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United States Patent Application Publication	20250260151
Kind Code	A1
Publication Date	August 14, 2025
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ANTENNA SPACER

Abstract

Assemblies, apparatuses, and methods are presented herein for coupling elements of an antenna assembly. A coupling apparatus for coupling antennas of an antenna assembly includes a spacer. A first end of the spacer is configured to interface with a first antenna. A second end of the spacer is configured to interface with a second antenna. An internal passageway extends from an end opening in the first end. The internal passageway also extends from a side opening between the first end and the second end.

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Family ID: **1000007697113**

Appl. No.: **18/438132**

Filed: **February 09, 2024**

Publication Classification

Int. Cl.: **H01Q1/12** (20060101); **H01Q1/24** (20060101); **H01Q9/30** (20060101)

U.S. Cl.:

CPC **H01Q1/1235** (20130101); **H01Q9/30** (20130101); H01Q1/246 (20130101)

Background/Summary

INTRODUCTION

[0001] The present disclosure is directed to assemblies, apparatuses, and methods for coupling

elements of an antenna assembly, and more particularly, to coupling antennas to each other and to a base plate for rapid assembly of an antenna assembly that is of a manageable weight in a remote environment in order to facilitate one or more of aircraft guidance or ground to air communication.

SUMMARY

[0002] Transponder-based aircraft landing systems generally facilitate guidance of aircraft during approach and landing with respect to an airport or other landing field. Typical transponder-based systems include electronics, antennas, and other equipment for sending and receiving signals to incoming aircraft to facilitate aircraft guidance. While these landing systems may be permanently installed at a landing field, deployable instrument landing systems (ILSs) have also been developed that can be deployed to a remote airfield and/or taken down from the airfield relatively quickly, e.g., for defense and emergency response applications. Known deployable ILSs can provide multiple essential functions for air operations at remote or temporary airfields including precision approach guidance, secondary surveillance for tracking and separation (ATC), and precision approach radar for ground-controlled approaches in military and/or emergency applications, thus providing a complete ATC solution.

[0003] Existing deployable ILSs generally include electronics, multiple antennas, power supply, and other components, and as a result are complex and difficult to transport. Existing deployable ILSs also generally require delivery to the remote airfield in multiple large, heavy payloads. Additionally, deployment of these ILSs typically requires at least approximately 18 man-hours of installation time (e.g., 6 hours by 3 personnel) once the equipment is delivered to the location for the remote airfield. As a result, delivery and deployment of known deployable ILSs to a remote airfield requires multiple deliveries or delivery vehicles, and setup of the deployable ILS is time-intensive upon delivery. Accordingly, there is a need for an antenna tower assembly that can be rapidly transported to a remote area and rapidly assembled with minimal personnel.

[0004] In some embodiments, this disclosure is directed to a coupling apparatus comprising a spacer. The spacer comprises a first end configured to interface with a first antenna and a second end configured to interface with a second antenna. An internal passageway is also part of the spacer and extends from an end opening in the first end as well as from a side opening between the first end and the second end.

[0005] The coupling apparatus, and additional elements described herein, solve the problems of other approaches described above. In particular, this approach does not rely on bulky or heavy components to set up an antenna assembly in a remote location (e.g., distant from known or heavily populated residential areas) for any or all of the aforementioned uses. Thus, the spacer and other elements of this disclosure provide opportunity to rapidly establish an airfield for rapid grounding of aircraft or rapidly establish ground to air communication without a plurality of personnel being available in the remote location. Additionally, the approaches, assemblies, and apparatuses of this disclosure may not require multiple vehicles for delivery of components, and the various embodiments of this disclosure may not require complex or long in duration assembly processes. By reducing the complexity of the assemblies required for establishing a remote airfield or remote ground to air communication, as opposed to relying on intricate or more permanent structure, the various embodiments of this disclosure provide means for rapid deployment, assembly, and establishment of antennas for various uses in a variety of remote environments.

[0006] In some embodiments, an end cap is fixedly attached to the second end of the spacer, wherein the second end of the spacer is configured to interface with the second antenna via the end cap. The spacer comprises a flange configured to be fixedly attached to the end cap and the end cap comprises a plurality of evenly spaced eyelets that extend away from a radially outer surface of the end cap. In some embodiments, an accessory platform (e.g., for mounting a sensor or other component) is arranged between the spacer and the end cap.

[0007] In some embodiments, at least one of the first end or the second end comprises at least one feature for fixedly attaching the spacer to either the first antenna or the second antenna.

Additionally, or alternatively, the side opening is a first side opening and the spacer further comprises a second side opening arranged opposite of the first side opening.
[0008] In some embodiments, the first end comprises a flange configured to interface with one or more pull latches. Additionally, or alternatively, when the first antenna is coupled to the first end, a cable that a comprises a connector passes through the internal passageway from the side opening and towards a complementary connector on a surface of the first antenna. The connector may then be coupled to the complementary connector.
[0009] In some embodiments, the disclosure is directed to an antenna assembly. The antenna assembly includes a spacer having a first ring shaped end surface and an internal passageway extending between an opening in the first ring shaped end surface and a side opening between the first ring shaped end surface and a second ring shaped end surface. A first antenna segment is fixedly attached to the first ring shaped surface of the spacer, wherein a cable comprising a connector passes through the internal passageway from the side opening and towards a complementary connector on a surface of the first antenna segment. A second antenna segment is coupled to the second ring shaped end surface of the spacer.
[0010] In some embodiments, the assembly also includes an antenna base comprising a base spacer pivotably attached to a base plate. The antenna base comprises a hinge assembly defining a hinge axis for rotating the base spacer. Additionally, or alternatively, a pair of slots are coupled to the base spacer. Each of the pair of slots extends radially outward from the hinge axis.
[0011] In some embodiments, the assembly also incorporates at least one pull latch that fixedly attaches an end of the second antenna segment to a top surface of the base spacer. Additionally, or alternatively, a flange of the base spacer comprises at least one alignment feature for locating the at least one pull latch before clamping the end of the second antenna segment to the top surface of the base spacer via the at least one pull latch. The at least one pull latch may include a plurality of pull latches. Additionally, or alternatively, a flange comprises the top surface of the base spacer. Each pull latch of the plurality of pull latches may be fixedly attached to the flange. Each pull latch of the plurality of pull latches may interface with a respective alignment feature of a flange of an antenna segment.
[0012] In some embodiments, the assembly additionally has a clamp assembly. The clamp assembly incorporates a hinge rotatably coupling a first arched arm to a second arched arm. Each of the first arched arm and second arched arm comprise a channel that is configured to accommodate a flange of the spacer and a flange of one of the first antenna segment and the second antenna segment. The channel comprises a width that narrows towards a bottom of the channel. An adjustable handle may be arranged on the clamp assembly to increase a clamping force between an end of the first arched arm and an end of the second arched arm.
[0013] In some embodiments, the disclosure is directed to a method of assembling an antenna assembly. A bottom end of a first antenna segment is secured to a base spacer of a base plate. A top end of the first antenna segment is coupled to a first end of a spacer. A bottom end of a second antenna segment is fixedly attached to a second end of the spacer with at least one pull latch.
[0014] In some embodiments, the method includes feeding a wire through a side opening of the spacer and into a passageway of the spacer. A connector of the wire is secured to a complementary connector on an exposed bottom surface of the second antenna segment. A first end of at least one guy wire is secured to at least one guy wire eyelet of a coupling apparatus comprising the spacer. A distal second end of the at least one guy wire is fixedly attached to a grounded anchoring apparatus.

Description

BRIEF DESCRIPTIONS OF THE DRAWINGS
[0015] The above and other objects and advantages of the disclosure may be apparent upon

consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which:

[0016] FIG. **1** depicts an antenna assembly, in accordance with some embodiments of the disclosure;

[0017] FIG. **2**A depicts an antenna subassembly where ends of antennas are coupled to opposite ends of a spacer, in accordance with some embodiments of the disclosure;

[0018] FIG. **2**B depicts an antenna subassembly incorporating the multiple of the antenna subassembly of FIG. **2**A, in accordance with some embodiments of the disclosure;

[0019] FIG. **3**A depicts a coupling apparatus, in accordance with some embodiments of the disclosure;

[0020] FIG. **3**B depicts a cross sectional view of the coupling apparatus of FIG. **3**A, in accordance with some embodiments of the disclosure;

[0021] FIG. **4**A depicts a top view of an end cap of a coupling apparatus, in accordance with some embodiments of the disclosure;

[0022] FIG. **4**B depicts a side cross sectional view of the coupling apparatus of FIG. **4**A, in accordance with some embodiments of the disclosure;

[0023] FIG. **4**C depicts a side cross sectional view of an eyelet of the coupling apparatus of FIGS. **4**A and **4**B, in accordance with some embodiments of the disclosure;

[0024] FIG. **5** depicts a spacer between a pair of antennas with an accessory platform, in accordance with some embodiments of the disclosure;

[0025] FIG. **6**A depicts an antenna base interfacing with a gin pole as part of an antenna subassembly, in accordance with some embodiments of the disclosure;

[0026] FIG. **6**B depicts a base plate spacer of the antenna base of FIG. **6**A pivoting about a hinge axis as part of antenna subassembly **600**B, in accordance with some embodiments of the disclosure;

[0027] FIG. **6**C depicts the base plate of FIGS. **6**A and **6**B coupled at a bottom of an antenna subassembly, in accordance with some embodiments of the disclosure;

[0028] FIG. **7**A depicts a cross sectional side view of a clamp assembly that interfaces with a spacer and an antenna, in accordance with some embodiments of the disclosure;

[0029] FIG. **7**B depicts a perspective view of the clamp assembly of FIG. **7**A interfacing with a base plate spacer and an antenna, in accordance with some embodiments of the disclosure;

[0030] FIG. **8** depicts a manner of erecting an antenna assembly, in accordance with some embodiments of the disclosure;

[0031] FIG. **9**A depicts a first perspective view of routing a cable into a spacer towards an antenna coupled to the spacer, in accordance with some embodiments of the disclosure;

[0032] FIG. **9**B depicts a second perspective view of routing a cable into a spacer towards an antenna coupled to the spacer, in accordance with some embodiments of the disclosure; and

[0033] FIG. **10** is a flow chart representing an illustrative process for assembling an antenna assembly, in accordance with some embodiments of the disclosure.

DETAILED DESCRIPTION

[0034] Apparatuses, assemblies, and methods are provided herein for coupling elements of an antenna assembly.

[0035] FIG. **1** depicts antenna assembly **100**, in accordance with some embodiments of the disclosure. Antenna assembly **100** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **2**A-**9**B. Additionally, or alternatively, antenna assembly **100** may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0036] Antenna assembly **100** is shown in an erected configuration after being assembled (e.g., via process **1000** of FIG. **10**). As shown in FIG. **1**, antenna assembly **100** includes at least one of spacer **102** between a pair of antenna segments **104**. In some embodiments, each of antenna segments **104** may be considered an individual antenna. Antenna assembly **100** includes three of spacer **102** and has antenna base **106** that affixes antenna assembly **100** to surface **108**. In some embodiments

antenna base **106** comprises a base plate spacer pivotably coupled, or pivotably attached, by a hinge assembly to a base plate that gets affixed to surface **108**. Guy wires **110** extend from surface mounts **112** to guy wire eyelets **114**A and **114***b*. As shown in FIG. **1**, a plurality of guy wires **110** (e.g., two or more) may be utilized to erect and secure antenna assembly **100**. Surface mounts **112** are fixedly attached to surface **108**. Surface mounts **112** may be configured to remain secured to surface **108** when exposed to one or more of vertical loads, lateral loads, or combinations thereof, depending on forces caused by one or more of wind blowing against antenna assembly **100** or the collective weight of each portion of antenna assembly **100**.

[0037] Each of spacer **102** has a first ring shaped end surface and an internal passageway extending between an opening in the first ring shaped end surface and a side opening between the first ring shaped end surface and a second ring shaped end surface (e.g., as shown in FIGS. **2**A, **3**A, **5**, **9**A and **9**B). The end surfaces may comprise any suitable geometry, including or in place of the ring shaped geometry shown in and described in reference to the figures. For example, any or all of a rectangular shape, polygonal shaped, triangular shaped, egg shaped, oval shaped, or other known spacer cross sectional geometry may be incorporated along the entire profile of spacer **102** or on each respective end to ensure the spacer comprises adequate surface area for mounting other elements of this disclosure and also comprises adequate strength, stiffness, rigidity, material mechanical compliance, or combinations thereof, for providing a spacer suitable for assembling and erecting one or more of the assemblies, or subassemblies, of this disclosure. In some embodiments, at least one pull latch may be utilized to fixedly attach at least one of the ring shaped end surfaces of each of spacer **102** to an end of one of antenna segments **104** (e.g., a top or bottom end of antenna segments **104**). In some embodiments, the at least one pull latch comprises a plurality of pull latches (e.g., as shown in FIGS. **2**A and **5**). Additionally, or alternatively, one or more pull latches may be used to secure a bottom most of antenna segments **104** to a top surface of a base plate spacer integrated into, or fixedly attached to, antenna base **106**. Each of spacers **102** and the base plate spacer of antenna base **106** may include at least one alignment feature that extends from, or is machined into or embedded into, a surface of a flange extending laterally away from ends of each of spacers **102** and the base plate spacer of antenna base **106** (e.g., as shown in FIGS. **2**A, **5**, **6**A, **9**A, and **9**B). These alignment features are structured for locating the at least one pull latch before clamping the end of one of antenna segments **104** to the top surface of one or more of spacers **102** or the base plate spacer via the at least one pull latch. In some embodiments, the alignment feature is configured to interface with a clamp (e.g., as shown in FIGS. **7**A and **7**B).

[0038] FIG. **2**A depicts antenna subassembly **200**A that includes spacer **102** for coupling ends of antenna segments **104**A and **104**B (e.g., corresponding to antenna segments, or antennas, **104** of FIG. **1**) to each other, in accordance with some embodiments of the disclosure. Antenna subassembly **200**A may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1** and **2**B-**9**B. Additionally, or alternatively, antenna subassembly **200**A may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0039] Antenna subassembly **200**A is a coupling apparatus. The coupling apparatus depicted via antenna subassembly **200**A includes spacer **102** (e.g., corresponding to spacers **102** of FIG. **1**). Spacer **102** comprises first end **202**A that is configured to interface with antenna segment **104**A. Spacer **102** also comprises second end **202**B that is configured to interface with antenna segment **104**B. Between first end **202**A and second end **202**B is internal passageway **204**. Internal passageway **204** extends from an end opening in first end **202**A, that is covered by antenna segment **104**A, to an end opening in second end **202**B, that is covered by antenna segment **104**B. In some embodiments, first end **202**A does not include an end opening and the internal passageway ends at or near first end **202**A. Internal passageway **204** also includes side opening **206** that is between first end **202**A and second end **202**B. As shown in FIG. **2**A, at least one of first end **202**A and second end **202**B includes at least one of attachment features **214** for attaching ends of spacer **102** to either antenna segment **104**A or **104**B. Attachment features **214** may include one or more of

fasteners, holes for receiving fasteners, pins, recesses for snap or press fitting pins, one or more areas for receiving bonding or adhesive material, or combinations thereof for enabling a quick attachment for mounting antenna segments to one or more spacers for creating an antenna assembly (e.g., antenna assembly **100** of FIG. **1**).

[0040] Extending laterally away from first end **202**A is flange **210**A. Flange **210**A is configured to interface with at least one of pull latches **212**. As shown in FIG. **2**A, a plurality of pull latches **212** are included. In some embodiments, at least one element of pull latches **212** are integrated into flange **210**A. Additionally, or alternatively, flange **210**A may comprise a cutout for receiving one or more bolts, or other securing or mounting features that are suitable for the available surface area of flange **210**A, for mounting one or more of pull latch **212**. For example, the feature may be at least one alignment feature comprising one or more of fasteners, holes for receiving fasteners, pins, recesses for snap or press fitting pins, one or more areas for receiving bonding or adhesive material, or combinations thereof for enabling a quick attachment. The features of flange **210**A for interfacing pull latches **212** with flange **210**A may be configured to align antenna segment **104**A with an end of spacer **102**. Extending laterally away from second end **202**B is flange **210**B. Flange **210**B comprises one or more holes for receiving one or more of fasteners **214**. In some embodiments, flange **210**B may be bonded, or adhesively coupled to an end of antenna segment **104**B. Arranged between second end **202**B and antenna segment **104**B is end cap **216**. End cap **216** may be integrated into spacer **102** or may be fixedly attached via fasteners **214** to second end **202**B and a top of antenna segment **104**B. End cap **216** also comprises extensions **218** which each have a through hole for mounting a guy wire eyelet. End cap **216** may have one or more of extensions **218** equally spaced around an outer diameter of end cap **216** to enable even loads to be applied to antenna segment **104**B to stabilize an antenna assembly that includes antenna subassembly **200**A. Antenna segment **104**B may considered a second antenna segment that is coupled to a second ring shaped end surface of spacer **102** and the second ring shaped end surface corresponds to an axial end of flange **202**B.

[0041] Antenna subassembly **200**A also comprises second side opening **208** arranged opposite side opening **206**. Each of side opening **206** and second side opening **208** can be used to feed a cable that comprises a connector into internal passageway **204**. The connector is configured to interface with, or be fixedly attached or coupled to, a complementary connector arranged on one or more of a bottom surface of antenna segment **104**A or a top surface of antenna segment **104**B.

[0042] FIG. **2**B depicts antenna subassembly **200**B incorporating multiple of antenna subassembly **200**A of FIG. **2**A, in accordance with some embodiments of the disclosure.

[0043] Antennas subassembly **200**B may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**, **2**A, and **3**A**9**B. Additionally, or alternatively, antenna subassembly **200**B may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0044] Antenna subassembly **200**B is considered a subassembly of antenna assembly **100** of FIG. **1** as antenna subassembly **200**B lacks the guy wires that anchor and stabilize antenna assembly **100**. Antenna subassembly **200**B is shown incorporating at least one of antenna subassembly **200**A. Three iterations of antenna subassembly **200**A are shown arranged above antenna base **106** of FIG. **1**.

[0045] FIG. **3**A depicts coupling apparatus **300**A, in accordance with some embodiments of the disclosure Coupling apparatus **300**A may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**2**B and **3**B-**9**B. Additionally, or alternatively, coupling apparatus **300**A may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0046] Coupling apparatus **300**A comprises spacer **102** and end cap **216**. End cap **216** is fixedly attached to second end **202**B of spacer **102**. As shown in FIG. **3**A, fastener **214** is used to affix second end **202**B to a top of end cap **216**. Additionally, or alternatively, end cap **216** may interface with second end **202**B or may be affixed to second end **202**B by threads, adhesive, bonding, or any other suitable form of coupling or affixing or fixedly attaching end cap **216** to second end **202**B.

Although not shown in FIG. **3**A, first end **202**A is arranged and configured to interface with, receive, be coupled to, to be affixed to an end of a first antenna. As shown in FIG. **3**A, end cap **216** is configured to interface with second antenna **304**, which corresponds to, for example, antenna segment **104**B. Interface **306**, which is arranged between end cap **216** and second antenna **304**, may comprise a threaded interface, fasteners through threaded holes, snap features, adhesive, bonding, or any other suitable interface materials or structure for fixedly attaching or coupling end cap **216** to a top of second antenna **304** such that interface **306** is configured to withstand various loads experienced via coupling apparatus (e.g., as caused by loads applied to an antenna assembly comprised of at least one of coupling apparatus **300**A which may be from guy wire securing loads, wind, weather conditions, or combinations thereof). Interface **306** is formed between flange **210**B of second end **202**B and end cap **216** as flange **210**B of spacer **102** is configured to be fixedly attached to end cap **216** (e.g., via fastener **214**).

[0047] End cap **216** also includes a plurality of evenly spaced eyelets **308**, which can be characterized as ring shaped structures that are coupled to respective through holes that extend through a material thickness of extensions **218**. Eyelets **308** may interface with, or be coupled to, respective through holes of respective extensions **218** by threaded fasteners, pinned rods, or any other suitable pivoting coupling mechanism. Eyelets **308** may be configured to rotate about a center axis defined by the respective through holes of each respective extension **218** to enable rapid and simple articulation of eyelets **308** when running guy wires for raising and securing an antenna assembly of this disclosure. Eyelets **308** are evenly spaced around radially outer surface **310** of end cap **216** and extend away from radially outer surface **310**.

[0048] FIG. **3**B depicts cross sectional view A-A′ of the coupling apparatus of FIG. **3**A, in accordance with some embodiments of the disclosure. Cross sectional view A-A′ corresponds to axis A-A′ of FIG. **3**A and depicts a ring shaped end surface of spacer **102**. The ring shaped end surface may be present on one or more of axial end faces of first end **202**A or second send **202**B of spacer **102**. One or more features (e.g., holes, pins, threaded interface, or combinations thereof) may be present on end surfaces of a spacer end defined via cross sectional view A-A′.

[0049] FIG. **4**A depicts top view **400**A of end cap **400** of a coupling apparatus, in accordance with some embodiments of the disclosure. End cap **400** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**3**B and **4**B-**9**B. Additionally, or alternatively, end cap **400** may be incorporated into any or all of the elements of process **1000** of FIG. **10**. Any or all corners, edges, or interfaces between features (e.g., between a flange and a radially outer surface of an end cap body) may include one or more of a rounded radius, a chamfer, or other machined feature to reduce stress at corners, edges, or interfaces.

[0050] End cap **400** corresponds to end cap **216** of FIGS. **2** and **3**A. End cap **400** is comprised of extensions **218** and mating surface **402**. Each of extensions **218** has a width **404**. Width **404** may be 0.5 inches up to 1.5 inches. Each of extensions **218** includes a respective through feature **406**. Each of through features **406** may be utilized to mount eyelets **308** of FIG. **3**A, for example, to provide a path for feeding guy wires or other cables that would be part of an antenna assembly comprised of end cap **400**. Evenly spaced around surface **402** are openings **408**. Each of openings **408** may be one or more of a through hole, a threaded hole, a recess, a blind hole, or an accommodating feature. Openings **408** may, for example, be used to receive fasteners for securing a flange of a spacer of this disclosure to surface **402**. Each of openings **408** may be an eight of an inch in diameter up to 1 inch in diameter (e.g., depending on a width of a flange of a spacer to be secured to surface **402**). As shown in FIG. **4**A, openings **408** are spaced 60 degrees apart, as represented by spacing **410**. Spacing **410** may be adjusted such that each of openings **408** are evening spaced around surface **308**. For example, although six of openings **408** are shown in FIG. **4**A, in some embodiments there may only be four of openings **408** and spacing **410** may increase from 60 degrees to 90 degrees. Spacing **410** is a function of the number of openings **408** present on surface **408** such that each of openings **408** are evenly spaced around surface **402** to ensure a levelled or even securing interface

between a flange of a spacer of this disclosure and surface **402** (e.g., capable of withstanding environmental conditions in a remote location where an antenna assembly of this disclosure is assembled and erected, or capable of withstanding an assembly and raising process of an antenna assembly of this disclosure). Each of openings may be displaced from each other along width **416**. Width **416** may be between 4 inches and 10 inches, depending on a diameter of antennas or antenna segments that are to be coupled to a surface of end cap **400** and a width of a flange of a spacer of this disclosure.

[0051] End cap **400** includes raised feature **412**. Raised feature **412** is centered on surface **402**. As shown in FIG. **4**A, raised feature **412** is of a hexagonal shape. In some embodiments, raised feature **412** may be any suitable shape to enable appropriate function of raised feature **412**. Raised feature **412** may comprise one or more of a recess, a through hole, a blind hole, or a threaded hole to enable securing (e.g., preferably in rapid fashion) end cap **400** to an end of an antenna or antenna segment. For example, a fastener may be fed into the opening or hole in the center of raised feature **412** and raised feature **412** may be used to apply a rotational torque to a body of end cap **400** to enable securing of end cap **400** to a component below end cap **400** (e.g., a top of an antenna or antenna segment). Raised feature **412** has width **414**. Width **414** may be from 1 inch up to 2.5 inches (e.g., from flat to flat of a hexagonal geometry), depending on how much torque is to be applied to raised feature **412** to secure end cap **400** to a top of an antenna segment.

[0052] FIG. **4**B depicts side cross sectional view **400**B along A-A of FIG. **4**A of end cap **400**, in accordance with some embodiments of the disclosure. End cap **400** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**4**A and **4**C-**9**B. Additionally, or alternatively, end cap **400** may be incorporated in any or all of the elements of process **1000** of FIG. **10**. Any or all corners, edges, or interfaces between features (e.g., between a flange and a radially outer surface of an end cap body) may include one or more of a rounded radius, a chamfer, or other machined feature to reduce stress at corners, edges, or interfaces.

[0053] View **400**B depicts end cap **400** along cross section A-A. Raised feature **412** is shown with through feature **418**. Width **420** of through feature **418** may be 0.5 inches up to 1.5 inches, depending on what kind of fastener, or securing element, is used to secure end cap **400** to a top of an antenna segment. As shown in FIG. **4**B, through feature **418** is comprised of a profile that expands radially outwards towards radially outer surface **422** of end cap **400** as through feature **418** extends from a top of raised feature **412** to bottom surface **424** of end cap **400**. Radially outer surface **422** includes height **436**. Heigh **436** may be between 2 inches and 4 inches, depending on spacing requirements between respective antenna segments and a size of a spacer affixed to surface **402**. Raised feature **412** has height **428** above surface **402**. Height **428** may be between 0.25 inches and 1 inch, depending on a size and shape of a spacer affixed to surface **402**. A first portion of through feature **418** has height **430**. Height **430** may be between 0.4 inches and 1 inch, depending on the size and shape of features of a top of an antenna segment to be secured to a bottom area of end cap **402** comprising ring extensions **426**A-C.

[0054] As shown in FIG. **4**B, through feature **418** expands radially outward at height **430** and again at height **432**, remaining consistent until height **434**. Height **432** may be between 0.1 inches and 0.5 inches. Height **434** may be between 0.4 inches and 0.8 inches. In some embodiments, a first portion of material of end cap **400** extends between ends of ring extensions **426**A. Second portions of material may extend between ends of ring extensions **426**B. Third portions of material may also extend between ends of ring extensions **426**C (e.g., as shown in FIG. **4**C). Ring extensions **426**A include height **438**. Height **438** may be between 1 inch and 1.5 inches. Ring extensions **426**B include height **440**. Height **440** may be between 2 inches and 3 inches. Ring extensions **426**C comprise height **436** of radially outer surface **422**. Inner diameter **442** of ring extensions **426**A may between 1.4 inches and 1.7 inches. Outer diameter **444** of ring extensions **426**A may be between 1.8 inches and 2.2 inches. Inner diameter **446** of ring extensions **426**B may be between 3 inches and 3.5 inches. Outer diameter **448** of ring extensions **426**B may be between 3.55 inches and 3.8

inches. Inner diameter **450** of ring extensions **426**C may be between 5.5 inches and 6.5 inches. Outer diameter **452** of ring extensions **426**C may be between 6.8 inches and 7.5 inches. The geometry and spacing of each of ring extensions **426**A-C may be modified from the above dimensions depending on features, geometry, and dimensions of a top surface of an antenna or antenna segment to which end cap **400** is affixed as a part of an antenna assembly of this disclosure.

[0055] FIG. **4**C depicts side cross sectional view **400**C along B-B of FIG. **4**A of end cap **400**, in accordance with some embodiments of the disclosure. End cap **400** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**4**B and **5**-**9**B. Additionally, or alternatively, end cap **400** may be incorporated into any or all of the elements of process **1000** of FIG. **10**. Any or all corners, edges, or interfaces between features (e.g., between a flange and a radially outer surface of an end cap body) may include one or more of a rounded radius, a chamfer, or other machined feature to reduce stress at corners, edges, or interfaces.

[0056] Cross sectional view **400**C depicts one of flanges **218**, based on the arrangement of B-B in FIG. **4**A. Flange **218** includes through feature **406**. Through feature **406** is arranged towards a radially outer corner of flange **218** and may be between 0.3 inches and 0.8 inches in diameter, depending on the sized guy wire eyelets required for an antenna assembly comprised of end cap **400**. Through feature **406** is displaced from a radially outer edge of flange **218** by measurement **456** and is also displaced from an axial bottom edge of flange **218** by measurement **456**. Measurement **456** may be between 0.5 and 1 inch, depending on a size of flange **218** in order to center through feature **406** relative to a radially outer and axially lower corner of flange **218**. Flange **218** is shown in FIG. **4**C has having axially upper corner modified to not have material in angle **458**. Angle **458** may be between 0 degrees and 90 degrees. In some embodiments, flange **218** is rectangular or square in profile. In other embodiments, flange **218** may comprise any suitable rounded profile for supporting loads corresponding to a guy wire or a guy wire eyelet for securing an antenna assembly comprised of end cap **400**. Angle **458** is shown as starting from a corner at height **454** of a radially outer edge of flange **218**. Height **454** may be between 0.8 inches and 2 inches.

[0057] Through feature **406** is radially displaced from flange inner surface **468**. Distance **460** between a center of through feature **406** and flange inner surface **468** may be between 0.5 inches and 1.5 inches. Distance **464** between flange inner surface **468** and ring extension inner surface **470** may be between 5.5 inches and 7 inches. Along section B-B, width **462** of end cap **400** may be between 6.5 inches and 10 inches, depending on tolerance stacks of the other dimensions of FIG. **4**C and geometry of an interfacing surface of an antenna segment on which end cap **400** is to be mounted. Arranged between flange inner surface **468** and ring extension inner surface **470** are connecting rings **466**. Connecting rings **466** connect axial ends of ring extensions **426**A and **426**B of FIG. **4**B.

[0058] FIG. **5** depicts antenna subassembly **500** which includes spacer **102** between antenna **502** and antenna **504** with accessory platform **506**, in accordance with some embodiments of the disclosure. Antenna subassembly **500** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**4**B and **6**A-**9**B. Additionally, or alternatively, antenna subassembly **500** may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0059] Antenna subassembly **500** may be utilized as part of or in replacement of antenna subassembly **200**A of FIG. **2**A (e.g., as part of antenna assembly **100** of FIG. **1** or antenna subassembly **200**B of FIG. **2**B). Antenna subassembly **500** comprises antenna **502**, which is directly coupled to first end **202**A of spacer **102** via pull latches **212**. Second end **202**B of spacer **102** is shown on top of accessory platform **506**, which is in direct contact with a top end of end cap **216**. Fasteners **214** extend through flange **210**B and through accessory platform **506** into end cap **216**. In some embodiments, fasteners **214** may also extend into antenna **504**. As shown in FIG. **5**,

accessory platform **506** is arranged between spacer **102** and end cap **216**. Additionally, or alternatively, accessory platform **506**, or additional iterations of accessory platform **506**, may be arranged between any two components depicted in FIG. **5**. Accessory platform **506** as shown in FIG. **5** supports tilt sensors **508**, which are configured to determine whether antenna subassembly **500**, or an antenna assembly comprised of one or more of antenna subassembly, is tilting about one or more axes extending from accessory platform **506**, or axes defined by multiple installations of accessory platform **506** up and down an antenna assembly comprised of multiple installments of antenna subassembly **500**. In some embodiments, accessory platform **506** may be utilized to hold one or more of tools, cables, or subcomponents pertinent to maintenance, assembly, or raising of an antenna assembly comprised of antenna subassembly **500**. Coupled to, affixed to, or arranged on radially outward surfaces of antenna **502** and antenna **504** are cable securing features **510**. Cable securing features **510** comprise any suitable dimension, configuration, or combination of components for fixedly attaching portions of cables that create channels of communication and/or provide power to different elements of an antenna assembly comprised of one or more iterations of antenna subassembly **500**.

[0060] FIG. **6**A depicts antenna base **602** interfacing with gin pole **604** as part of antenna subassembly **600**A, in accordance with some embodiments of the disclosure. Antenna base **602** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**5** and **6**B-**9**B. Additionally, or alternatively, antenna base **602** may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0061] Antenna base **602** is comprised of base spacer **604**. Base spacer **604** may be mounted to or incorporated into (e.g., comprising material of) antenna base **602**. Antenna base **602** is comprised of hinge assembly **608**, pivotable base plate surface **610**, and securing platform **612**. Pivotable surface **610**, from which base spacer **604** extends, is coupled to securing platform **612** via hinge assembly **608**. Accordingly, base spacer **604** is pivotably attached to securing platform **612** (e.g., a base plate). Hinge assembly **608** defines hinge axis **614** for rotating base spacer **604** relative to securing platform **612** by articulation of pivotable base plate surface **610**. Antenna segment **616** is fixedly attached to base spacer **604** via pull latches **212**. Antenna segment **616** also includes at least one of cable securing features **510**. Slots **620** are coupled to base spacer **604** along pivotable surface **610**. As shown in FIG. **6**A, there is a pair of slots **620**. In some embodiments, there may only be one of slots **620** or there may be more than two of slots **620**. Slots **620** each extend radially outward from hinge axis **614** of hinge assembly **608** towards a radially outward edge of pivotable surface **610**. Slots **620** receive a forked end of gin pole **622**. Gin pole **622** is used to pivot base spacer **604** and pivotable surface **610** relative to securing platform **612**, which is configured to be fixedly attached to a surface (e.g., ground of a remote location). In some embodiments, base spacer **604** is not pivotably actuatable relative to securing platform **612**. Additionally, or alternatively, base spacer **604** may be directly affixed to or extending from a top surface of securing platform **612**. In some embodiments, there may be one or more attachment features on antenna base **602** for attaching or storing gin pole **622** when gin pole **622** is not in use (e.g., interfacing with one or more of slots **620** for raising an antenna assembly comprising antenna base **602** into a vertical orientation). In some embodiments, gin pole **622** is not required to pivot base spacer **604** relative to securing platform **612**.

[0062] Base spacer **604** may incorporate or be comprised of any or all of the elements of spacer **102**. For example, base spacer **604** may comprise at least one flange that includes at least one alignment feature for locating at least one of pull latches **212** before clamping the end of antenna segment **616** to the top surface of base spacer **604** via at least one of pull latches **212**. For example, a flange may comprise a top surface of base spacer **604**. Each of pull latches **212** is fixedly attached to the flange. Each of pull latches **212** interfaces with a respective alignment feature of a flange of antenna segment **616**.

[0063] FIG. **6**B depicts, via view **600**B, base plate spacer **604** of antenna base **602** of FIG. **6**A

pivoting via hinge assembly **608**, in accordance with some embodiments of the disclosure. View **600**B depicts antenna base **602** without gin pole **622** interfacing with each of slots **620**. Clamping apparatus **618** may incorporate one or more of pull latches **212** or clamp assembly **700**A of FIG. **7**A to secure antenna segment **616** to a top flange or ring shaped surface of base spacer **604**.

[0064] FIG. **6**C depicts, via view **600**C, antenna base **602** of FIGS. **6**A and **6**B coupled at a bottom of antenna subassembly **600**C, in accordance with some embodiments of the disclosure. Antenna subassembly **600**C may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**6**B and **7**A-**9**B. Additionally, or alternatively, antenna subassembly **600**C may be assembled using any, or all, of the elements of process **1000** of FIG. **10**. Antenna subassembly **700**C includes view **600**B of antenna base **602**, which includes clamping apparatus **618**. Clamping apparatus **618** may include at least one of pull latches **212** that fixedly attaches an end of antenna segment **616** to a top surface of base spacer **604**. Arranged above antenna segment **616** is antenna subassembly **500** of FIG. **5**. There are also a plurality of cable securing features **510** arranged along a radially outer surface of antenna segments of antenna subassembly **600**C.

[0065] FIG. **7**A depicts cross sectional side view **700**A of clamp assembly **702** that interfaces with spacer **102** and antenna **104**A, in accordance with some embodiments of the disclosure. Clamp assembly **702** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**6**C and **7**B-**9**B. Additionally, or alternatively, clamp assembly **702** may be utilized as part of any, or all, of the elements of process **1000** of FIG. **10**.

[0066] Clamp assembly **702** includes opening **704**. Within opening **704** are tapered inner surfaces **706**A and **706**B, which narrow from opening **704** towards clamp rear **718**. The taper of these surfaces are exaggerated for illustrative purposes in FIG. **7**A. Any suitable taper for achieving the described clamping affect would be suitable for this embodiment. Clamp assembly **702** may be used instead of pull latch assemblies **212**. Inner surface **706**A interfaces with flange **708** of antenna segment **710**. Flange **708** includes alignment feature accommodation **712**, which receives alignment feature **714**. Alignment feature **714** extends from top flange **716** of base spacer **604** and provides a means to align flange **708** of antenna segment **710** with top flange **716** of base spacer **604**.

[0067] FIG. **7**B depicts perspective view **700**B of clamp assembly **702** of FIG. **7**A interfacing with base plate spacer **604** and antenna segment **710**, in accordance with some embodiments of the disclosure. Clamp assembly **702** comprises hinge **720**. Hinge **720** rotatably couples first arched arm **722** to second arched arm **724**. Each of first arched arm **722** and second arched arm **724** comprise channel **726** (e.g., corresponding to opening **704**, inner surfaces **706**A and **706**B, and clamp rear **718**) that is accommodates flange **716** of base spacer **604** and flange **708** of antenna segment **710**. In some embodiments, channel **726** accommodates a flange of spacer **102** of FIG. **1** in addition to flange **708** of antenna segment **710**. Channel **726** comprises a width corresponding to opening **704** that narrows (e.g., based on a profile of inner surfaces **706**A and **706**B) towards a bottom of channel **726** (e.g., as defined by clamp rear **718**). Clamp assembly **702** also includes adjustable handle **728**. Adjustable handle **728** increases a clamping force between an end of first arched arm **722** and an end of second arched arm **724** as clamp assembly **702** encompasses flange **716** and flange **708**. Alignment feature **714** interfaces with flange **708** to align antenna segment **710** with a ring shaped surface of flange **716** of base spacer **604**. Base spacer **604** extends from antenna base **602**. Clamp assembly **702** may be utilized in any or all antenna assemblies or subassemblies of this disclosure as an alternative securing means between spacers, antennas, or antenna segments to the pull latches described herein.

[0068] FIG. **8** depicts a manner of erecting antenna assembly **800**, in accordance with some embodiments of the disclosure. Antenna assembly **100** may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **2**A-**7**B and **9**A-**9**B. Additionally, or alternatively, antenna assembly **100** may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0069] As shown in FIG. **8**, antenna subassembly **600**A is arranged at the base of antenna assembly **800** to enable antenna assembly **800** to be raised from a horizontal orientation towards a vertical orientation. Gin pole **622** is inserted into slots **620** and provides a leverage point. Gin pole **622** also comprises guy wire wheel **804** for running guy wire **806** from antenna coupling interface **808** to guy wire anchor **112**. In some embodiments, guy wire anchor **112** may include a motorized apparatus for retracting guy wire **806** to pull a distal end of antenna assembly **800** such that antenna assembly **800** is moved from a horizontal (e.g., laid down) orientation to a vertical orientation. Antenna assembly **800** also includes accessory platform **506**, which may incorporate one or more tilt sensors to indicate when antenna assembly **800** is in a vertical orientation. In some embodiments, an actuator at guy wire anchor **112** may be configured to stop pulling guy wire **806** when a tilt sensor of accessory platform **506** provides data indicating antenna assembly **800** is in a vertical orientation.

[0070] FIG. **9**A depicts first perspective view **900**A of routing cable **902** into spacer **102** towards antenna **904** coupled to spacer **102**, in accordance with some embodiments of the disclosure. First perspective view **900**A may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**8** and **9**B. Additionally, or alternatively, first perspective view **900**A depicts a subassembly may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0071] First perspective view **900**A shows antenna **904** coupled to a top of spacer **102**. Pull latch assemblies **212** couple antenna **904** to the top of spacer **102**. A bottom end of spacer **102** is fixedly attached to end cap **216**, which is affixed to a top of antenna **906**. Using cable securing feature **510**, cable **902** is coupled to a radially outer surface of antenna **906**. Cable **902** may be considered a wire. Cable **902** is fed through a side opening of spacer **102** and into a passageway of spacer **102**. Connector **908** is on an end of cable **902**. Connector **908** is secured to a complementary connector on an exposed surface of antenna **904**, for example, a bottom surface accessible via the passageway of spacer **102**. Cable **902** extends out of the side opening of spacer **102** and along the radially outer surface of antenna **906** towards the base of antenna **904**, which is stacked on, or affixed to, a top of spacer **102**. Cable **902** may be fed from a ground cable or wire source, and snaked up an antenna assembly, making connections via connector **908** and being secured to an outer surface via a plurality of cable securing features **510**.

[0072] FIG. **9**B depicts second perspective view **900**B of routing a cable into a spacer towards an antenna coupled to the spacer, in accordance with some embodiments of the disclosure. Second perspective view **900**B may include, or incorporate, any or all of the elements showed in, or described in reference to FIGS. **1**-**9**A. Additionally, or alternatively, second perspective view **900**B depicts a subassembly may be assembled using any, or all, of the elements of process **1000** of FIG. **10**.

[0073] FIG. **10** is a flow chart representing process **1000** for assembling an antenna assembly, in accordance with some embodiments of the disclosure. Process **1000** may utilize, or incorporate, any or all of the elements, or components, depicted in or described in reference to FIGS. **1**-**9**B. An antenna assembly assembled using any or all elements of process **1000** may incorporate, or be incorporated into, any or all of the elements shown in, or described in reference to FIGS. **1**-**9**B.

[0074] At process block **1002**, a bottom end of a first antenna segment is secured to a base spacer of a base plate. For example, clamp assembly **702** or pull latches **212** may be utilized. At process block **1004**, a top end of the first antenna segment is coupled to a first end of a spacer.

[0075] At process block **706**, a bottom end of a second antenna segment is fixedly attached to a second end of the spacer with at least one pull latch. At process block **1008**, a wire is fed through a side opening of the spacer and into a passageway of the spacer. At process block **1010**, a connector of the wire is secured to a complementary connector on an exposed bottom surface of the second antenna segment. At process block **1012**, a first end of at least one guy wire is secured to at least one guy wire eyelet of a coupling apparatus comprising the spacer. At process block **1014**, a distal

second end of the at least one guy wire is fixedly attached to a grounded anchoring apparatus.
[0076] The assemblies, apparatuses, systems and processes discussed above are intended to be illustrative and not limiting. One skilled in the art would appreciate that the actions of the processes discussed herein may be omitted, modified, combined, and/or rearranged, and any additional actions may be performed without departing from the scope of the invention. More generally, the above disclosure is meant to be exemplary and not limiting. Furthermore, it should be noted that the features and limitations described in any one embodiment may be applied to any other embodiment herein, and flowcharts or examples relating to one embodiment may be combined with any other embodiment in a suitable manner, done in different orders, or done in parallel. In addition, the methods described herein may be performed in real time. It should also be noted that the assemblies, apparatuses, systems and/or methods described above may be applied to, or used in accordance with, other assemblies, apparatuses, systems and/or methods.

Claims

1. A coupling apparatus comprising: a spacer comprising: a first end configured to interface with a first antenna, a second end configured to interface with a second antenna, and an internal passageway extending from an end opening in the first end and a side opening between the first end and the second end.
2. The coupling apparatus of claim 1, further comprising an end cap fixedly attached to the second end of the spacer, wherein the second end of the spacer is configured to interface with the second antenna via the end cap.
3. The coupling apparatus of claim 2, wherein the spacer comprises a flange configured to be fixedly attached to the end cap.
4. The coupling apparatus of claim 2, wherein the end cap comprises a plurality of evenly spaced eyelets that extend away from a radially outer surface of the end cap.
5. The coupling apparatus of claim 2, further comprising an accessory platform arranged between the spacer and the end cap.
6. The coupling apparatus of claim 1, wherein at least one of the first end or the second end comprises at least one feature for fixedly attaching the spacer to either the first antenna or the second antenna.
7. The coupling apparatus of claim 1, wherein the side opening is a first side opening and the spacer further comprises a second side opening arranged opposite of the first side opening.
8. The coupling apparatus of claim 1, wherein the first end comprises a flange configured to interface with one or more pull latches.
9. The coupling apparatus of claim 1, wherein: when the first antenna is coupled to the first end, a cable that a comprises a connector passes through the internal passageway from the side opening and towards a complementary connector on a surface of the first antenna; and the connector is coupled to the complementary connector.
10. An antenna assembly comprising: a spacer having a first ring shaped end surface and an internal passageway extending between an opening in the first ring shaped end surface and a side opening between the first ring shaped end surface and a second ring shaped end surface; a first antenna segment fixedly attached to the first ring shaped surface of the spacer, wherein a cable comprising a connector passes through the internal passageway from the side opening and towards a complementary connector on a surface of the first antenna segment; and a second antenna segment coupled to the second ring shaped end surface of the spacer.
11. The antenna assembly of claim 10, further comprising an antenna base comprising a base spacer pivotably attached to a base plate.
12. The antenna assembly of claim 11, wherein the antenna base comprises a hinge assembly defining a hinge axis for rotating the base spacer.

13. The antenna assembly of claim 12, further comprising: a pair of slots coupled to the base spacer; and each of the pair of slots extends radially outward from the hinge axis.
14. The antenna assembly of claim 11, further comprising at least one pull latch that fixedly attaches an end of the second antenna segment to a top surface of the base spacer.
15. The antenna assembly of claim 14, wherein a flange of the base spacer comprises at least one alignment feature for locating the at least one pull latch before clamping the end of the second antenna segment to the top surface of the base spacer via the at least one pull latch.
16. The antenna assembly of claim 14, wherein the at least one pull latch comprises a plurality of pull latches.
17. The antenna assembly of claim 16, wherein: a flange comprises the top surface of the base spacer; each pull latch of the plurality of pull latches is fixedly attached to the flange; and each pull latch of the plurality of pull latches interfaces with a respective alignment feature of a flange of an antenna segment.
18. The antenna assembly of claim 11, further comprising a clamp assembly, the clamp assembly comprising: a hinge rotatably coupling a first arched arm to a second arched arm, wherein: each of the first arched arm and second arched arm comprise a channel that is configured to accommodate a flange of the spacer and a flange of one of the first antenna segment and the second antenna segment, and the channel comprises a width that narrows towards a bottom of the channel; and an adjustable handle for increasing a clamping force between an end of the first arched arm and an end of the second arched arm.
19. A method of assembling an antenna assembly, the method comprising: securing a bottom end of a first antenna segment to a base spacer of a base plate; coupling a top end of the first antenna segment to a first end of a spacer; and fixedly attaching a bottom end of a second antenna segment to a second end of the spacer with at least one pull latch.
20. The method of claim 19, further comprising: feeding a wire through a side opening of the spacer and into a passageway of the spacer; securing a connector of the wire to a complementary connector on an exposed bottom surface of the second antenna segment; securing a first end of at least one guy wire to at least one guy wire eyelet of a coupling apparatus comprising the spacer; and fixedly attaching a distal second end of the at least one guy wire to a grounded anchoring apparatus.