or more of the conventional technical aspects discussed herein.

SUMMARY

[0008] The present invention may address one or more of the problems and deficiencies of the prior art discussed above. However, it is contemplated that the invention may prove useful in addressing other problems and deficiencies, or provide benefits and advantages, in a number of technical areas. Therefore the claimed invention should not necessarily be construed as limited to addressing any of the particular problems or deficiencies discussed herein.

[0009] According to certain aspects, the present invention can provide a modular composite utility pole, sections thereof, and methods of making such sections and poles.

[0010] According to further optional aspects, the invention can be utilized in a number of potential applications, including but not limited to support of power distribution cables and communications lines.

[0011] It can be desirable for utility poles to exhibit long life by virtue of being weather resistant. It may also be desirable for such poles to provide for convenient repair in the field in the event of damage, for example damage caused by impact with a motor vehicle.

[0012] According to one aspect of the present invention there is provided a section of a modular composite utility pole comprising a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end; at least one aperture proximate to an end and adapted to receive a fastener; and a built-up ledge around the periphery of the tapered hollow tube and proximate to the second end thereof, the ledge comprising a plurality of plies having one or more filaments wound at an angle relative to a longitudinal axis of the tapered hollow tube.

[0013] According to a further aspect, the present invention provides a modular composite utility pole comprising a plurality of sections, each comprising a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end, wherein each section is adapted to join at least one adjoining section at a joint wherein the first end of an upper section overlaps the second end of a lower section, the lower section further comprising a ledge proximate to the second end of the lower section, the ledge comprising a plurality of plies having one or more filaments wound at an angle relative to a longitudinal axis of the tapered hollow tube, wherein each section includes at least one aperture proximate to an end, the aperture being adapted to align with a corresponding aperture in the at least one adjoining section and to receive a fastener passing through the joint, and wherein, when the modular composite utility pole is erected, substantially all vertical load is transferred between sections via the a surface of the second end of the upper section resting upon the ledge of the lower section.

[0014] According to another aspect, there is provided a method of making a section of a composite utility pole, the method comprising: (a) wetting a filament in resin; (b) winding the wetted filament on a tapered mandrel; (c) curing the wetted filament to create a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end; (d) machining an end of the tapered hollow tube at a predetermined position along the length of the tapered hollow tube; and (e) creating an aperture through the tapered hollow tube at a predetermined distance from the machined end.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a schematic illustration of an exemplary cross-section of a wall of a section of a modular utility pole of the present invention.

[0016] FIG. **2** is a schematic illustration of an exemplary joint between two sections of a modular utility pole of the present invention.

[0017] FIG. **3**A is a schematic illustration of an exemplary section of a section of a modular utility pole, and FIG. **3**B is a schematic illustration of two such sections joined together according to certain aspects of the present invention.

[0018] FIG. **4** is a schematic illustration of an embodiment of a four-section modular composite utility pole of the present invention.

[0019] FIG. **5** is schematic illustration of an embodiment of an exemplary section with a built-up area adapted for the attachment of heavy equipment, formed according to the present invention.

[0020] FIG. **6**A is an exploded view of an exemplary sensor bay assembly and

[0021] FIG. **6**B is a schematic illustration of an exemplary sensor top cap according to certain aspects of the present invention.

[0022] FIG. **7** is an illustration of the end of a mandrel wrapped with a resin impregnated fiber in an axial pattern according to conventional technology.

[0023] FIG. **8** is an illustration of the end of a mandrel wrapped with a resin impregnated fiber in a variable wind pattern according to the present invention.

DEFINITIONS

[0024] Unless otherwise defined herein or below in the remainder of the specification, all technical and scientific terms used herein have meanings commonly understood by those of ordinary skill in the art to which the present invention belongs.

[0025] Before describing the present invention in detail, it is to be understood that the terminology used in the specification is for the purpose of describing particular embodiments, and is not necessarily intended to be limiting. As used in this specification and the appended claims, the singular forms "a", "an" and "the" do not preclude plural referents, unless the content clearly dictates otherwise.

[0026] Although many methods, structures and materials similar, modified, or equivalent to those described herein can be used in the practice of the present invention without undue experimentation, the preferred methods, structures and materials are described herein. In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set out below.

DETAILED DESCRIPTION

[0027] According to certain aspects of the present invention, a modular composite utility pole provides for an interlocking joint between sections. The sections can fit together precisely and can be assembled without field drilling and without requiring special tools on site. In contrast, existing systems must be field-drilled and require special methods and tools to be assembled in the field.

[0028] The modular composite utility pole may have sections that are predrilled to ensure accurate end location, so that the sections are easily interchangeable with a minimum of work on-site. For example, in the event of a collision, the pole can be disassembled in the field and only the damaged section replaced.

[0029] In an embodiment, the sections can be nested together prior to assembly in order to be stored in a smaller space, thereby reducing the logistical burden and transportation costs.

[0030] In one embodiment, one section, for example the top section, is specially adapted for the attachment of heavy equipment or objects. In another embodiment, a section includes a sensor bay. Optionally, the section includes both of these features. Further details regarding these features are found below.

[0031] Features of an exemplary section of a modular utility pole are illustrated in FIG. **1**. FIG. **1** is a schematic of an exemplary cross-section through one wall of a tapered hollow tube of the section of the pole. The longitudinal axis is represented by line A_L. The section **101** includes a ledge **102** (a feature which can be absent from a top section of the pole). In one embodiment, the ledge has a surface **103** to enable precise fitting of the section with an adjoining section. In the event that the section is not the bottom section of the pole, it is preferred that a surface **104** of the section is also adapted to precisely locate the section against a lower section. In making the section, an area including that denoted by dashed line **106** may be built up, then machined away to make surface **103**. Optionally, or in addition, the ledge **102** may be supported with forming material during curing. The section further includes an aperture **105** passing through the wall and adapted to receive a fastener.

[0032] In an embodiment, the ledge **102** extends about two inches laterally from the wall of the section **101**. Preferably, the ledge includes plies wound at about 80 to about 90 degrees relative to the longitudinal axis. Although the ledge is illustrated as having a rectangular cross-section, it may take other many forms, for example with a tapered side opposite the machined surface **103**.

[0033] A section may generally take the form of a tapered hollow tube optionally with fibrous plies wound at angle A_W about 80 to about 90 degrees or about 85 to about 90 degrees, plies wound at about 40 to about 65 degrees, and/or plies wound at about 5 to about 25 degrees, wherein the degrees are measured relative to a longitudinal axis A_L. (See, e.g., FIG. **8**). Moreover, the winding angle of the fibrous pieces may vary along the longitudinal length of the pole or pole section. For example, the plies may be wound at angle A_W of about 85 degrees to about 90 degrees in the region corresponding to the area of the joint between pole sections, the decrease in any suitable manner, such as gradually abruptly, constantly, or decreasing on a gradient, such that the winding angle A_W decreases along the longitudinal direction away from the joint area. According to one embodiment, the winding angle A_W is about 90 degrees proximate the end of the pole section in the joint area of the pole, then gradually decreases along the longitudinal direction away from the joint area along a transition zone T approximately 24 inches from the end of the pole, the winding angle A_W being about 65 degrees to about 40 degrees on this zone T. Further, along the longitudinal direction of the pole, moving away from the transition zone T, the winding angle A_W varies from about 40 degrees to about 25 degrees or about 40 degrees to about 5 degrees until reaching the opposite end of the pole or pole section.

[0034] The wall of the tapered hollow tube optionally has a thickness of about 0.2 to about 0.8 inches. The tapered hollow tube may have any suitable length, for example about 72 to about 224 inches. It also has any suitable amount of taper, such as tapering at an angle of about 0.2 to about 0.8 degrees per side, thus forming a relatively larger diameter and a relatively smaller diameter end. In an exemplary embodiment, each section has a length of about 12 feet and 4 inches. The top section optionally has holes for the attachment of a crossbar and/or a neutral line.

[0035] FIG. **2** is a schematic illustration of an exemplary cross-section of a joint between two sections of a modular utility pole. Line A_L illustrates the longitudinal axis through the sections. The pole is adapted so that aperture **105** in the lower section aligns with aperture **205** in the upper section in order to permit the joint to be secured by fastener **206**. An exemplary fastener **206** is a ⅝" grade 5 double arming bolt.

Optionally, the fastener may comprise a pin or any other suitable fastener. A surface **205** of the larger end of the upper section **201** rests on the machined surface **103** of the ledge **102** of the lower section **101**.

[0036] The joint may be formed so that it does not rely on friction, but instead substantially all vertical load is transferred between sections **101** and **201** via the surface **205** of the second end of the upper section **201** resting upon the surface **103** of ledge **102** of the lower section **101**. In an embodiment, a nominal gap **208** exists in the joint between inner and outer peripheral wall surfaces of said adjoining sections. For example, the gap **208** may span 0.020 to 0.060 inches. The fastener can bear primarily only bending and torsion loads, and optionally does not carry a significant amount of the weight of the upper section(s).

[0037] FIG. **3**A is another schematic illustration of an exemplary section of a modular utility pole. The surface **103** of the ledge **102** is precisely located with respect to the end with surface **104** of the section, in order to facilitate interchangeability of the sections. In addition to the illustrated aperture **105**, other openings may exist, for example near the opposite end of the section. FIG. **3**B is a schematic illustration of two such sections **101** and **201** joined together. Optionally, instead of the joint having two fasteners **206** as illustrated, a single fastener passes entirely through the joint through both pairs of apertures.

[0038] FIG. **4** is a schematic illustration of an embodiment of a four-section modular composite utility pole. The pole **400** is assembled from sections **401**, **402**, **403**, and **404**. The sections overlap each other at joints **411**, **412**, and **413**. The apertures of the sections are aligned in each joint at **421**, **422**, and **423**. An optional additional opening exists in the top section at **431**, for example for the mounting of a crossbar or other object.

[0039] The bottom section may be buried in the ground to a certain depth, depending on the height of the pole **400** and other factors. The ground line of such a pole is indicated at **441**. According to one optional embodiment, the length of the sections **401** and **402** and location of the first joint **411** therebetween is such that joint **411** of pole **400** is positioned below a typical impact point P on the pole **400** (for example, a typical impact point from a motor vehicle). Thus, if the modular pole **400** is damaged at impact point P, the damaged section **402** can be removed at joints **411** and **421** for replacement and/or repair, without resorting to removing the entire pole **400** and while leaving section **401** in the ground. Thus, the modular utility pole **400** of the present invention can be much more easily and economically repaired and maintained than other utility poles.

[0040] FIG. **5** is schematic illustration of an embodiment of a section with a built-up area adapted for the attachment of heavy equipment. In this embodiment, the section **504** has a built-up area **502** of greater wall thickness on the tapered hollow tube adapted for the attachment of heavy equipment. For example, the built-up area **502** may include apertures **503** to enable attachment of heavy equipment. Preferably, this section **504** is adapted to a standard of a utility company so that hardware, special transformers, and other equipment can be attached. This feature can reduce or eliminate the need to drill holes in the pole in the field, thereby avoiding the costs and delays associated with such.

[0041] The built-up area **502** can include plies adapted to increase torsional stiffness and wound at winding angles A_W of about 40 degrees to about 65 degrees and plies adapted to increase bending stiffness and wound at about 5 degrees to about 25 degrees, wherein the degrees are measured relative to said longitudinal axis. The built-up area preferably increases the ability of the pole to handle loads without adding significant weight, which provides particular advantage near the top of the pole. By allowing the pole to carry additional loads, for example two inch diameter cabling for telephony in addition to electrical power carried by conventional poles, the pole of the present invention can provide the opportunity to generate additional revenue.

[0042] A section such as the top section of the utility pole can house a sensor bay assembly for receiving one or more sensor packages S, as seen in FIG. **6**A. A sensor bay **612** fits into the hollow tubular form of a section of the pole (e.g., 101, 201). A bottom cap **611**, optionally of a rubbery nature, can mount to the bottom of the bay **612**. A top cap **600** can fit over the top of the bay **612** and contact the end face of the pole section **101**, **201**. The sensor bay **612** is optionally made by pultrusion process in one embodiment. The sensor bay **612** can optionally serve as a harness to carry data between the sensor bay **612** and ground equipment or up to an antenna array for transmission of the sensor signal. This conduit can also serve as a pathway to bring solar power from the top down to the sensor package house within the sensor bay **612**, for autonomous operation. The harness can be made of radio frequency transparent materials that can allow signals to be transmitted or received through the wall of the sensor bay **612**. The sensor bay assembly can be long enough to extend down the inner periphery of the pole to a location, for example, where the cross members lie in order to minimize distance to the lines if inductive sensing devices or methods are employed.

[0043] FIG. **6**B is a schematic illustration of an exemplary top cap **600** for a top section of a modular utility pole and/or sensor bay assembly. The top cap **600** includes a lower receiving collar **603** to fit snugly into the sensor bay **612** and/or inner periphery of the pole section **101**, **201**. The upper flange **602** rests on top of the pole, and a receiving groove **604** is adapted to mount the top cap **600** into the sensor bay **612** in a relatively fixed position. A solar panel **606** can be provided in the top of the upper flange **602** along with an optional antenna **607** for wireless communication. The top cap **600** may also include a battery B, communications hardware H, and/or one or more sensor packages, such as power line monitoring sensors S_M.

[0044] The hollow tubes comprising the sections of the modular composite utility poles can be made by filament winding. In filament winding, a filament is wetted in polymer or resin prior to winding the wetted filament on a mandrel (typically with a fully automated, continuous process) before curing. Filament winding provides advantages in being able to make the desired tapered geometries that are structurally optimized, with high quality of the finished goods, full automation, and cost effectiveness. The fiber can comprise any suitable fiber such as continuous E-glass roving, E-CR glass roving, or other similar fiber product. The polymer or resin can comprise, for example, a polyester resin, a vinyl-ester, a polyester and vinyl ester blend, or an epoxy. The resin may include pigment and UV blocking additive throughout the structure, so that no secondary coating is required. The finished sections should have little or no volatile organic compound content.

[0045] The full or partial wall thickness of one or both ends of the tapered hollow tube can machined at a predetermined

position on the section, optionally after being built up to an increased wall thickness as schematically illustrated in FIG. **1**. Furthermore, the one or more apertures for securing the joint can be created at a predetermined position. At least one of these operations are preferably accomplished via computer controlled machining. As a result, the corresponding features are precisely located. This ensures that each example of a particular section has the same dimensions, so that the sections can be readily interchanged in the field.

[0046] Winding axial reinforcing typically requires that the resin impregnated fiber be wrapped around the end of a mandrel as shown in FIG. **7**, or that the fibers be captured with tooling pins in process of turning around at the end of the part, also known as pin winding. The wind angle is determined by the following formula:

$$\text{wind angle} = \arcsin\left(\frac{\text{pole diameter } (P_D) + \text{band width } (B_W)}{\text{part diameter } (P_{DM})}\right)$$

However, both of these methods result in scrap or offal material that must be removed and discarded in a wet uncured state before further curing and processing of the pole section. This process requires time and handling of wet resin impregnated fiber material.

[0047] Provided is a variable wind pattern that is nonlinear and allows the wind pattern to start in a hoop wrap **600** (A_W=85° to 90°) and transition into a substantially axial pattern **602** as shown in FIG. **8**. The variable wind pattern approach allows for greater bearing strength within the joint region of the modular pole section without giving up axial stiffness or strength in the main body of the pole section. In conventional filament wound tubular structure, this change in angle may be detrimental to overall structural performance locally, since the wind angle determines performance and the angle will vary along the length of the part. However, unlike conventional tubular pole structures, according to the present invention the variable wind angle enhances the joint performance and adds greater hoop/bearing strength locally in the joint region, whereby it will simultaneously lower the local axial stiffness. The net effect of this change is that the joint performance improves. Meanwhile, outside the joint region and within the transition zone (T) (A_W=40° to 65°), within about 24 inches of an end of the part **604**, the wind angle approaches a high axial fiber alignment **602** (A_W=5° to 25°) from conventional wind pattern that is needed to give the main pole section the bending stiffness and strength required. The additional benefits of this approach are that it will speed up wind time, reduce operator contact with resin impregnated fiber in uncured state, and enable program transitions more rapidly from other ply angles to axial wind angle patterns.

[0048] A modular composite utility pole as described can provide numerous advantages. It can seamlessly replace existing utility poles while being easier to install and repair than conventional poles. It is environmentally friendly (it provides a long service life and does not require harvesting from forests) and is recyclable. It resists environmental damage, including corrosion, climate changes, acid rain, insects, animals, and rot. It is structurally robust and energy absorbent. It is lightweight for ease of installation. It is non-conductive.

[0049] All numbers expressing quantities of ingredients, constituents, reaction conditions, and so forth used in the specification are to be understood as being modified in all instances by the term "about." Notwithstanding that the numerical ranges and parameters set forth, the broad scope of the subject matter presented herein are approximations, the numerical values set forth are indicated as precisely as possible. Any numerical value, however, may inherently contain certain errors resulting, for example, from their respective measurement techniques, as evidenced by standard deviations associated therewith.

[0050] Although the present invention has been described in connection with preferred embodiments thereof, it will be appreciated by those skilled in the art that additions, deletions, modifications, and substitutions not specifically described may be made without departing from the spirit and scope of the invention. Terminology used herein should not be construed in accordance with 35 U.S.C. §112, ¶6 unless the term "means" is expressly used in association therewith.

We claim:

1. A section of a modular composite utility pole, comprising:

a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end;

at least one aperture proximate to an end and adapted to receive a fastener; and

a built-up ledge around the periphery of the tapered hollow tube and proximate to the second end thereof, the ledge comprising a plurality of plies having one or more filaments wound at an angle relative to a longitudinal axis of the tapered hollow tube.

2. The section of claim **1**, wherein said angle of the plies in the ledge is between 80 and 90 degrees relative to said longitudinal axis.

3. The section of claim **1**, wherein said tapered hollow tube comprises plies wound at an angle of about 85 to about 90 degrees, plies wound at an angle of about 40 to about 65 degrees, and plies wound at an angle of about 5 to about 25 degrees,

wherein the degrees are measured relative to said longitudinal axis.

4. The section of claim **3**, wherein the plies are wound at an angle of about 85 degrees to about 90 degrees in the region corresponding to the area of the joint between pole sections, the plies are wound at an angle of about 65 degrees to about 40 degrees at a transition zone, and the plies are wound at an angle which varies from about 40 degrees to about 25 degrees or about 40 degrees to about 5 degrees until reaching the opposite end of the pole or pole section.

5. The section of claim **1**, wherein:

(a) said tapered hollow tube comprises a wall having a thickness of about 0.2 to about 0.8 inches;

(b) said tapered hollow tube has a length of about 72 to about 224 inches; and/or

(c) said tapered hollow tube tapers at an angle of about 0.2 to about 0.8 degrees per side.

6. The section of claim **1**, wherein said tapered hollow tube comprises glass fiber filament and a polyester resin blend.

7. A modular composite utility pole, comprising:

a plurality of sections, each comprising a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end,

wherein each section is adapted to join at least one adjoining section at a joint wherein the first end of an upper section overlaps the second end of a lower section, the lower section further comprising a ledge proximate to the second end of the lower section, the ledge compris-

ing a plurality of plies having one or more filaments wound at an angle relative to a longitudinal axis of the tapered hollow tube,

wherein each section includes at least one aperture proximate to an end, the aperture being adapted to align with a corresponding aperture in the at least one adjoining section and to receive a fastener passing through the joint, and

wherein, when the modular composite utility pole is erected, substantially all vertical load is transferred between sections via the a surface of the second end of the upper section resting upon the ledge of the lower section.

8. The modular utility pole of claim **7**, comprising a top section comprising a sensor bay assembly.

9. The modular utility pole of claim **8**, wherein said sensor bay comprises a tubular insert and a top cap comprising a top flange.

10. The modular utility pole of claim **8**, wherein said sensor bay assembly contains one or more sensor or communications packages.

11. The modular utility pole of claim **7**, comprising a top section comprising a built-up area on said tapered hollow tube adapted for the attachment of heavy equipment.

12. The modular utility pole of claim **11**, wherein said built-up area adapted for the attachment of heavy equipment comprises plies adapted to increase torsional stiffness and wound at about 40 to about 65 degrees and plies adapted to increase bending stiffness and wound at about 5 to about 25 degrees, wherein the degrees are measured relative to said longitudinal axis.

13. The modular utility pole of claim **7**, comprising a common impact point, wherein the pole sections and joints are configured such that, when the pole is buried in the ground, a first joint between a bottom buried section and the next section adjoining the bottom section is positioned outside the common impact point.

14. The modular utility pole of claim **7**, wherein said pole comprises three or more sections.

15. The modular utility pole of claim **7**, wherein a nominal gap of about 0.020 to about 0.060 inches exists in the joint between inner and outer peripheral wall surfaces of said adjoining sections.

16. The modular utility pole of claim **7**, wherein said angle of the plies in said ledge is about 80 to about 90 degrees relative to said longitudinal axis.

17. The modular utility pole of claim **7**, wherein said tapered hollow tube comprises plies wound at an angle of about 85 to about 90 degrees, plies wound at an angle of about 40 to about 65 degrees, and plies wound at an angle of about 5 to about 25 degrees,

wherein the degrees are measured relative to said longitudinal axis.

18. The modular utility pole of claim **17**, wherein the plies are wound at an angle of about 85 degrees to about 90 degrees in the region corresponding to the area of the joint between pole sections, the plies are wound at an angle of about 65 degrees to about 40 degrees at a transition zone, and the plies are wound at an angle which varies from about 40 degrees to about 25 degrees or about 40 degrees to about 5 degrees until reaching the opposite end of the pole or pole section.

19. The modular utility pole of claim **7**, wherein:

(a) each tapered hollow tube comprises a wall having a thickness of about 0.2 to about 0.8 inches;

(b) each tapered hollow tube has a length of about 72 to about 224 inches; and/or

(c) each tapered hollow tube tapers at an angle of about 0.2 to about 0.8 degrees per side.

20. A method of making a section of a composite utility pole, the method comprising:

(a) wetting a filament in resin;

(b) winding the wetted filament on a tapered mandrel;

(c) curing the wetted filament to create a tapered hollow tube comprising a plurality of plies, a first end, and a second end, wherein the first end has a larger diameter than the second end;

(d) machining an end of the tapered hollow tube at a predetermined position along the length of the tapered hollow tube; and

(e) creating an aperture through the tapered hollow tube at a predetermined distance from the machined end.

21. The method of claim **20**, further comprising:

before said curing, winding one or more plies to build up a ledge,

wherein said curing further comprises curing the ledge, and

wherein the ledge is proximate to said second end of said tapered hollow tube and comprises plies wound at an angle relative to a longitudinal axis of said tapered hollow tube.

22. The method of claim **21**, wherein said winding one or more plies to build up said ledge comprises winding plies at an angle of about 80 to about 90 degrees relative to said longitudinal axis.

23. The method of claim **21**, further comprising forming a built-up area on a discrete portion of said tapered hollow tube adapted for the attachment of heavy equipment.

24. The method of claim **23**, wherein said forming the built-up area adapted for the attachment of heavy equipment comprises winding plies at an angle of about 40 to about 65 degrees and winding plies at an angle of about 5 to about 25 degrees,

the degrees measured relative to a longitudinal axis of said tapered hollow tube.

25. The modular utility pole of claim **7**, wherein each tapered hollow tube comprises plies having a variable wind pattern.

26. The section of the modular composite utility pole of claim **1**, wherein the tapered hollow tube comprises plies having a variable wind pattern.

27. The modular utility pole of claim **13**, wherein pole sections are adapted to be disassembled and replaced.

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