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(54) Title: INTEGRATED CELL SITE SECTOR

(57) Abstract: A cell site sector includes: a mounting frame; an RF antenna mounted to one side of the mounting frame; and at least one (RRU mounted to a second, opposed side of the mounting frame and operationally connected with the antenna. The RRU and the RF antenna have horizontal width and depth dimensions, the width dimension being greater than the depth dimension, wherein the width dimension of the RRU is generally parallel with the width dimension of the RF antenna.

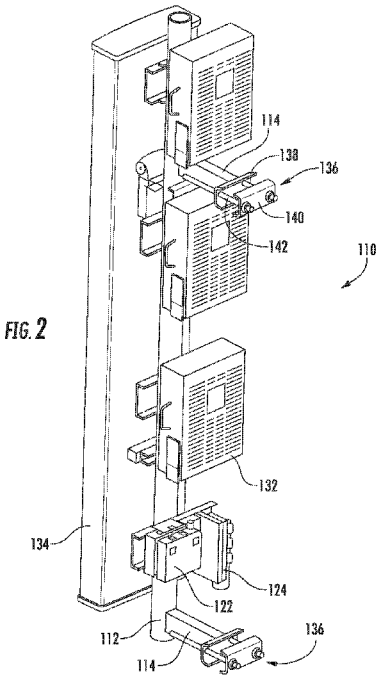


FIG. 2

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INTEGRATED CELL SITE SECTOR

Related Application

[0001] The present application claims priority from and the benefit of U.S. Provisional Patent Application No. 62/366,395, filed July 25, 2016, the disclosure of which is hereby incorporated herein in its entirety.

Field of the Invention

[0002] present inventions relate generally to wireless communications. In particular, they relate to improvements in wireless base station antenna and radio deployments.

Background

[0003] One known wireless radio network system that may be mounted at the top of the tower comprises a remote radio unit (RRU) and a separate antenna. These components are mounted in separate locations and are then cabled together using jumper cables to pass the radio frequency (RF) signal between them. Such an installation, when done on site, may involve complex and time consuming installations, and may introduce opportunities for installation errors. For example, current installations typically require multiple jumper cables and multiple mounting kits/hardware. This involves substantial installation time (approximately 12-15 hours per site). In addition, doing this installation at the site outdoors in variable temperature and humidity conditions can adversely affect interconnect quality and overall system performance.

[0004] Typically, it is up to the installation team to determine a mounting method. For example, once the antenna and RRU are mounted at the tower top, it is up to the installer to cable and connect the components together correctly. The installer will need a schematic or wiring diagram to understand how such connections should be made. This introduces the possibility of

installing cables at the wrong locations, installing cables of incorrect lengths, improperly assembling connectors to the jumper cables, not engaging them correctly, or other installation errors.

[0005] One approach involves the use of a pre-assembled cell site sector. This approach, illustrated in **FIG. 1** and described in detail in WO 2015/095779 (incorporated herein by reference in its entirety), employs two parallel vertical members **12, 14** that are spanned by RRU mounting sites **16** on which RRUs **32** are mounted. The vertical member **12** provides a site for mounting of an antenna **34**, and the other vertical member **14** can be mounted to the leg of an antenna tower or the like. The ability to assemble the entire site remotely, confirm that the connections have been made correctly and test their performance, then mount it in place on an antenna tower, can provide significant time savings for installation.

Summary

[0006] As a first aspect, embodiments of the invention are directed to a cell site sector. The cell site sector comprises: a mounting frame; an RF antenna mounted to one side of the mounting frame; and at least one (RRU mounted to a second, opposed side of the mounting frame and operationally connected with the antenna. The RRU and the RF antenna have horizontal width and depth dimensions, the width dimension being greater than the depth dimension, wherein the width dimension of the RRU is generally parallel with the width dimension of the RF antenna.

[0007] In some embodiments, three cell site sectors are mounted to a tri-sector frame having three vertical mounting members, wherein each of the cell site sectors is mounted to a respective one of the vertical mounting members.

[0008] In other embodiments, the mounting frame comprises a backplane. The backplane may include connectors configured to connect with the RRU. A fiber/power distribution unit mounted to the second side of the backplane. In some embodiments, the RRU includes connectors, and the RRU connectors are blind-mated to connectors mounted on the backplane.

[0009] In additional embodiments, the mounting frame further comprises a subfloor attached to the backplane, wherein the antenna is mounted to the subfloor and the RRU is mounted to the backplane. Other components, such as a battery, an RF conditioning unit, a fiber/power distribution unit (including at least one of a voltage regulator, a power redundancy circuit, and an overvoltage protection unit) may be mounted on the backplane.

[0010] The mounting frame may also include baffling to promote cooling.

Brief Description of the Figures

[0011] FIG. 1 is a side view of a prior pre-assembled cell site sector.

[0012] FIG. 2 is a perspective view of a pre-assembled cell site sector according to embodiments of the invention.

[0013] FIG. 3 is an enlarged perspective view of the top portion of the cell site sector of FIG. 2.

[0014] FIG. 4 is a side view of another pre-assembled cell site sector according to additional embodiments of the invention.

[0015] FIG. 5 is a top view of three cell site sectors of FIG. 4 mounted to a tri-sector frame.

[0016] FIG. 6 is a perspective view of the frame of FIG. 5.

[0017] FIG. 7 is a perspective view of the cell site sectors and frame of FIG. 5.

[0018] FIG. 8 is a perspective view of two tri-sector frames and cell site sectors mounted on the top of a pole.

[0019] FIG. 9 is a perspective view of three cell site sectors of FIG. 4 mounted to a monopole with mounting brackets.

[0020] FIG. 10 is a perspective view of a backplane-based cell site sector according to additional embodiments of the invention.

[0021] FIG. 11 is an exploded perspective view of a backplane-based cell site sector according to additional embodiments of the invention.

[0022] FIG. 12 is an enlarged exploded perspective view of one end of the cell site sector of FIG. 11.

[0023] FIG. 13 is a perspective view of a backplane-based cell site sector covered by a cover panel according to further embodiments of the invention.

[0024] FIG. 14 is an exploded perspective view of the cell site sector and cover panel of FIG. 13.

[0025] FIG. 15 is a perspective view of cell site sectors of FIG. 11 mounted on an upper story of a building, with reflective film on two of the cell site sectors to encourage "blending" with the environment.

[0026] **FIG. 16** is a perspective view of the cell site sector of **FIG. 11** with an AC-DC converter module mounted thereon.

[0027] **FIG. 17** is a perspective view of the cell site sector of **FIG. 11** illustrating how the cell site sector could be provided in modular fashion.

[0028] **FIG. 18** is a perspective view of an RRU for a cell site sector of **FIG. 11** being transported by a drone.

[0029] **FIG. 19** is a perspective view of the drone and RRU of **FIG. 18** hovering for remote installation of the RRU onto an existing cell site sector.

Detailed Description

[0030] The present invention is described with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments that are pictured and described herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. It will also be appreciated that the embodiments disclosed herein can be combined in any way and/or combination to provide many additional embodiments.

[0031] Unless otherwise defined, all technical and scientific terms that are used in this disclosure have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The terminology used in the below description is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used in this disclosure, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that when an element (e.g., an assembly, a housing, a cable, etc.) is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0032] Referring now to the drawings, a cell site sector according to embodiments of the invention, designated broadly at **110**, is shown in **FIG. 2-4**. The cell site sector **110** includes a single vertical mounting member **112** (typically formed of aluminum) on which an antenna **134**

and three RRUs **132** are mounted. The vertical member **112** may have a cross-section that is round, square (which can provide increased wind load resistance) or another shape as desired. Two horizontal members **114** are fixed to the vertical mounting member **112** and extend rearwardly (i.e., away from the antenna **134**). Each of the horizontal members **114** has a clamp **136** on its free end; each clamp **136** has two clamp brackets **138, 140** that may be clamped together via bolts **142**. The clamps **136** are employed to mount the cell site sector **110** to a mounting structure such as an antenna tower or the like (see **FIG. 4**, which illustrates the clamps **136** mounted to a vertical adapter pipe **118** that is mounted to an antenna tower **119** via U-bolts **121**). Note that the upper horizontal member is shown at **114** in **FIG. 2**, at **114'** in **FIG. 3**, and at **114"** in **FIG. 4** to illustrate three different locations on the vertical member **112**.

[0033] Two mounts **126** are fixed to the front surface of the vertical member **112** and provide mounting locations for the antenna **134** (see **FIG. 4**). Four horizontal mounts **120** are fixed to the rear surface of the vertical member **112** and provide mounting locations for the three RRUs **132** and for fiber/power distribution and RF signal combining units **122, 124** (**FIGS. 2** and **4**). Notably, the mounts **120** are configured so that each RRU **132** is oriented with its width dimension (i.e., the larger of its horizontal dimensions) generally parallel with the width dimension of the antenna **134**, and its depth dimension (i.e., the smaller of its horizontal dimensions) generally perpendicular to the width dimension of the antenna **134**. In this orientation, the cell site sector **110** may experience a reduced wind load compared to prior cell site sectors, as winds blowing parallel to the width direction face a reduced surface area from the RRUs **132**, and winds perpendicular to the width direction are blocked from the RRUs **132** by the antenna **134** (or from the antenna **134** by the RRUs **132**).

[0034] Referring again to **FIG. 4**, the vertical adapter pipe **118** used to mount the cell site sector **110** to the antenna tower **119** has a safety stop collar **127** at its lower end. The adapter pipe **118** serves as an axis of azimuth rotation **A** for the cell site sector **110**. The safety stop collar **127** is configured to prevent the cell site sector **110** from slipping off of the lower end of the adapter pipe **118** when the clamps **136** are loosened to allow for azimuth adjustment of the antenna **134**.

[0035] As shown in **FIG. 3**, the cell site sector **110** may have a lifting hoist flange **144** located at the upper end of the vertical member **112**. The hoist flange **144** (or other hoisting device) may be positioned at or near the vertical center of gravity of the cell site sector **110** to

reduce rocking, swaying, twisting or the like during hoisting of the cell site sector **110** during installation.

[0036] Referring now to **FIGS. 5-7**, a tri-sector assembly **150** is shown therein. The assembly **150** includes three cell site sectors **110** largely as described above. The cell site sectors **110** are mounted to a frame **160** (best seen in **FIG. 6**) that includes three vertical members **162** spanned by numerous braces **164** that form a triangular pattern. End plates **166** are attached at the upper and lower ends of the vertical members **162**. **FIG. 5** shows that the cell site sectors **110** may be mounted to the vertical members **162** of the frame **160** via clamps **136** as shown in **FIG. 4**. Alternatively, as shown in **FIG. 7**, each of the three cell site sectors **110** nay be mounted to a respective vertical member **162** via U-bolts **168** inserted into a plate **167** mounted on the ends of the horizontal members **114**.

[0037] **FIG. 7** illustrates the assembly **150** mounted atop a pole or tower **170**. Notably, the tri-sector assembly **150** can be fully assembled on the ground, then hoisted in its entirety to the top of a structure for mounting. **FIG. 8** illustrates two tri-sector assemblies **150** mounted in vertically stacked fashion on top of the pole/tower **170**. Such an arrangement may be particularly advantageous if different cell site operators own and deploy each of the tri-sector assemblies **150**.

[0038] **FIG. 9** illustrates a tri-sector assembly **150'** that is mounted on a monopole **180**. The assembly **150'** includes three cell site sectors **110** with vertical adapter poles **114**. Each of the adapter poles **114** is mounted to a respective pair of six brackets **171** that are secured with horizontal bolts **172** to form two mounting rings **174**. The mounting rings **174** are then secured onto the monopole **180** at a desired height. As with the assembly **150**, the assembly **150'** can be fully assembled on the ground and hoisted in its entirety for mounting on the monopole **180**.

[0039] Referring now to **FIG. 10**, another cell site sector, designated broadly at **210**, is shown therein. The cell site sector **210** includes an antenna **234**, three RRUs **232**, and a fiber/power distribution unit **236**. These are all mounted to a structural backplane **238**, which replaces the vertical member, horizontal members, mounts, etc. of the cell site sector **110** as a mounting frame, with the RRUs **232** and fiber/power distribution unit **236** mounted on one side of the backplane **238**, and the antenna **234** mounted on the opposite side. Mounting features for mounting the RRUs **232** and the antenna **234** onto the backplane **238** are integrated into the backplane **238**.

[0040] The backplane **238** includes three sets of connectors **240**. Each of the RRUs **232** is mounted to the backplane **238** adjacent the connectors **240**, such that connectors **242** on each RRU **232** can be connected to the adjacent set of connectors **240** via jumper cords **244**. The antenna **234** is connected to mating connectors (not shown) on the opposite side of the backplane **238** via jumper cables (also not shown). In this manner the RRUs **232** are connected to the antenna **234**. The short length of jumper cords **244** can improve signal propagation, and the proximity of the connectors **242** of the RRUs **232** to the connectors **240** of the backplane **238** can reduce the risk of incorrect connections.

[0041] The fiber/power distribution unit **236** is mounted directly to the backplane **238**. Three hybrid fiber/power connectors **246** are located on the lower end of the fiber/power distribution unit **236** to receive cables routed from the ground. In some embodiments, the connectors **246** may be separate power and fiber connectors to receive separate fiber and power cables routed from the bottom of the tower.

[0042] A horizontal mounting bar **248** extends from the fiber/power distribution unit **236** to a mounting panel **250** with U-bolts **252**. A horizontal mounting bar **254** extends rearwardly from the opposite end of the backplane **238**. A mounting panel **256** with U-bolts **258** is attached to the free end of the mounting bar **254**. The cell site sector **210** can be mounted to an antenna tower or the like via the U-bolts **252, 258** in much the manner described above.

[0043] Referring now to **FIGS. 11** and **12**, another embodiment of a cell site sector, designated broadly at **310**, is illustrated therein. The cell site sector **310** includes an antenna **334**, three RRUs **332**, a structural backplane **338** to which the RRUs **332** mount, and further includes a subfloor **340** that is sandwiched between the antenna **334** and the backplane **338**. The subfloor **340** is spaced from and sealed to the backplane **338** to form a cavity **339**. These components are described in greater detail below.

[0044] In addition to being structurally mounted to the backplane **338**, each of the RRUs **332** is electrically connected directly to connectors **342** mounted in the backplane **338**. Each RRU **332** includes connectors (for example, connectors that satisfy the "4.3/10" standard proposed by the International Electrical Commission (46F/243/NP)) that blind mate with the connectors **342** mounted on the backplane **338**. Exemplary connectors include, for example, those described in U.S. Patent Application No. 14/594,727, filed January 12, 2015, and U.S. Patent Application No. 15/141,526, filed April 28, 2016, the disclosures of which are hereby incorporated herein by

reference in their entirety. In some embodiments, the blind mating connection may occur with the RRUs **332** simply being slid into place along a direction normal to the backplane **338** (see the arrows in **FIG. 11**). An exemplary configuration is shown in U.S. Patent Publication No. 2016/0104969, filed October 8, 2015, the disclosure of which is hereby incorporated herein in its entirety.

[0045] Antenna interface connections **344** are mounted to the subfloor **340** to enable interconnection with the antenna **334**. The cavity **339** between the subfloor **340** and the backplane **338** allows room for cables to extend between the connectors **342** and the antenna interface connections **344**. The subfloor **340** also serves as a potential mounting location for RF conditioning components **346**, such as RF combiners, RF diplexers, RF filters, and the like.

[0046] A fiber/power distribution unit **337** is mounted on the backplane **338** (**FIG. 12**). The fiber/power distribution unit **337** includes connectors **339** on its lower surface to receive cables routed up the tower. In addition to the conventional fiber/power distribution components typically found in such a unit, the fiber/power distribution unit **337** may also include other components that can improve/facilitate performance of the cell site sector **310**. Such components may provide voltage regulation, power redundancy, overvoltage protection, and the like. Any of all of these components may be configured to be replaceable in a "plug and play" manner. Exemplary components are discussed in U.S. Provisional Patent Application Nos. 62/280,549, filed January 19, 2016, and 62/256,318, filed November 17, 2015, the disclosures of which are hereby incorporated herein in their entirety.

[0047] Referring now to **FIGS. 13** and **14**, a backplane-based cell site sector **410** is illustrated therein that includes an optional cover panel **450** that overlies the backplane **438** and contacts the antenna **434**. The cover panel **450** has ventilation perforations **452** at each end that allow air to flow through the cavity created beneath the cover panel **450** in a directed manner. In some embodiments, baffling **456** is included near and between the RRUs **432** to direct air flow within the cavity, providing some cooling for heat-sensitive components, such as the RRUs **432**. The perforations **452** should be sized to provide adequate air flow, but prevent insect and/or animal intrusion.

[0048] **FIGS. 13** and **14** also illustrate a cable cover **458** that compliments the cover panel **450** at the lower end of the cell site sector **410**. The cable cover **458** provides shelter for cables

460 routed to the RRUs 432 from the fiber/power distribution unit 436, as well as any cables 462 routed from the RRUs 432 to the antenna 434.

[0049] FIG. 15 illustrates that a cover panel and/or an antenna itself may be covered with a reflective film that can "match" the cell site sector color to the sky or background. Such a covering (seen in antenna 534 in FIG. 15, but not in antenna 534') can provide some degree of camouflage to enable an antenna to blend in with its surroundings for aesthetic reasons.

[0050] FIG. 16 illustrates an alternative cell site sector 610 that includes a battery module 664 mounted in a position occupied by an RRU in embodiments discussed above (the cell site sector 610 still includes two RRUs 632 in other positions). The presence of the battery module 664 can provide reserve capacity to power the RRUs 632 in the event of a grid power failure. Because the battery module 664 is located at the top of the antenna tower (rather than at the base of the tower as is typical), opportunities for theft are reduced considerably, and lower line losses are present due to a much shorter cable length from battery to RRU. FIG. 16 also illustrates an integrated AC-DC converter 666 attached to (or integrated with) the battery module 664 that accepts AC power at the top of the tower and delivers steady state or backup power to the RRUs 632. Locating the AC-DC converter 666 at the top of the tower provides AC power at the top of the tower (rather than at the bottom of the tower), thereby reducing energy losses.

[0051] FIG. 17 illustrates a modular cell site sector 710 that includes one RRU 732 and one antenna 734 per module 733. The lowermost module 733 includes the fiber/power distribution unit 737 (potentially with the components discussed above with respect to unit 337 discussed above) as well as the RF conditioning components 746 mounted on the subfloor 740. Subsequent modules 733 can be added later (likely in a stacked fashion as illustrated) and can utilize the fiber/power distribution unit 737 and the RF conditioning components 746 of the lowermost module 733.

[0052] FIGS. 18 and 19 illustrate one of the potential advantages of the "plug and play" nature of the RRUs of the cell site sectors discussed in FIGS. 11-17. For the purposes of installing or replacing an RRU 832 in a cell site sector 810, a flighted drone 870 may be employed to both transport an old RRU 832 from the cell site sector 810 as it is mounted on the top of the tower and convey a new RRU 832 from the ground to the top of the tower and mount it thereon. Such operations may be much quicker and less expensive than requiring a technician to scale the tower to perform such a replacement operation.

[0053] It should also be noted that the cell site sectors discussed above may be combined with a system for adjusting the beam of the antennas mounted thereon, whether the systems are manually adjusted, automatically adjusted, or even adjusted in real time. Such systems are discussed, for example, in U.S. Provisional Patent Application No. 62/331,703, filed May 4, 2016, the disclosure of which is hereby incorporated herein by reference in its entirety.

[0054] The several embodiments of cell sector radio assemblies and their components described herein and/or shown in the drawings are presented by way of example only and are not limiting as to the scope of the invention. Unless otherwise specifically stated, individual aspects and components of the cell sector radio assemblies may be modified without departing from the scope and spirit of the invention.

That Which is Claimed is:

1. A cell site sector, comprising:

a mounting frame;

a radio frequency (RF) antenna mounted to one side of the mounting frame;

at least one remote radio unit (RRU) mounted to a second, opposed side of the mounting frame and operationally connected with the antenna;

wherein the RRU and the RF antenna have horizontal width and depth dimensions, the width dimension being greater than the depth dimension, and wherein the width dimension of the RRU is generally parallel with the width dimension of the RF antenna.

2. The cell site sector defined in Claim 1, wherein the mounting frame comprises a vertical member to which the RF antenna and the RRU are mounted, and further comprises at least one horizontal member attached to the vertical member and extending away from the RF antenna.

3. The cell site sector defined in Claim 1, further comprising a fiber/power distribution unit mounted to the second side of the mounting frame.

4. The cell site sector defined in Claim 2, wherein the mounting frame comprises a vertical adapter member mounted to the horizontal member opposite the vertical member, the vertical adapter member configured for mounting to a cellular mounting structure and positioned to define an azimuth adjustment pivot axis.

5. A tri-sector assembly, comprising:

three cell site sectors as defined in Claim 1, and

a tri-sector frame including three vertical mounting members, wherein each of the cell site sectors is mounted to a respective one of the vertical mounting members.

6. A cellular site, comprising at least two tri-sector assemblies as defined in Claim 5 in stacked relationship.

7. The cell site sector defined in Claim 2, wherein the horizontal members are attached to brackets configured to be mounted on a monopole.

8. The cell site sector defined in Claim 1, wherein the mounting frame comprises a backplane.

9. The cell site sector defined in Claim 8, wherein the backplane includes connectors configured to connect with the RRU.

10. The cell site sector defined in Claim 9, wherein the connectors are connected with cables that are in turn connected with the RRU.

11. The cell site sector defined in Claim 8, further comprising a fiber/power distribution unit mounted to the second side of the backplane.

12. The cell site sector defined in Claim 9, wherein the RRU includes connectors, and RRU connectors being blind-mated to the backplane connectors.

13. The cell site sector defined in Claim 8, wherein the mounting frame further comprises a subfloor attached to the backplane, and wherein the antenna is mounted to the subfloor and the RRU is mounted to the backplane.

14. The cell site sector defined in Claim 13, further comprising RF conditioning components mounted to the subfloor.

15. The cell site sector defined in Claim 13, further comprising a fiber/power distribution unit mounted to the backplane.

16. The cell site sector defined in Claim 15, wherein the fiber/power distribution unit includes at least one of: a voltage regulator; a power redundancy circuit; and an overvoltage protection unit.

17. The cell site sector defined in Claim 13, further comprising a cover panel that overlies the backplane and the RRU, the cover panel including perforations for permitting air flow between the cover panel and the backplane.

18. The cell site sector defined in Claim 17, further comprising one or more baffles mounted between the cover panel and the backplane for selectively directing air flow.

19. The cell site sector defined in Claim 1, wherein a surface of the antenna is covered with a reflective layer.

20. The cell site sector defined in Claim 13, further comprising a battery module mounted to the backplane.

21. The cell site sector defined in Claim 20, further comprising an AC-DC convertor module mounted to the backplane adjacent the battery module.

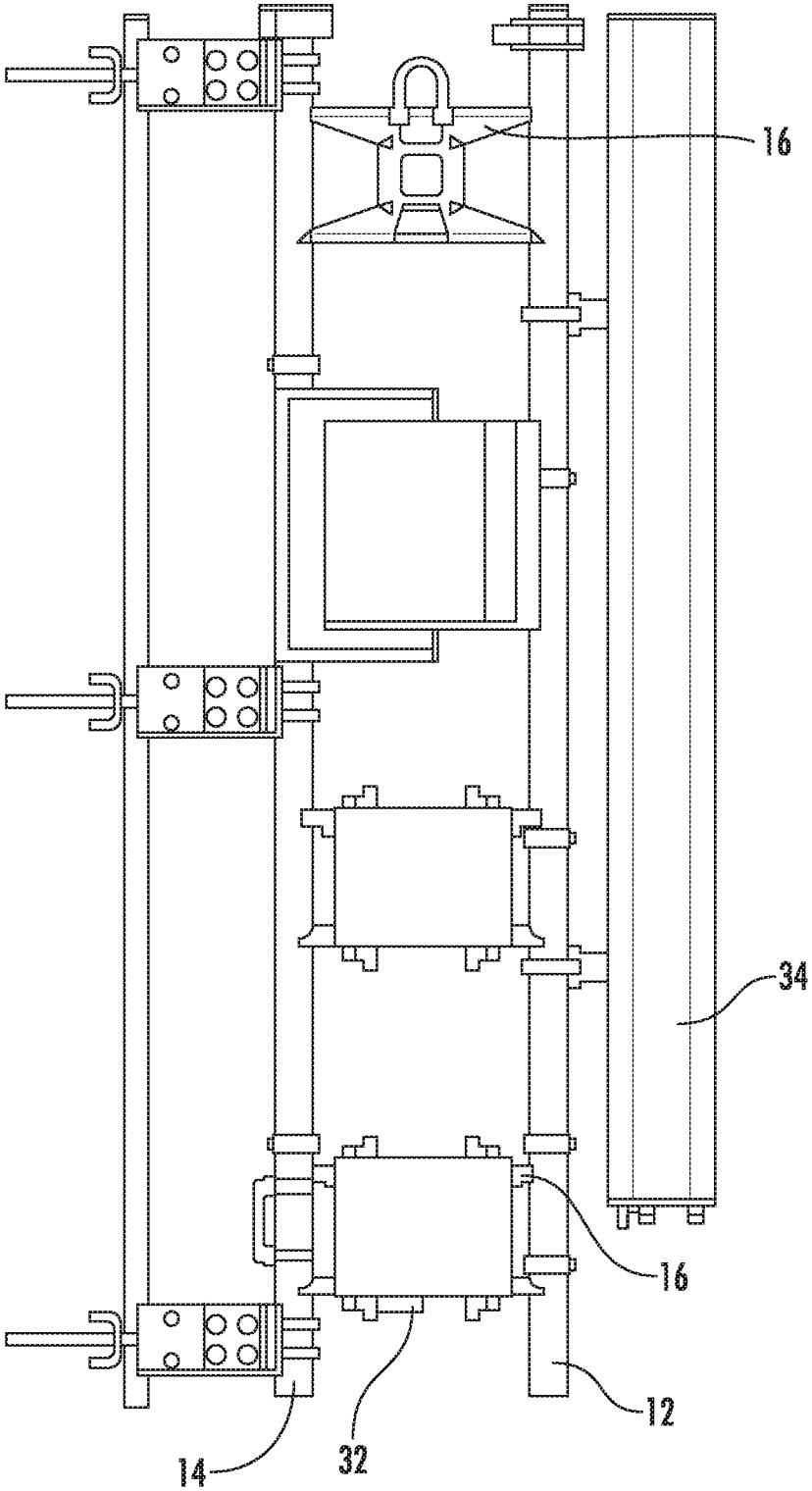


FIG. 1

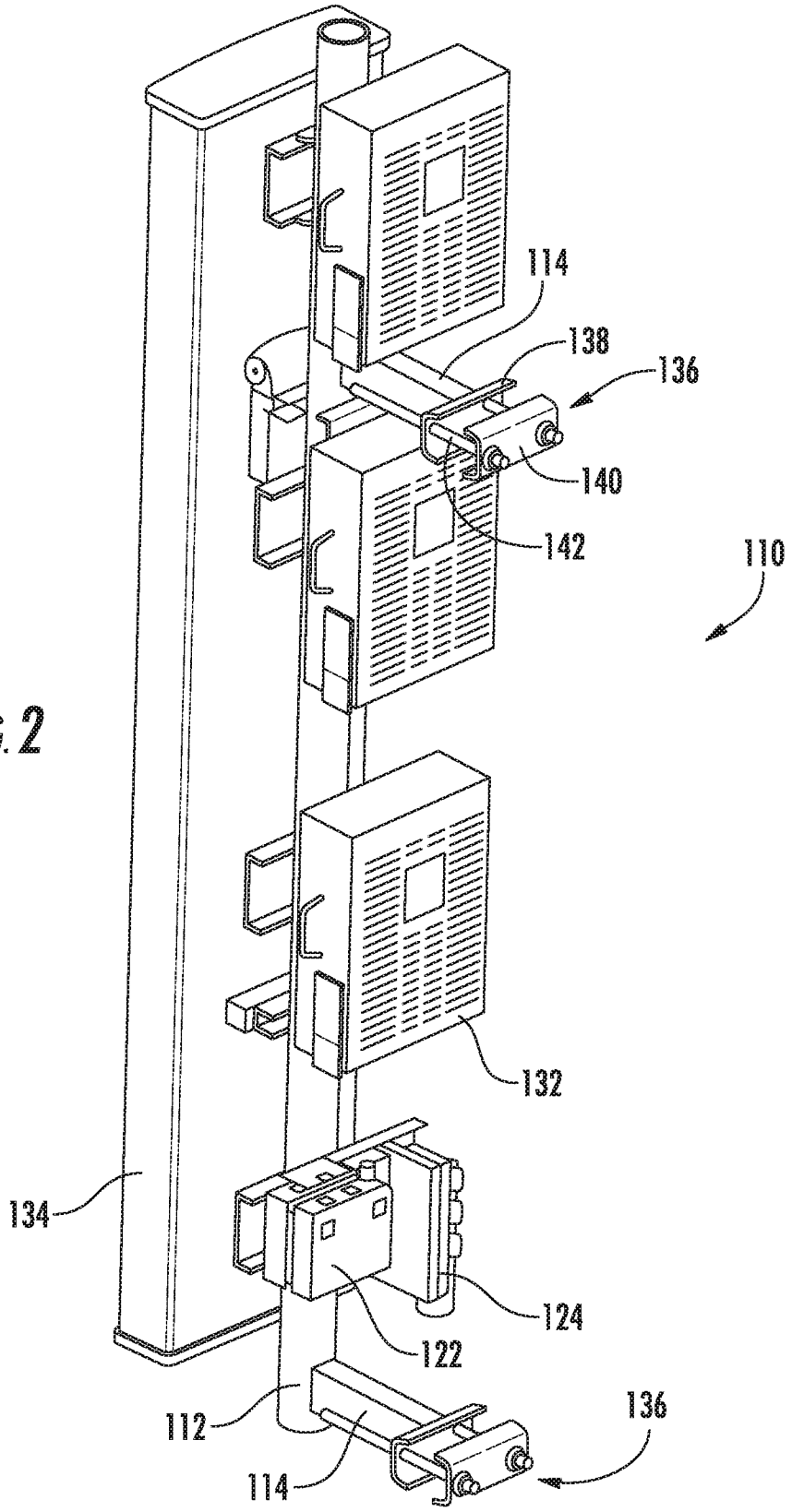


FIG. 2

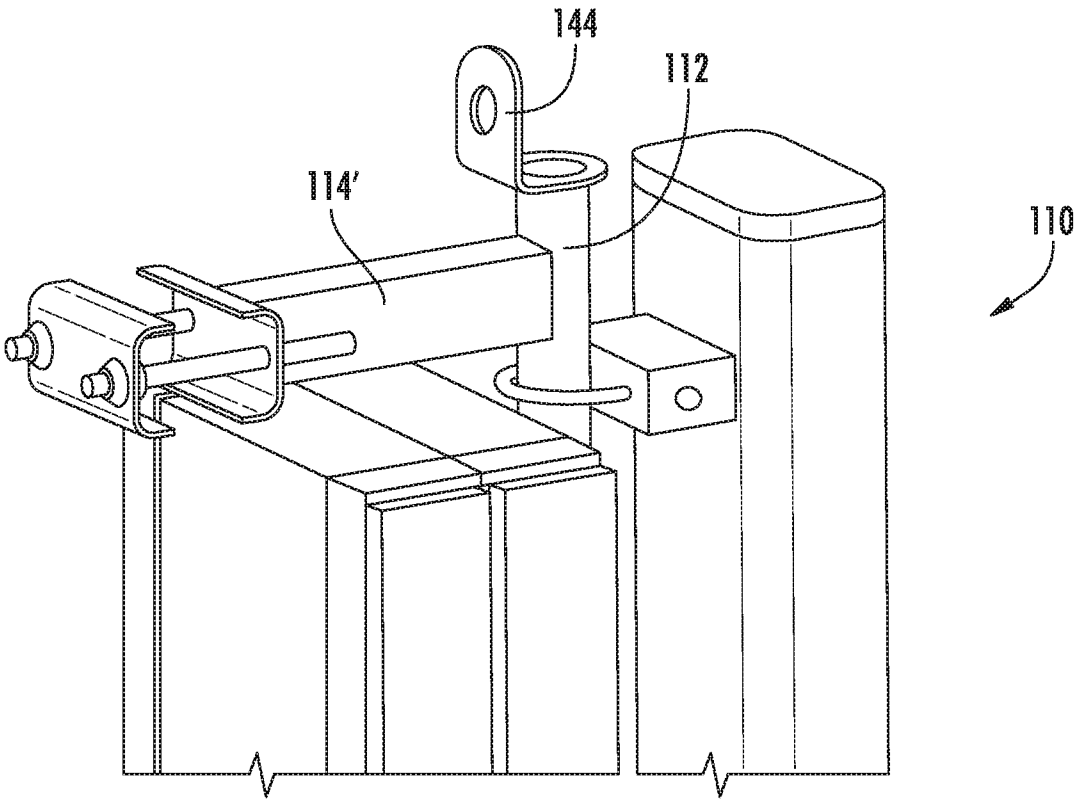


FIG. 3

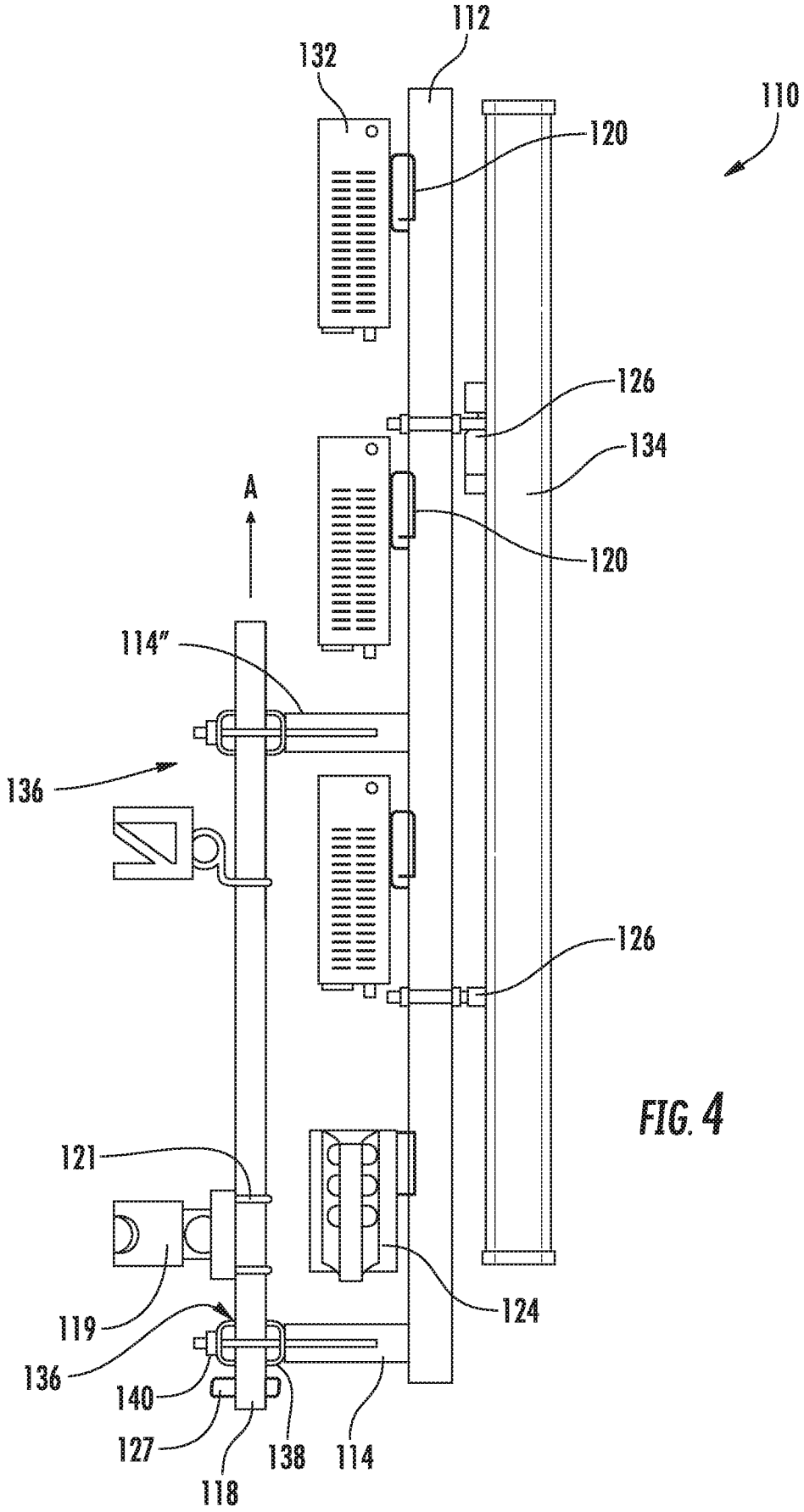

112
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FIG. 4

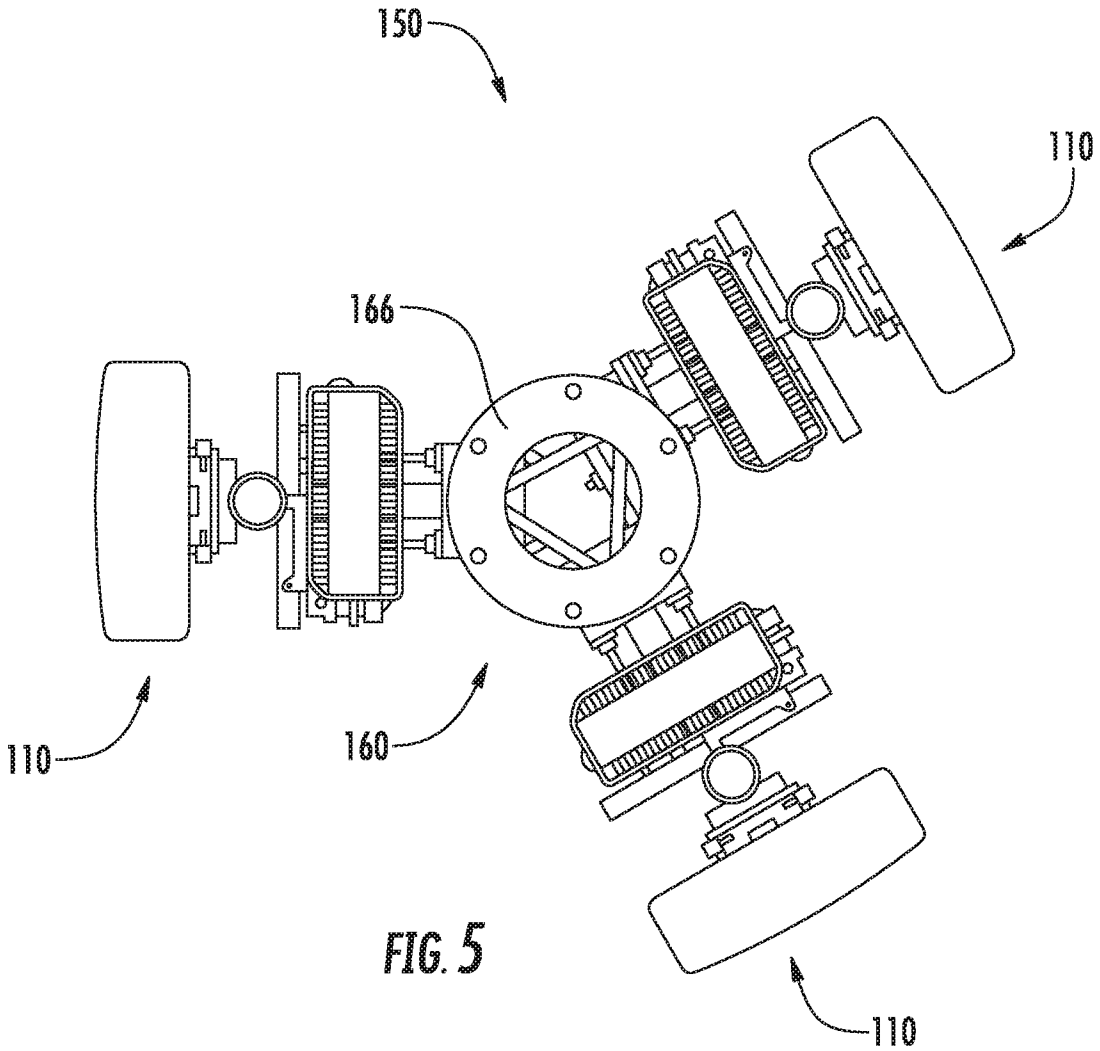


FIG. 5

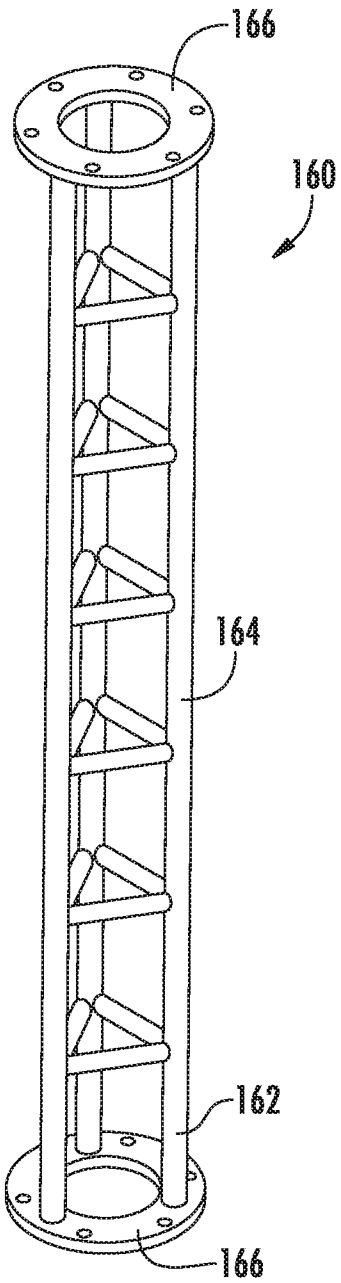


FIG. 6

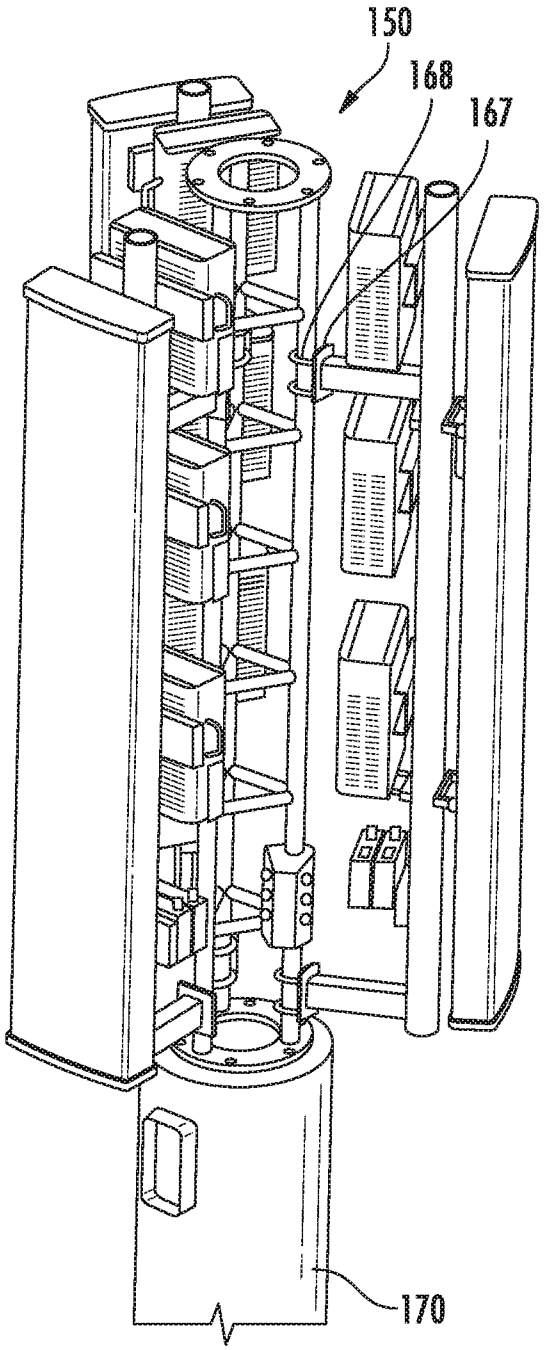


FIG. 7

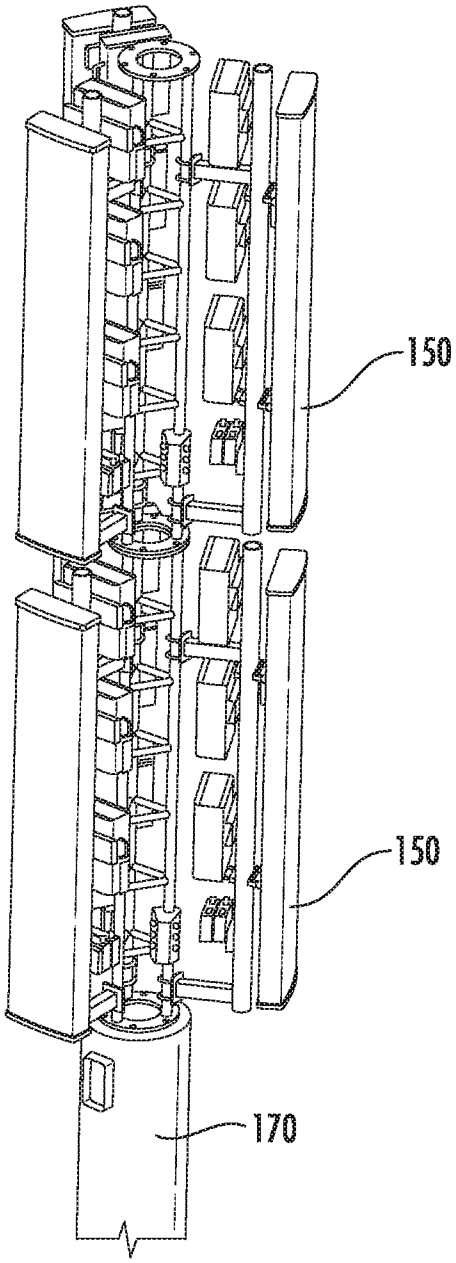


FIG. 8

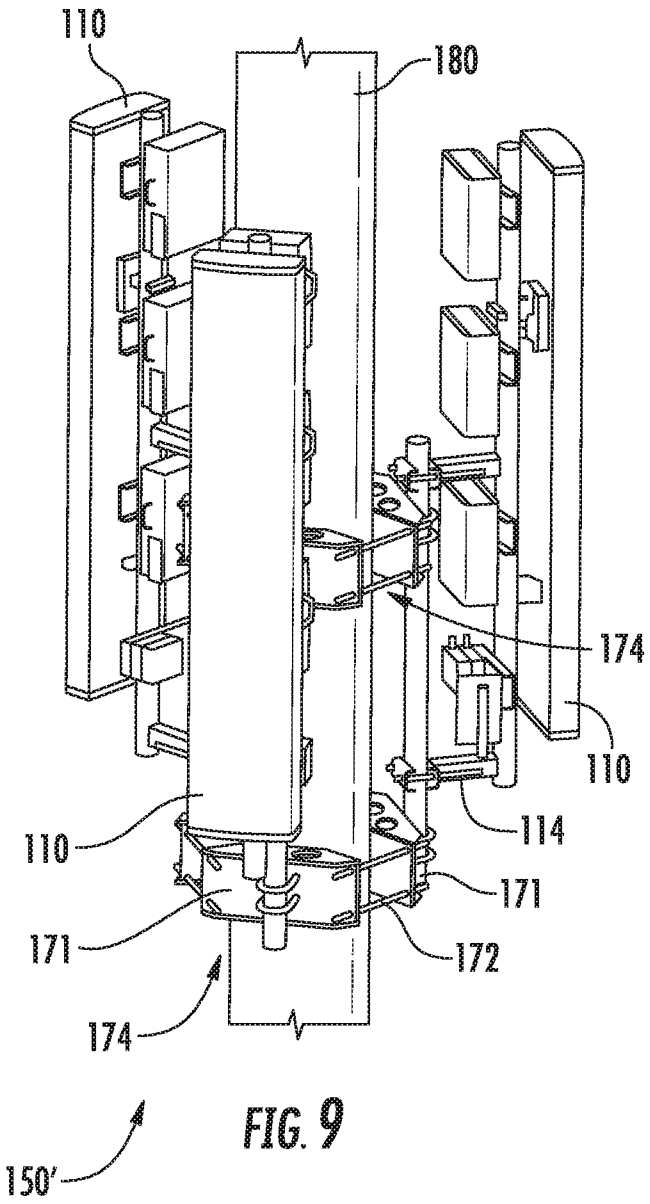


FIG. 9

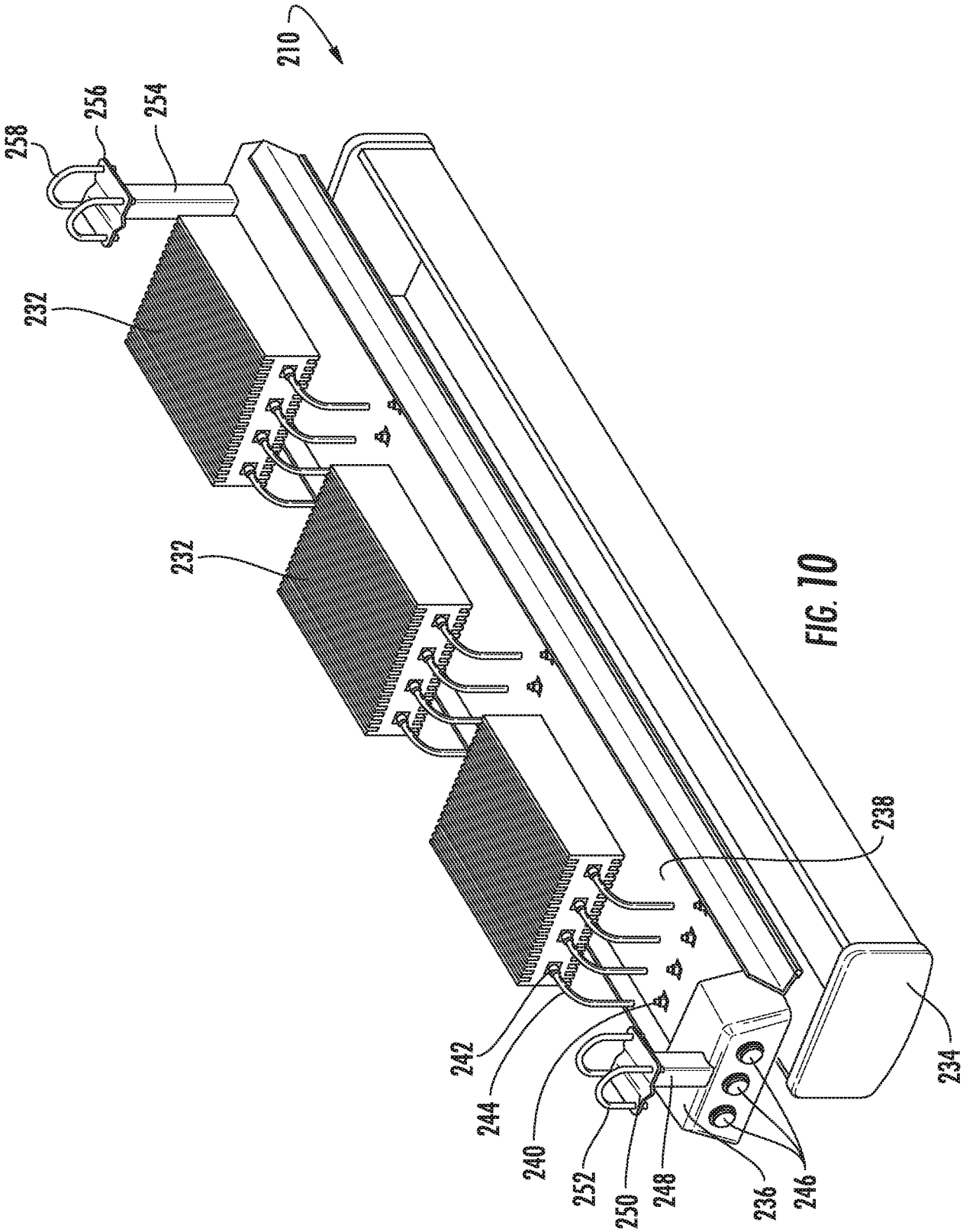


FIG. 10

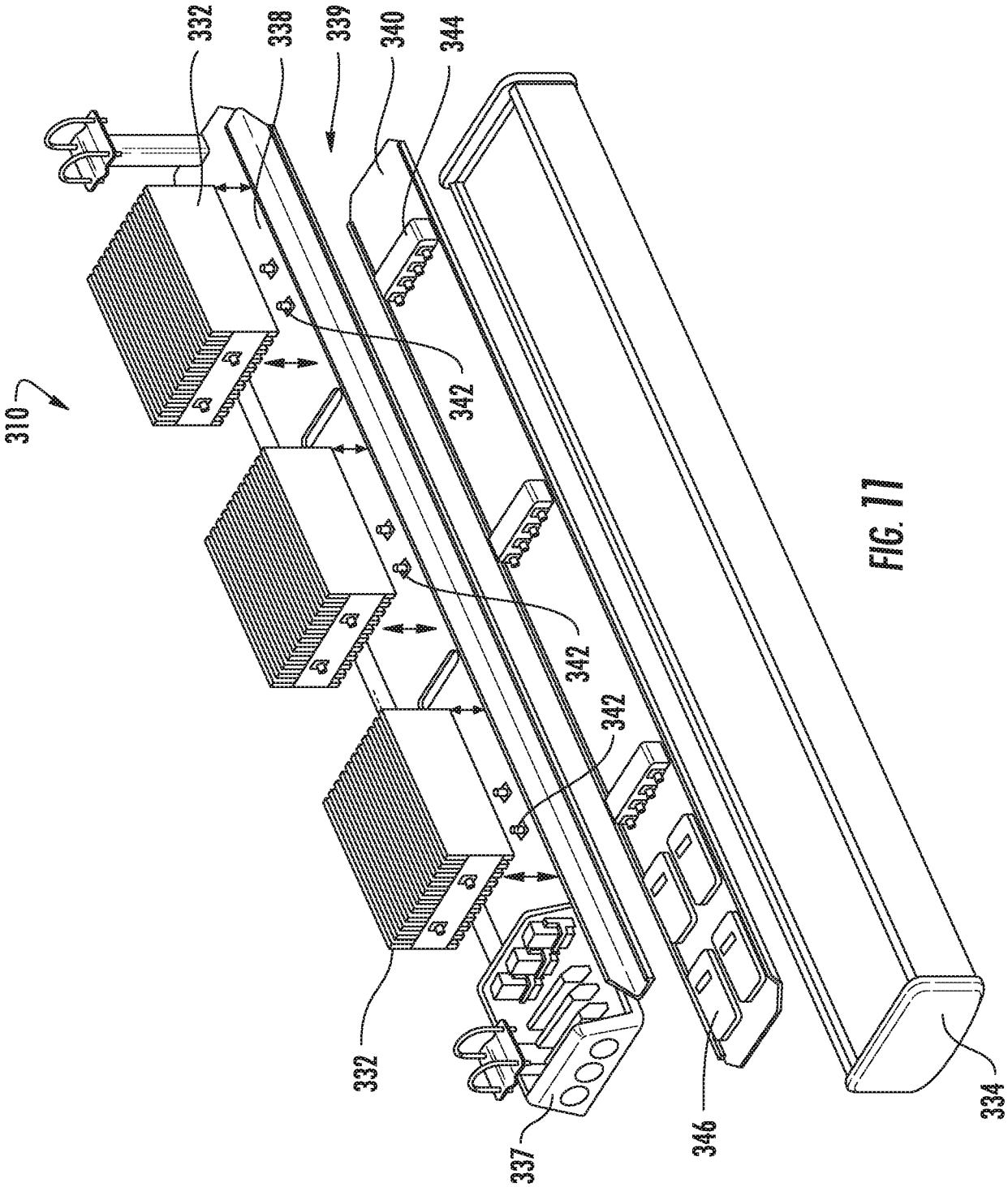


FIG. 11

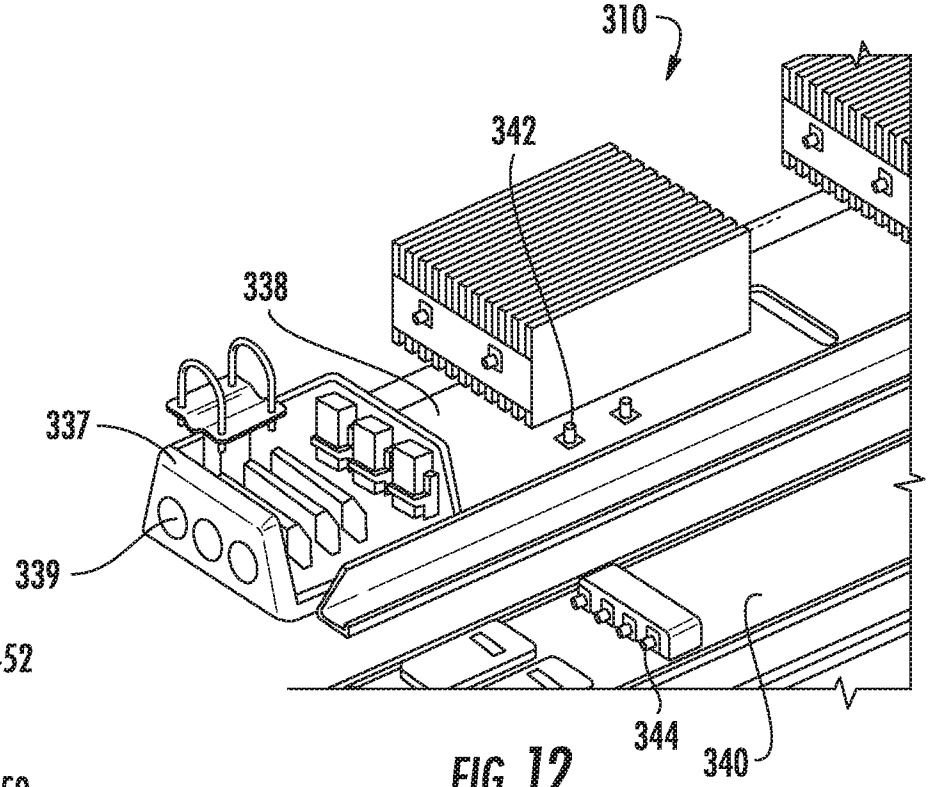


FIG. 12

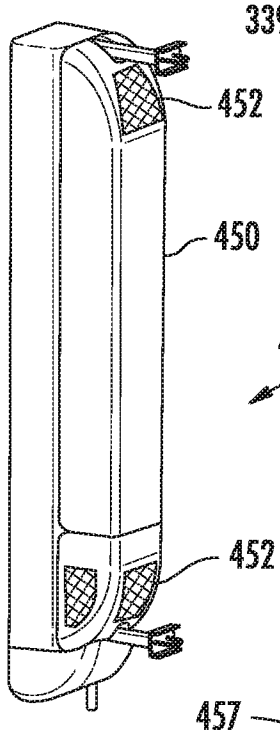


FIG. 13

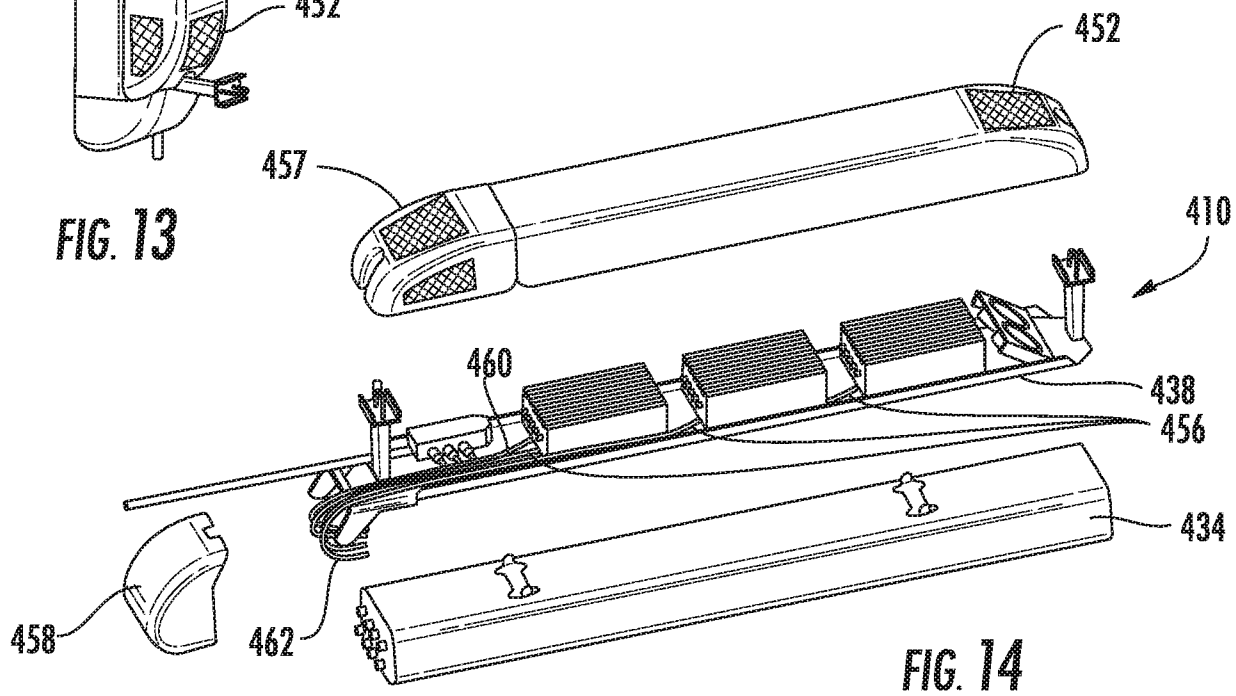


FIG. 14

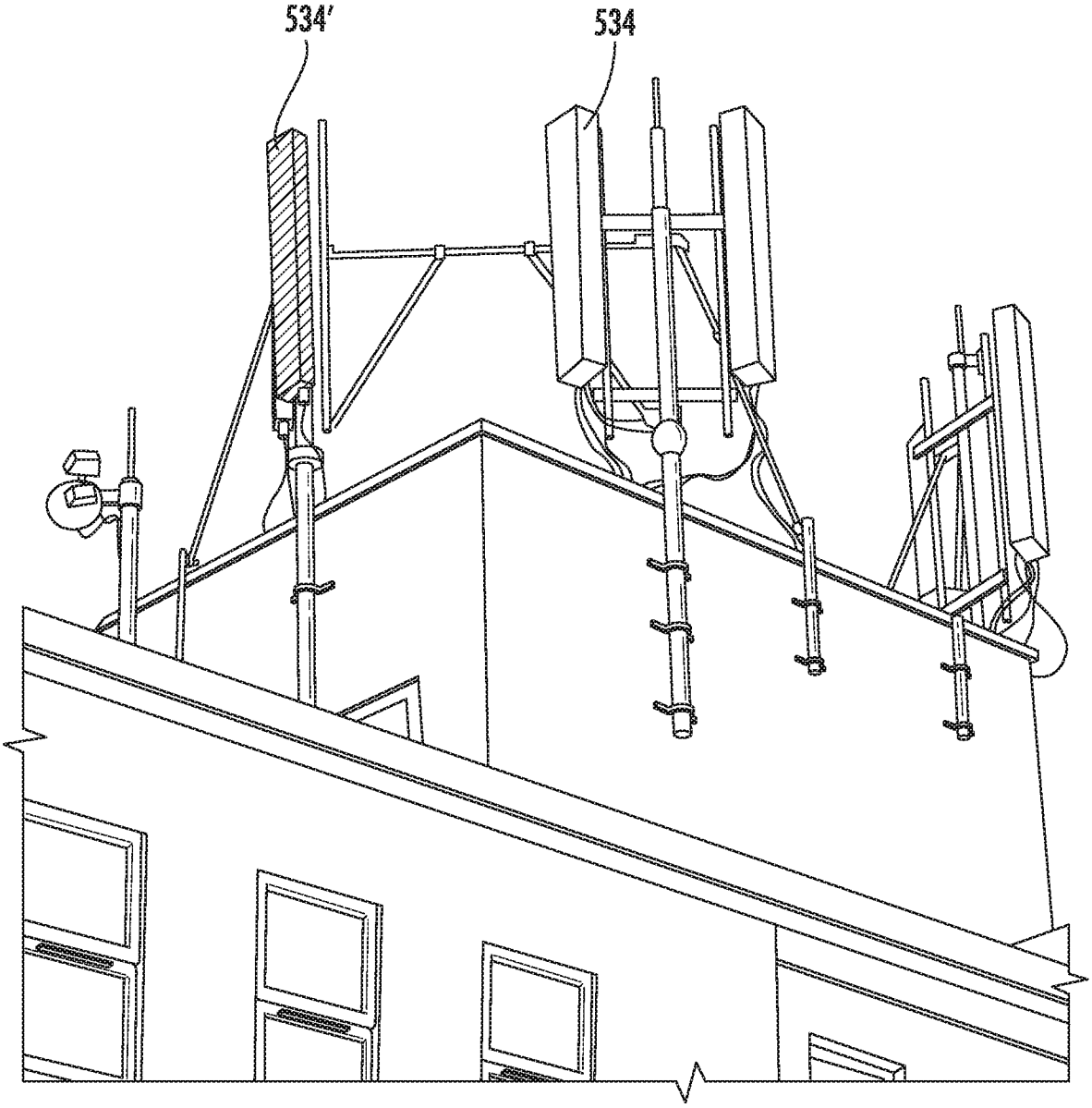


FIG. 15

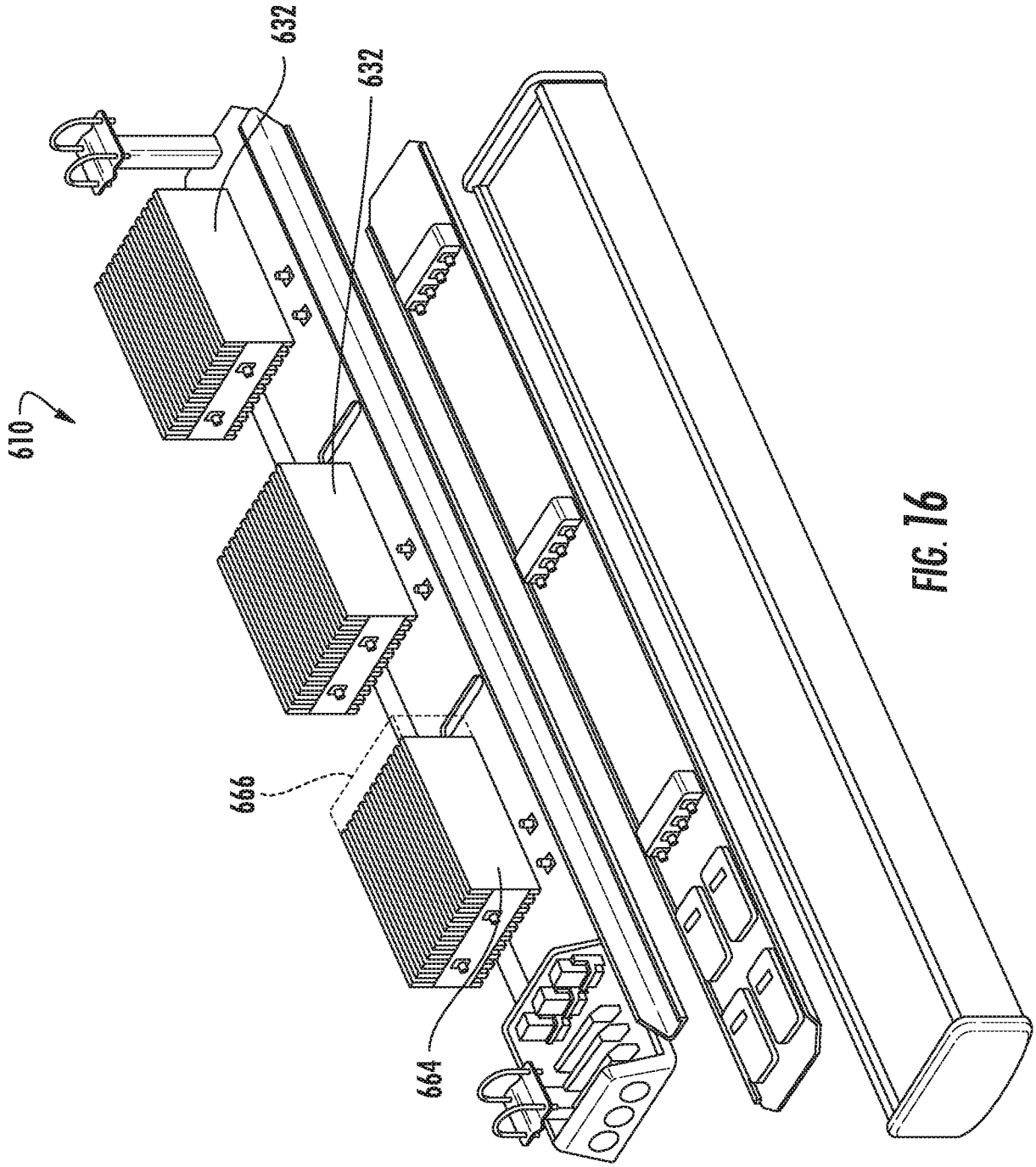


FIG. 16

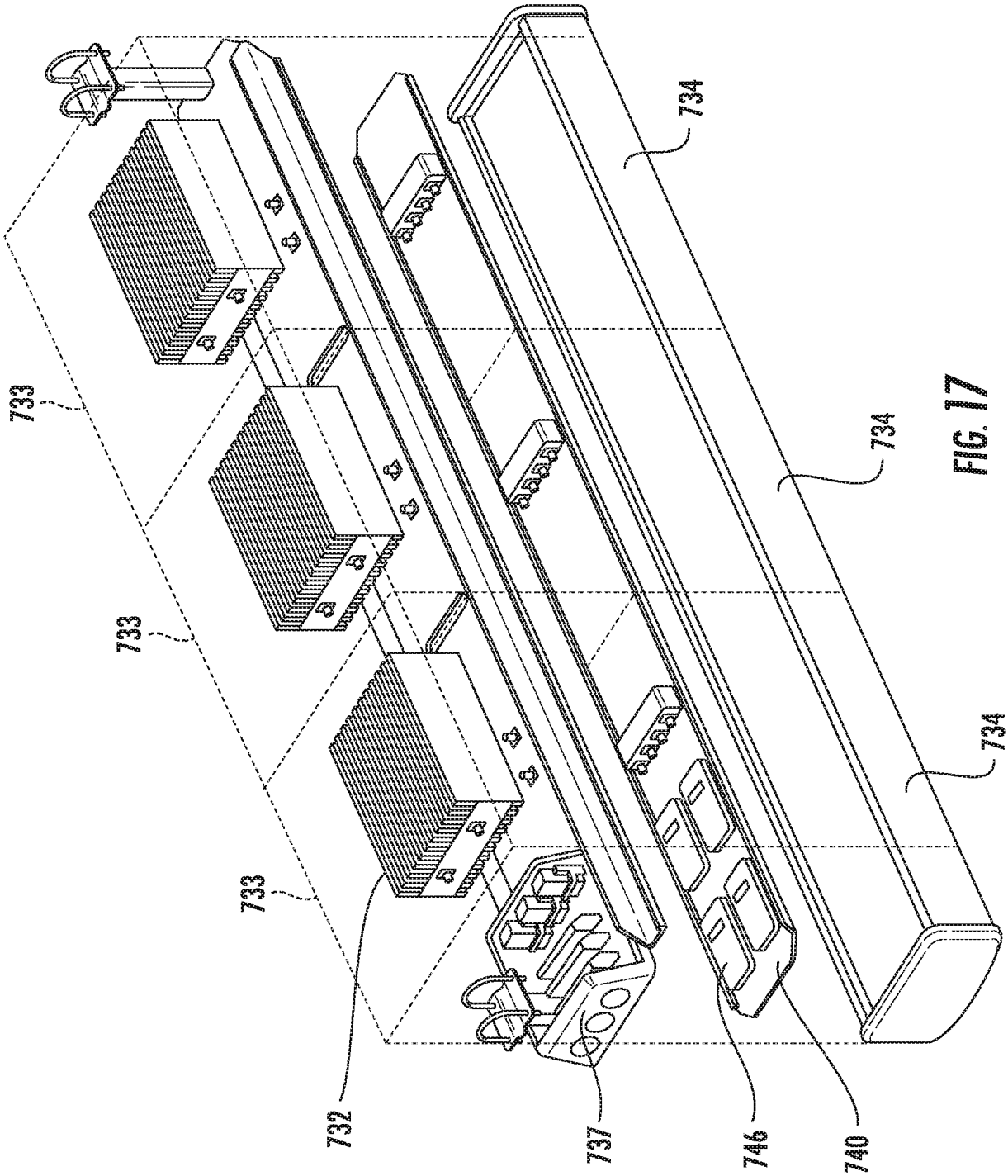


FIG. 17

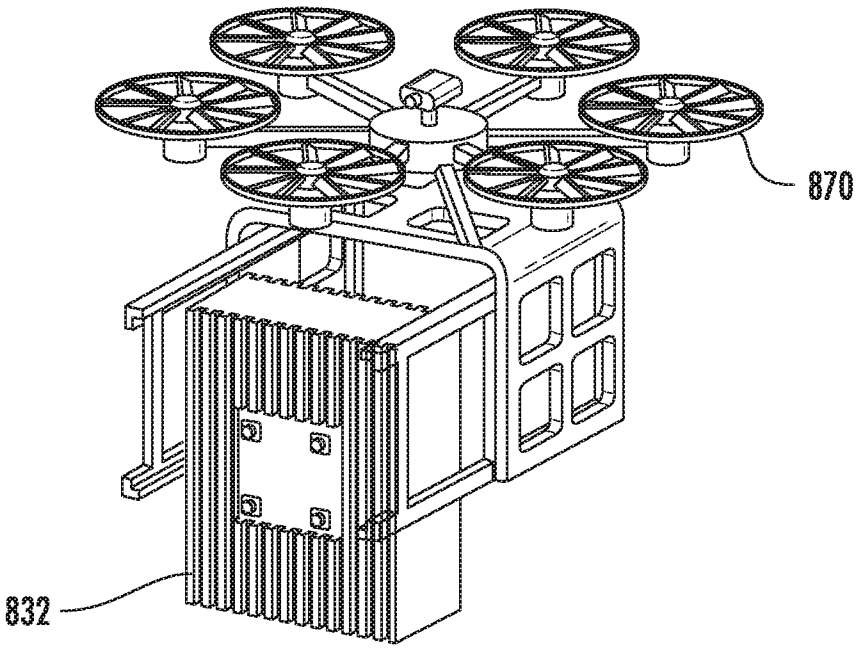


FIG. 18

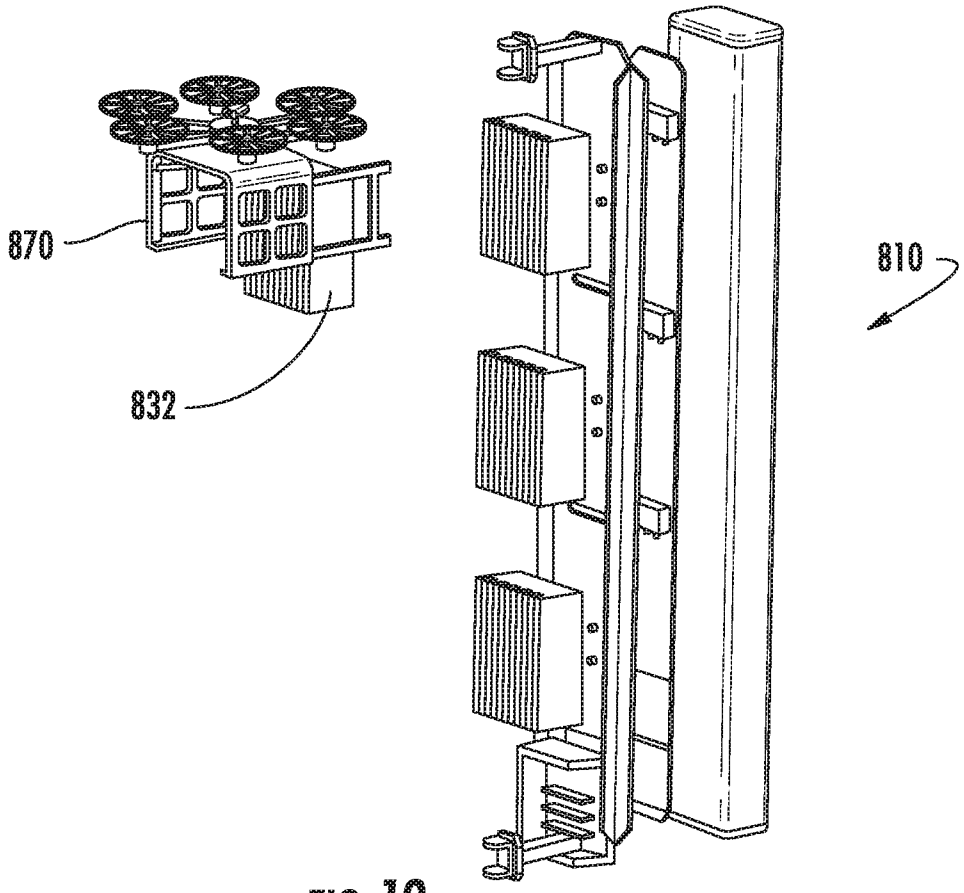


FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/041821

A. CLASSIFICATION OF SUBJECT MATTER

H04Q 1/08(2006.01)i, H04Q 1/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04Q 1/08; H02J 7/34; H01Q 3/01; H04W 88/08; E04C 3/30; H01Q 1/12; H04B 1/036; H04W 84/04; H01Q 3/26; H04Q 1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: antenna, remote radio unit, multi-sector, mounting, parallel, air, cover, ventilation, stack

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2015-095779 A1 (ANDREW LLC) 25 June 2015 See paragraphs [0031], [0034]-[0035], [0038], [0040], [0047] and figures 4-5, 7.	1-21
Y	WO 2015-072727 A1 (KMW INC.) 21 May 2015 See paragraphs [51], [56], [60], [66]-[67] and figures 3, 6, 8, 12-13, 19-20.	1-21
Y	US 2015-0080055 A1 (ANDREW LLC) 19 March 2015 See paragraphs [0033], [0053], [0055] and figure 9.	16,20-21
Y	US 2015-0017937 A1 (ANDREW LLC) 15 January 2015 See paragraphs [0014]-[0016] and figures 1A-3, 5A-6.	5-6,17-18
Y	US 2013-0225222 A1 (FUTUREWEI WEI TECHNOLOGIES, INC.) 29 August 2013 See paragraph [0033] and figure 2B.	19
A	US 2003-0205021 A1 (RALPH E. RYAN) 06 November 2003 See paragraphs [0023]-[0030] and figures 1-2.	1-21

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

☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2017 (12.10.2017)	**12 October 2017 (12.10.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/041821

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