



(43) **Pub. Date:** **Jan. 28, 2010**

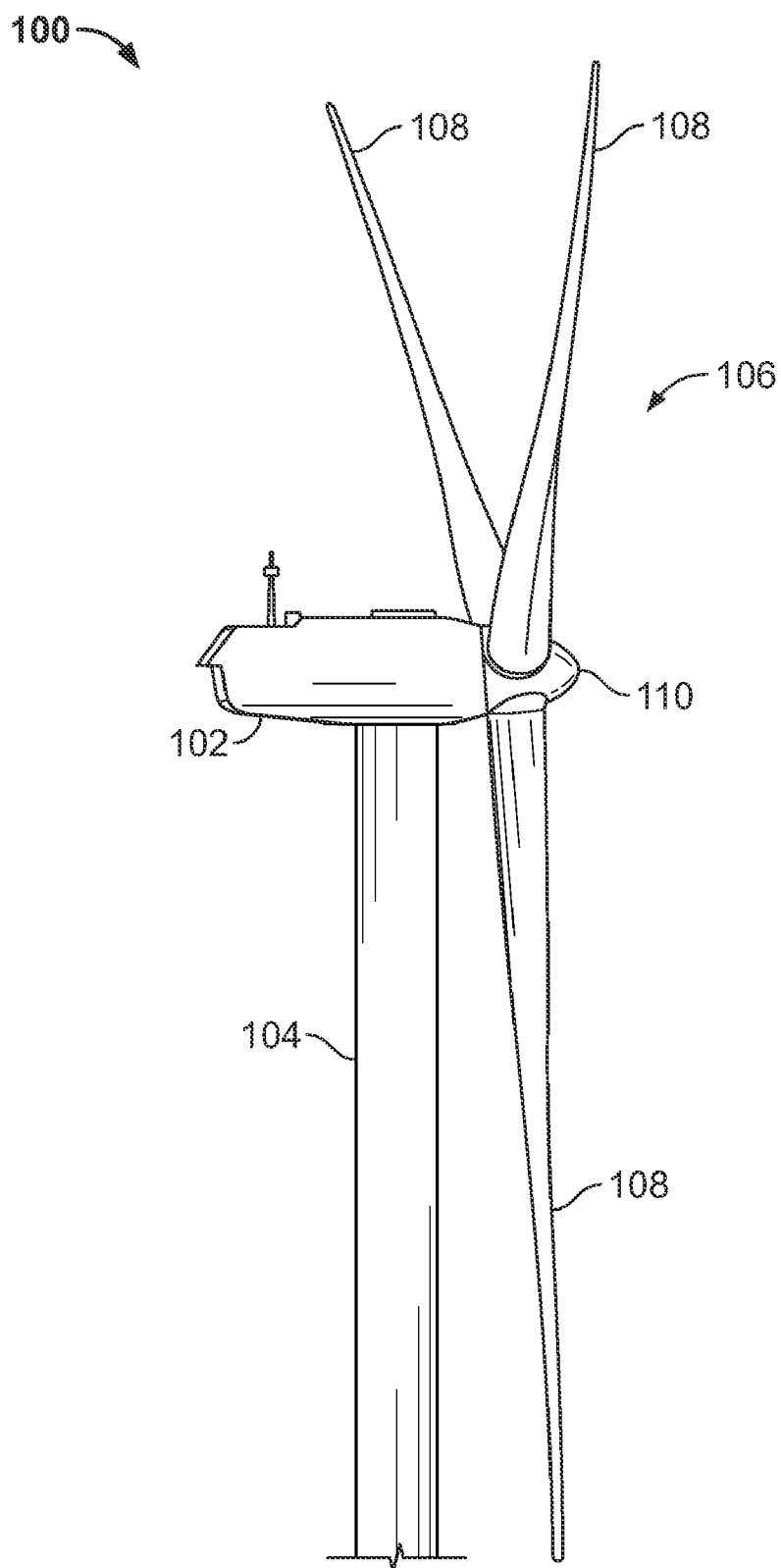


FIG. 1

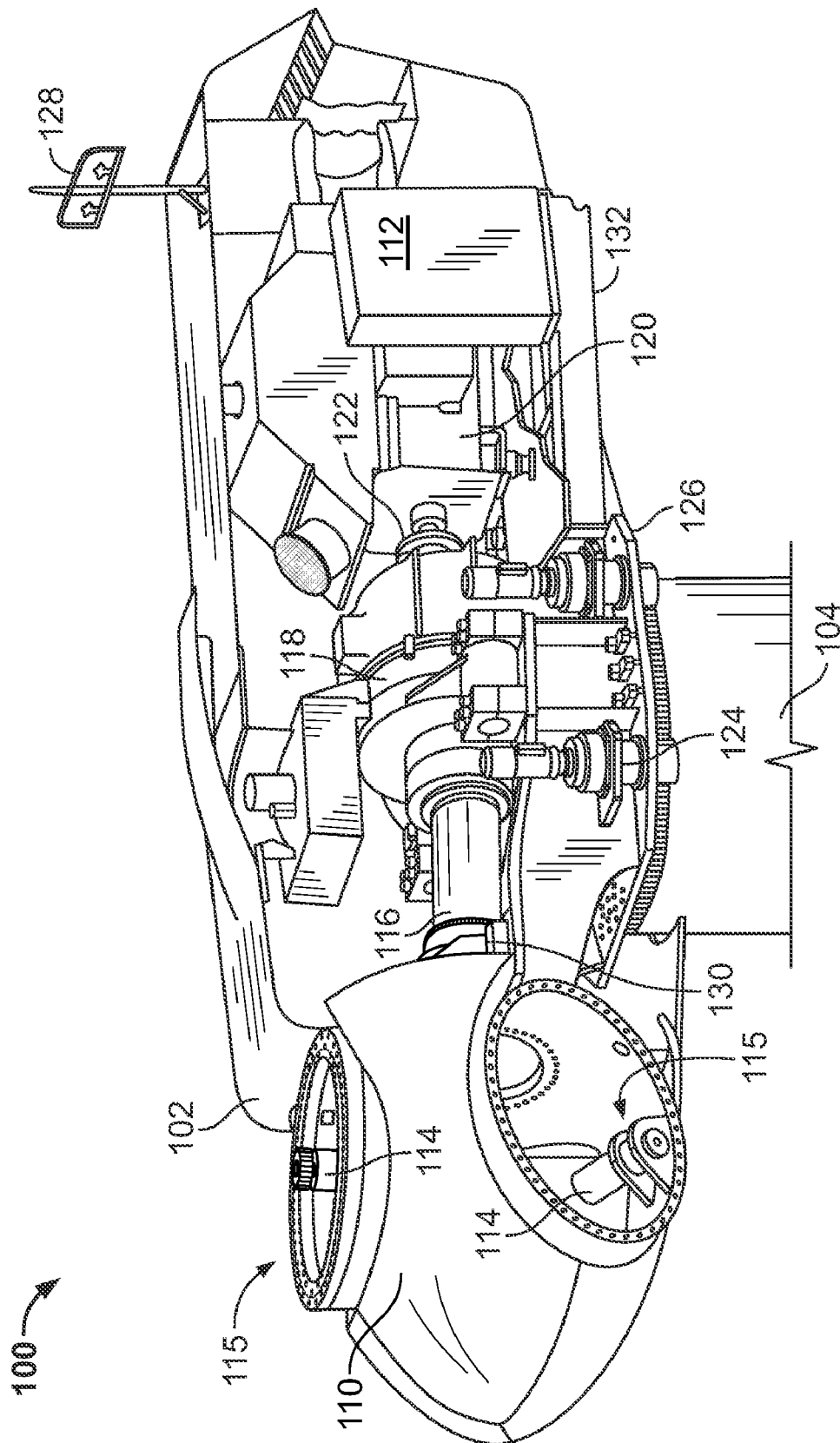


FIG. 2

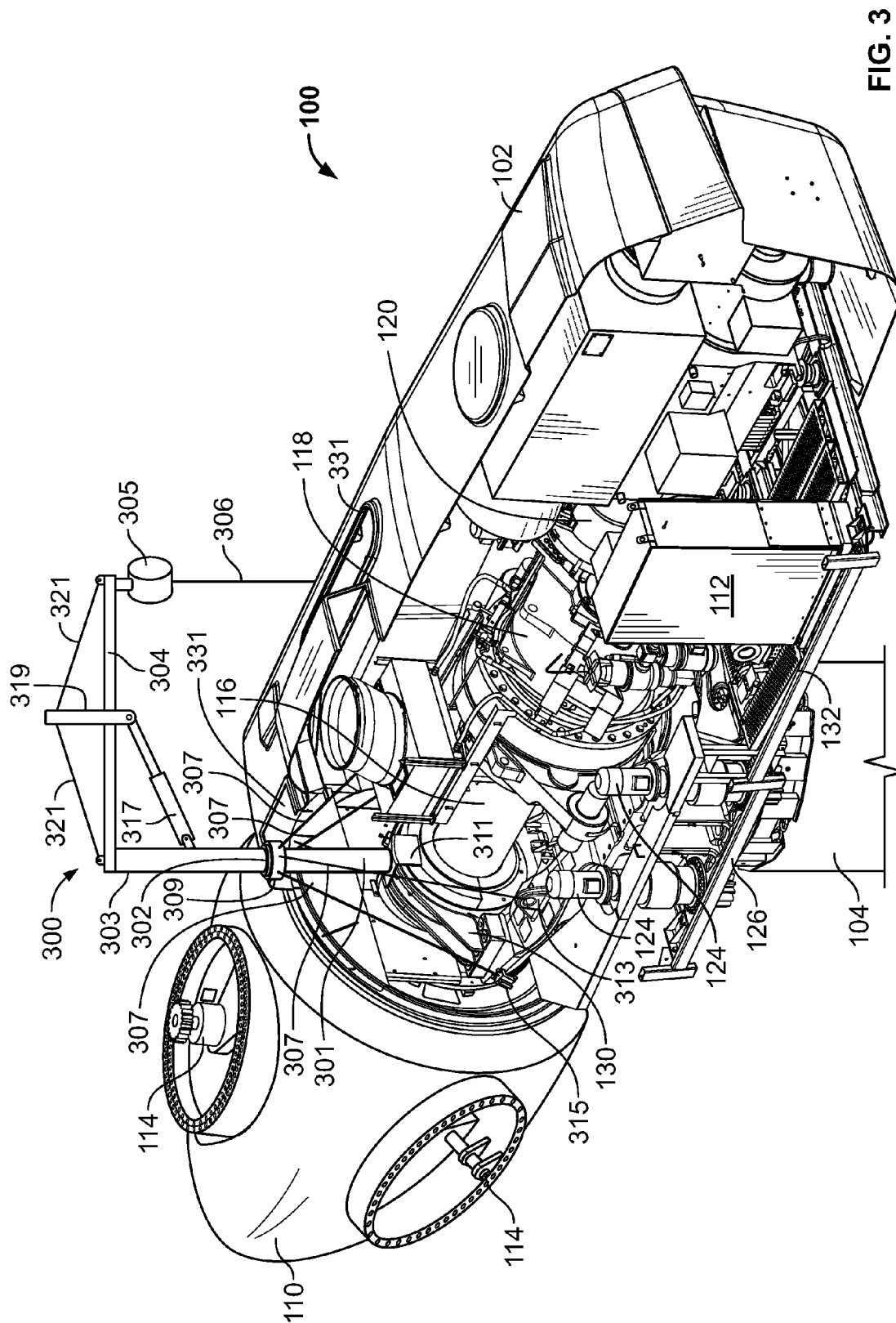


FIG. 3

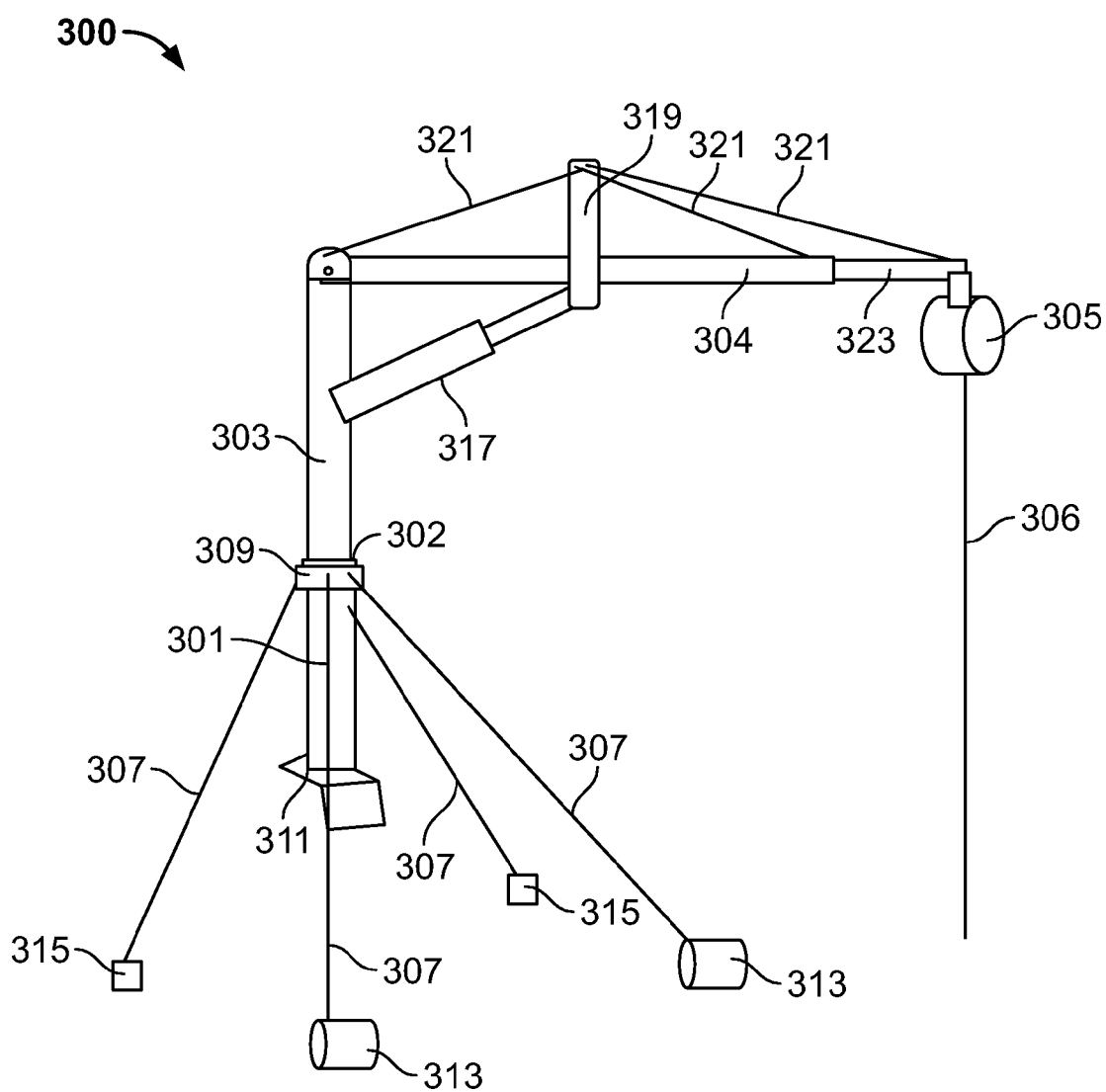


FIG. 4

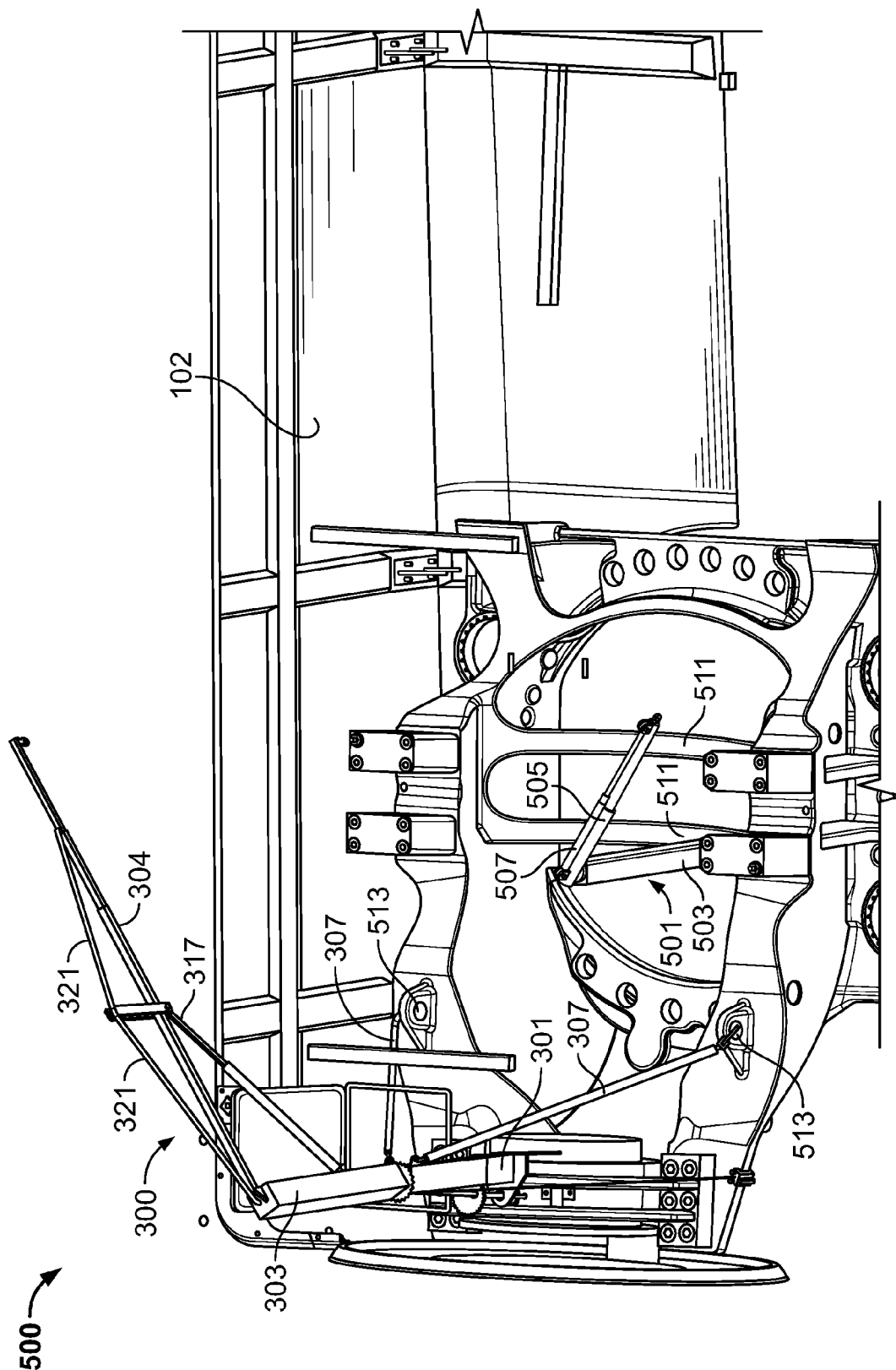


FIG. 5

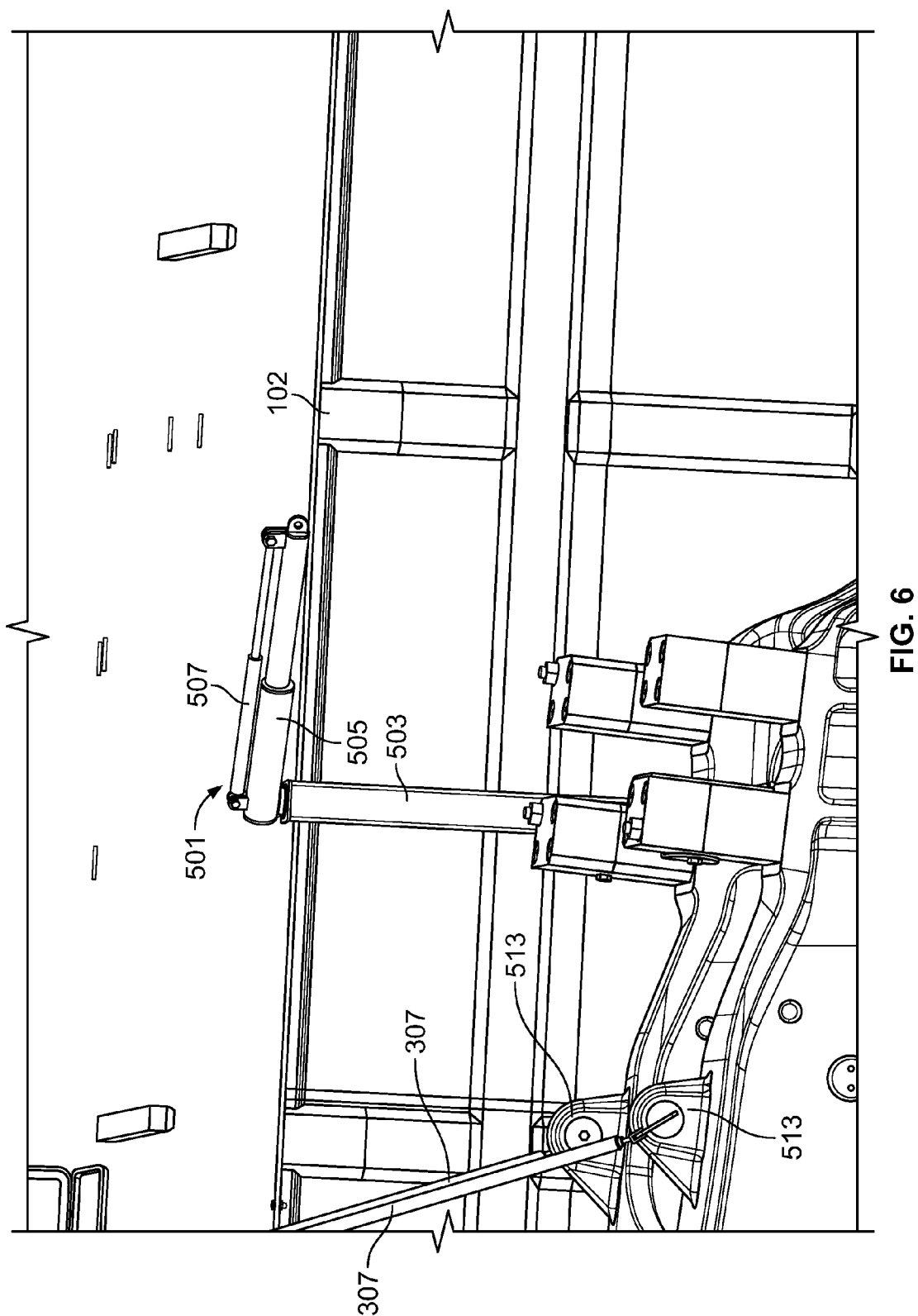


FIG. 6

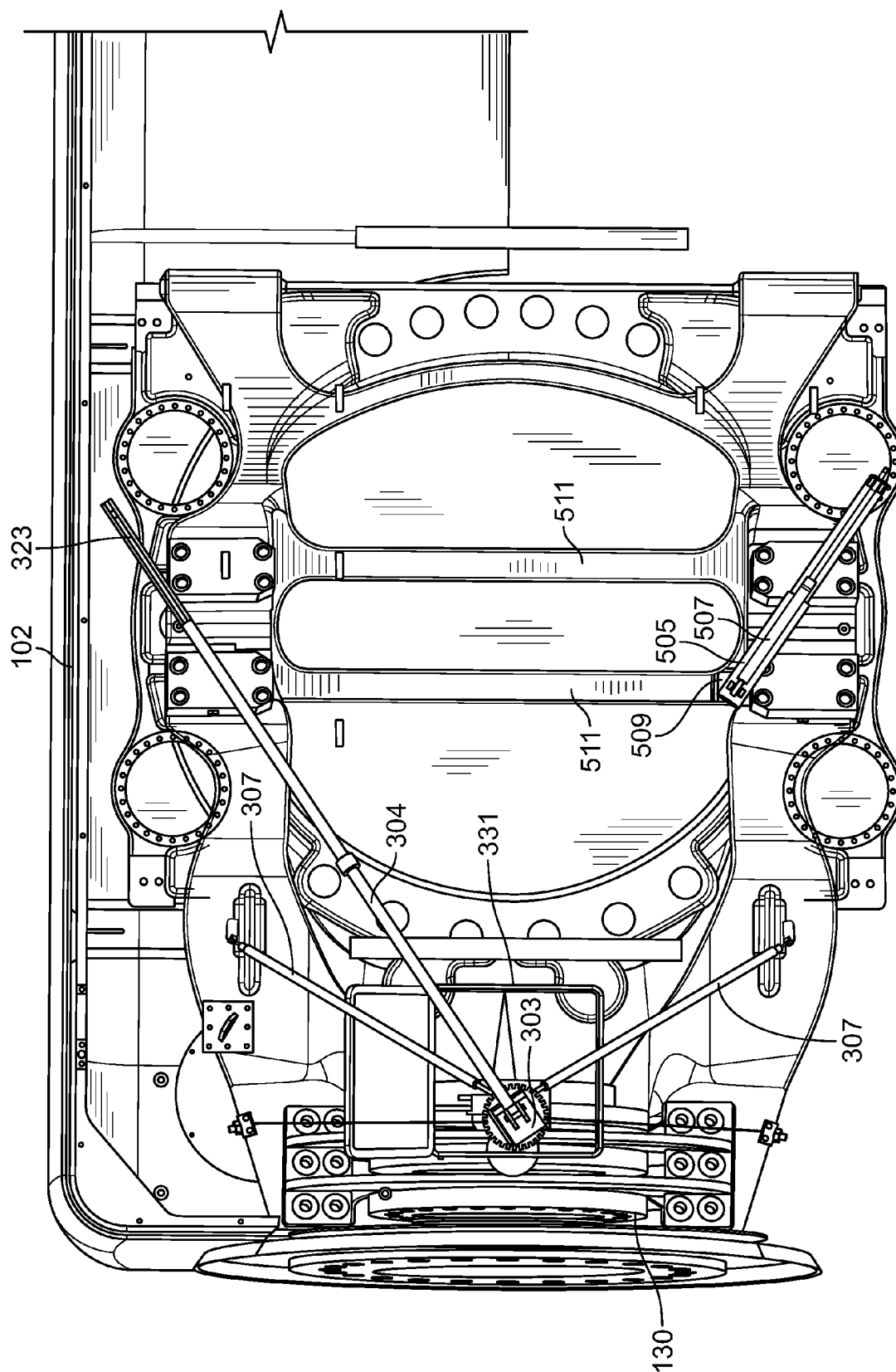


FIG. 7

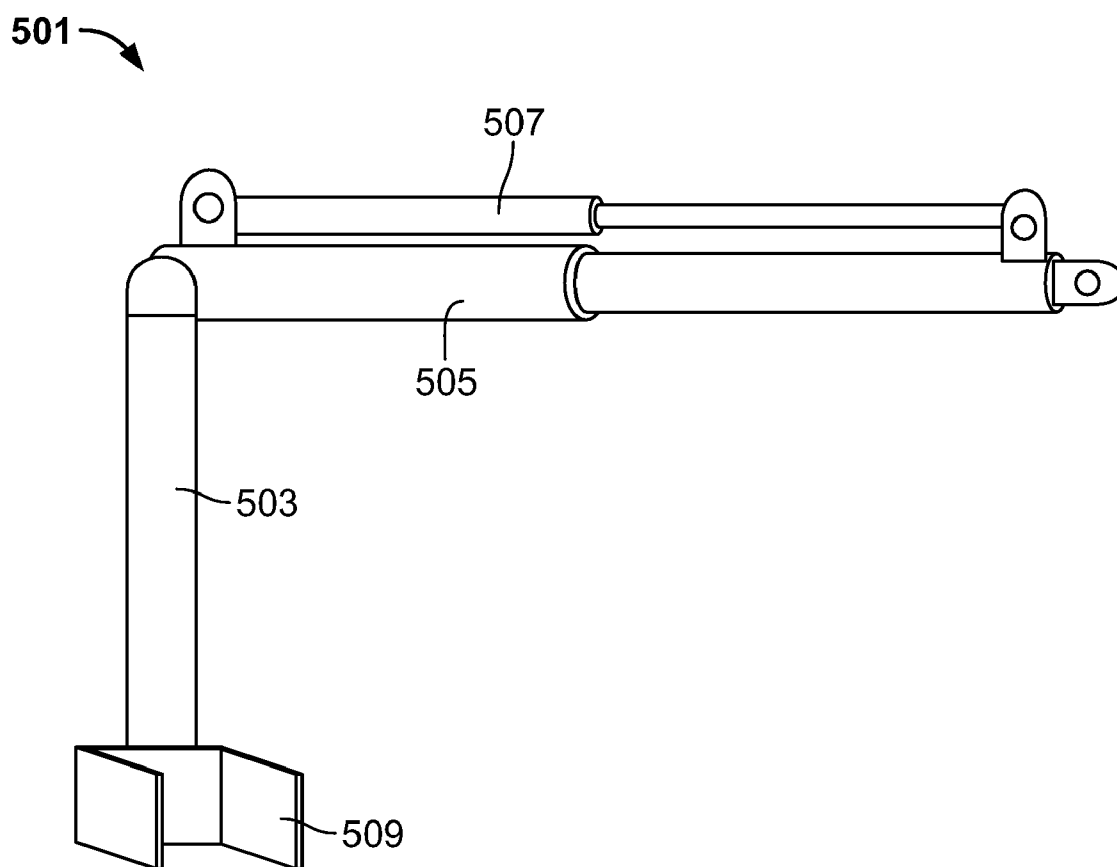


FIG. 8

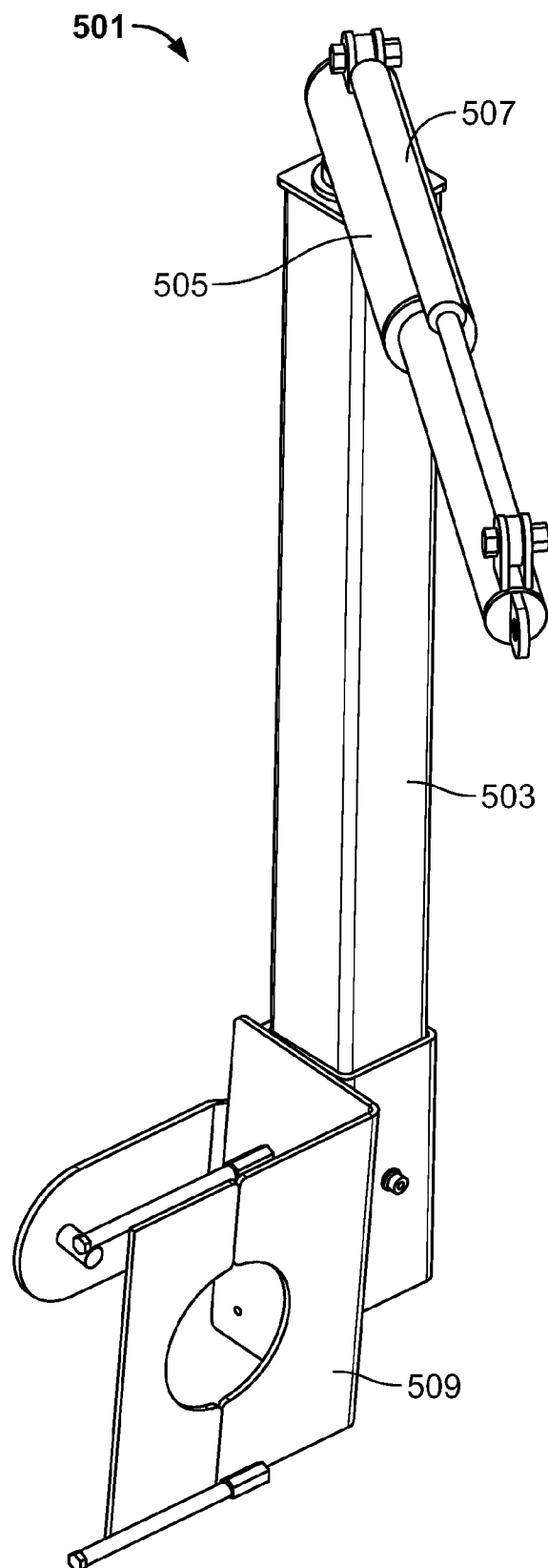


FIG. 9

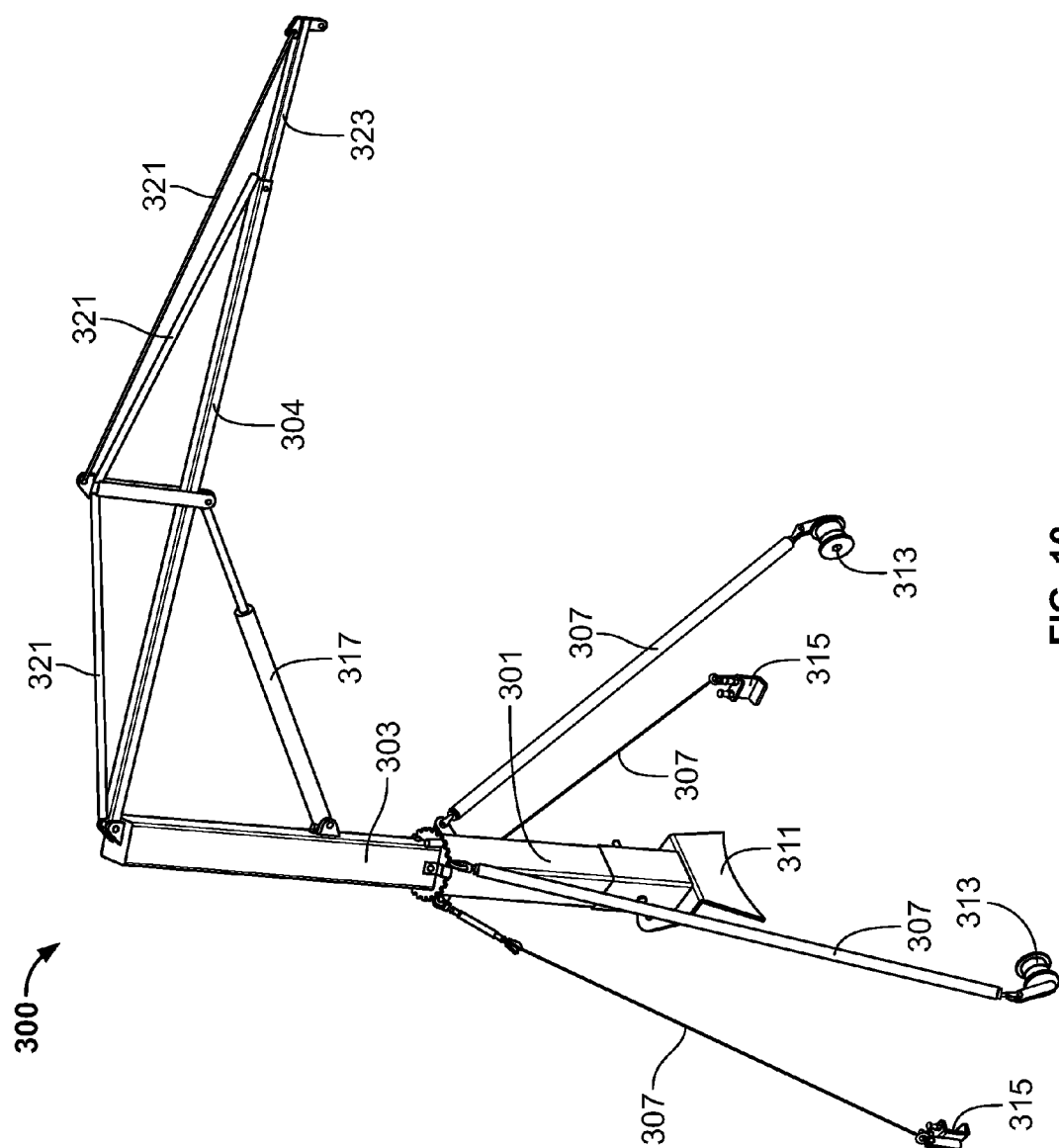


FIG. 10

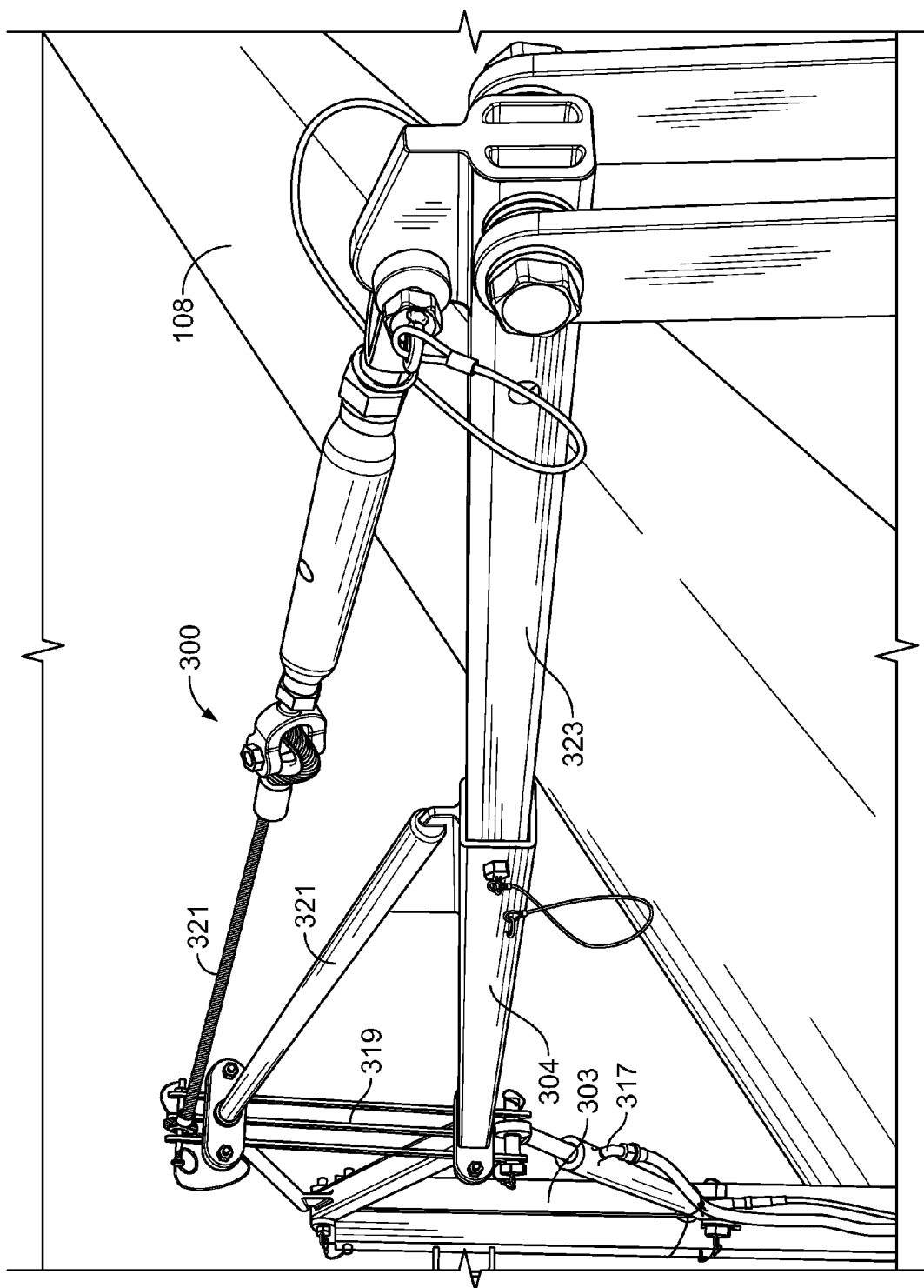


FIG. 11

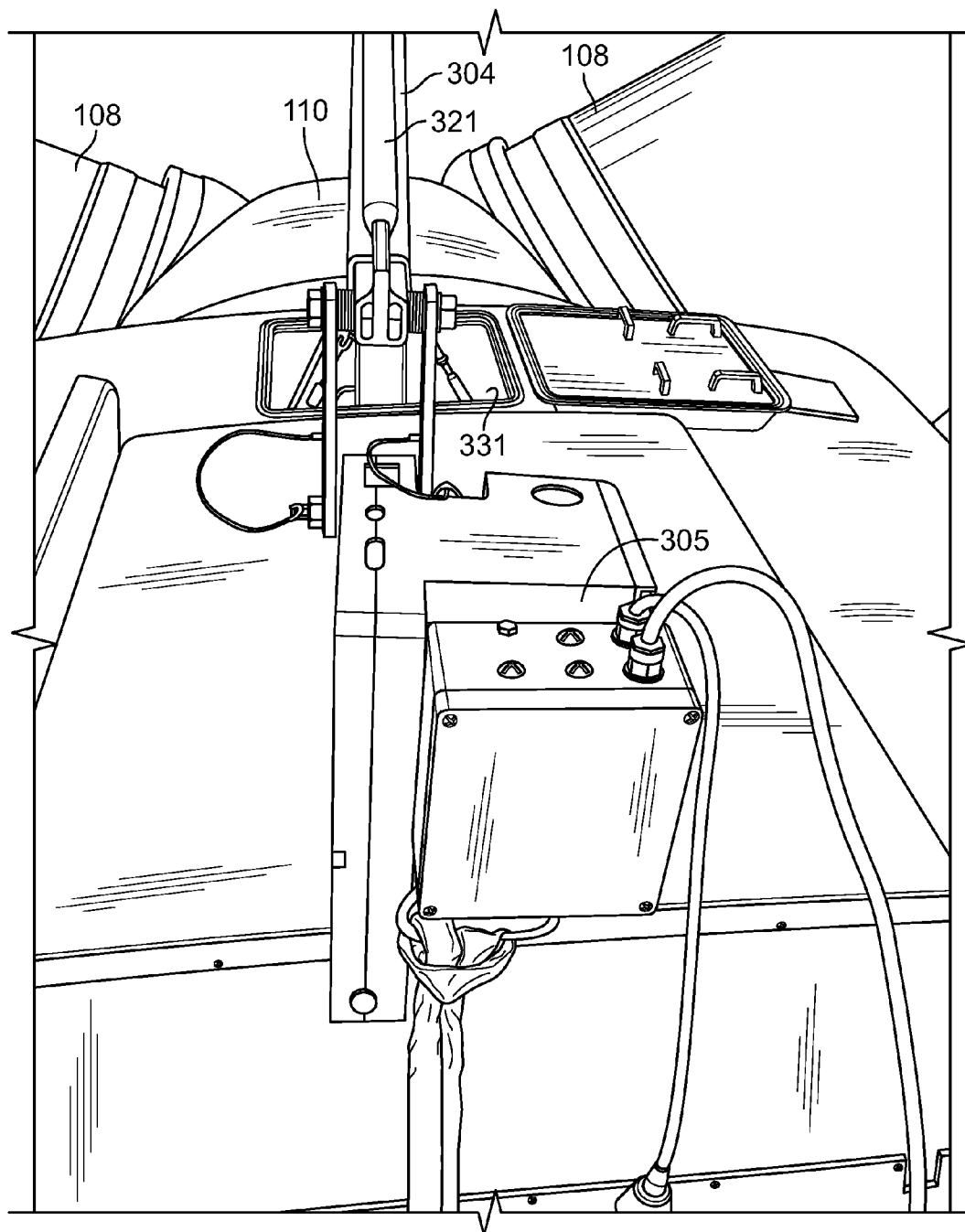


FIG. 12

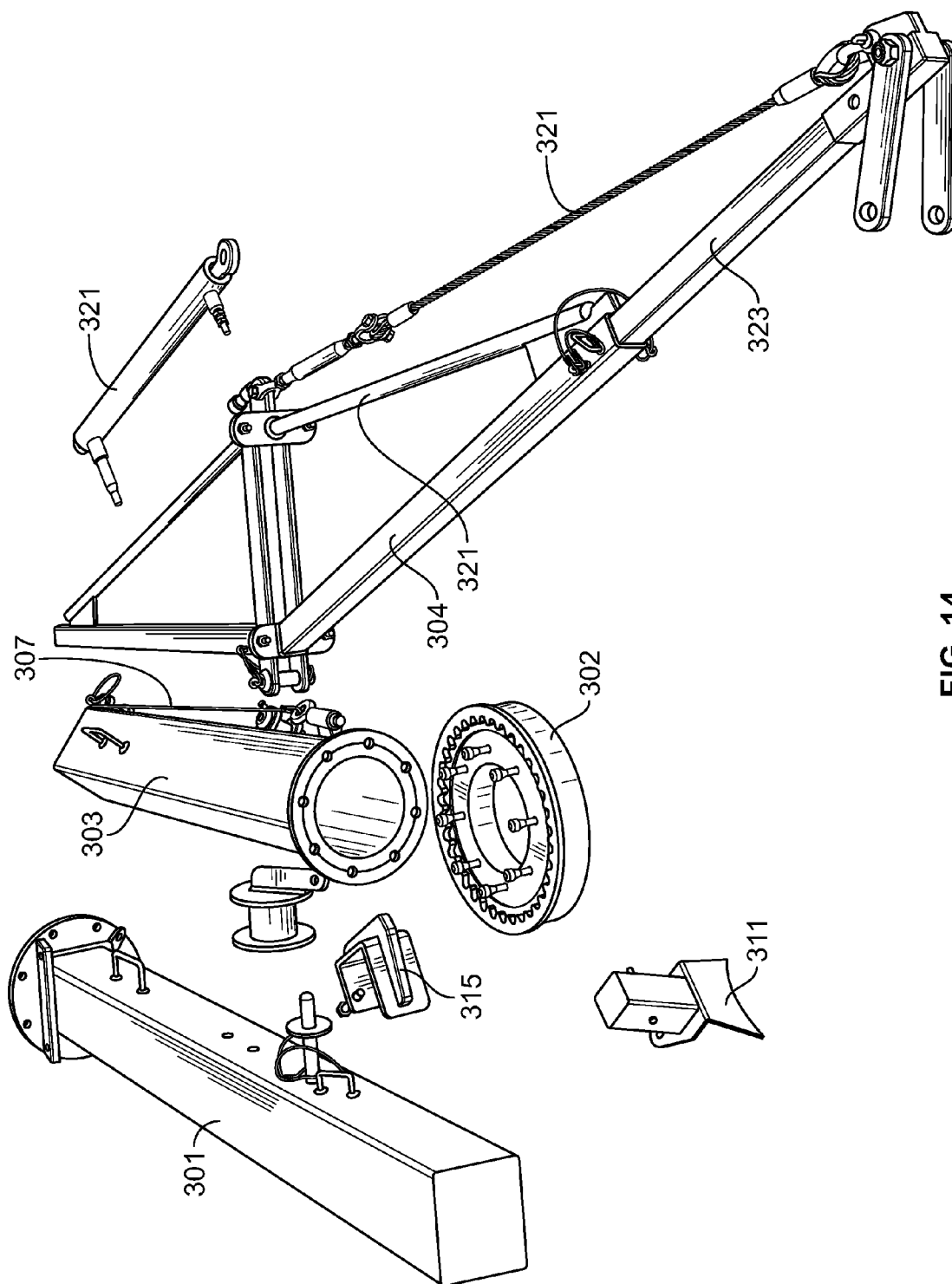


FIG. 14

PORTABLE CRANE SYSTEM FOR WIND TURBINE COMPONENTS

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/083,485, filed Jul. 24, 2008, which Application is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present disclosure is directed to crane assemblies and methods for servicing and installing wind turbines and components thereof.

BACKGROUND

[0003] Recently, wind turbines have received increased attention as environmentally safe and relatively inexpensive alternative energy sources. With this growing interest, considerable efforts have been made to develop wind turbines that are reliable and efficient.

[0004] Generally, a wind turbine includes a rotor having multiple blades. The rotor is mounted to a housing or nacelle, which is positioned on top of a truss or tubular tower. Utility grade wind turbines (i.e., wind turbines designed to provide electrical power to a utility grid) can have large rotors (e.g., 30 or more meters in length). In addition, the wind turbines are typically mounted on towers that are at least 60 meters in height. Blades on these rotors transform wind energy into a rotational torque or force that drives one or more generators that may be rotationally coupled to the rotor through a gearbox. The gearbox steps up the inherently low rotational speed of the turbine rotor for the generator to efficiently convert mechanical energy to electrical energy, which is fed into a utility grid. In order to provide the efficient conversion of mechanical energy to electrical energy, the wind turbine utilizes a variety of wind turbine components that are too heavy and/or awkward to manually carry, such as shafts, gearing components, pitch drives, generator components and other components within the wind turbine.

[0005] Components in the wind turbine typically have to be installed, serviced or replaced using mobile land-based cranes and/or manually carrying components to remove and/or replace components. Wind turbine components may be huge or awkward to handle, precluding manual transportation of the components. Further, wind turbines may be installed on uneven terrain and/or on very high towers (e.g., towers that are at least 60 meters in height) that are inaccessible to mobile land-based cranes. In addition, operation of mobile land-based cranes is expensive.

[0006] Therefore, what is needed is an inexpensive method and apparatus for installing, servicing or replacing components in wind turbines that is portable, lightweight and/or is capable of operation at the operating heights of wind turbines and in the various terrains in which wind turbines may be installed.

SUMMARY

[0007] One aspect of the present disclosure includes a portable crane assembly for servicing a wind turbine. The crane assembly includes a first primary support member and a second primary support member being rotatably attached to one another. The first primary support member is configured to

attach to a wind turbine component. The second primary support is coaxially rotatable with respect to the first primary support member. The crane assembly further includes a boom member pivotably attached to an end of the second primary support member. The portable crane assembly is disassemblable into components that can be manually carried.

[0008] Another aspect of the present disclosure includes a wind turbine servicing system having a first crane assembly and a second crane assembly arranged and disposed on a wind turbine. The first crane assembly includes a first primary support member and a second primary support member being rotatably attached to one another. The first primary support member is configured to attach to a wind turbine component. The second primary support is coaxially rotatable with respect to the first primary support member. The crane assembly further includes a boom member pivotably attached to an end of the second primary support member. The first and second crane assemblies are disassemblable into components that can be manually carried. The second crane assembly is arranged and disposed to permit manipulation of components within the wind turbine.

[0009] Still another aspect of the present disclosure is a method for servicing a wind turbine. The method includes assembling a first crane assembly on a wind turbine. The first crane assembly includes a first primary support member and a second primary support member being rotatably attached to one another. The first primary support member is configured to attach to a wind turbine component. The second primary support is coaxially rotatable with respect to the first primary support member. The crane assembly further includes a boom member pivotably attached to an end of the second primary support member. The first crane assembly is disassemblable into components that can be manually carried. A service load is lifted from the ground with the first crane assembly and providing the component to a hatch of the wind turbine. The service load is then positioned in a desired position.

[0010] An advantage of an embodiment of the present disclosure is that wind turbine components may be transported to and from a wind turbine safely and easily.

[0011] Another advantage of an embodiment of the present disclosure is the crane assembly is portable and may disassemble into components easily carried by installers and/or servicers.

[0012] Another advantage of an embodiment of the present disclosure is that the components may be transported to and from the wind turbine, even when the wind turbine is installed on rugged terrain or when installed offshore.

[0013] Another advantage of an embodiment of the present disclosure is the crane assembly is easily assembled onto existing wind turbines with few, if any, modifications required of current wind turbines.

[0014] Still another advantage of an embodiment of the present disclosure is that the lift and drop operation may be accomplished without requirement of full exposure of service personnel on top of nacelle hatch, which provides increase personnel safety.

[0015] Still another advantage of an embodiment of the present disclosure is that heavy and/or larger service tools may be brought up to the nacelle by easily attaching a lifting basket or other structure to the winch/lifting rope.

[0016] Other features and advantages of the present disclosure will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with

tion with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a drawing of an exemplary configuration of a wind turbine.

[0018] FIG. 2 is a cut-away perspective view of a nacelle of an exemplary wind turbine configuration.

[0019] FIG. 3 is a cut-away perspective view of a nacelle of another exemplary wind turbine configuration having a crane assembly installed.

[0020] FIG. 4 is a perspective view of a crane assembly according to an embodiment of the present disclosure.

[0021] FIG. 5 is a cut-away perspective view of a nacelle of another exemplary wind turbine configuration having a first crane assembly and second crane assembly installed.

[0022] FIG. 6 is a perspective view of a second crane assembly according to an embodiment of the disclosure.

[0023] FIG. 7 is a plan view of a nacelle of another exemplary wind turbine configuration having a first crane assembly and second crane assembly installed.

[0024] FIG. 8 is a perspective view of a second crane assembly according to an embodiment of the disclosure.

[0025] FIG. 9 is a perspective view of a second crane assembly according to another embodiment of the disclosure.

[0026] FIG. 10 is a perspective view of a crane assembly according to an embodiment of the present disclosure.

[0027] FIG. 11 is a perspective view of a crane assembly in an installed position according to another embodiment of the disclosure.

[0028] FIG. 12 is a perspective view of a crane assembly in an installed position according to another embodiment of the disclosure.

[0029] FIG. 13 is a perspective view of a crane assembly in an installed position according to another embodiment of the disclosure.

[0030] FIG. 14 is a perspective view of a disassembled crane according to another embodiment of the disclosure.

[0031] Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

DETAILED DESCRIPTION

[0032] The present disclosure now will be described more fully hereinafter with reference to the accompanying drawings, in which a preferred embodiment of the disclosure is shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the disclosure to those skilled in the art.

[0033] The present disclosure is related to a portable wind turbine servicing system including at least one crane assembly for use with a wind turbine that is easily assembled, portable, disassembles into lightweight easily transported components, and is capable of transporting various wind turbine components both to and from the wind turbine. As utilized herein, the “load” and “service load” include any component, device, or other load that may be lifted by the system of the present disclosure. As utilized herein, the “ground”, from which service loads may be lifted or dropped, is not limited to dry ground and may include any surface or water condition onto which the wind turbine may be mounted. For

example, the ground may be terrain, water (e.g. ocean or lake surface) or any other location onto which a wind turbine may be installed. Embodiments according to the disclosure can be adapted to cranes for multi megawatt turbines of rating 2.5 MW and higher on land and/or offshore installations.

[0034] As shown in FIG. 1, a wind turbine **100** generally comprises a nacelle **102** housing a generator (not shown in FIG. 1). Nacelle **102** is a housing mounted atop a tower **104**, only a portion of which is shown in FIG. 1. The height of tower **104** is selected based upon factors and conditions known in the art, and may extend to heights up to 60 meters or more. The wind turbine **100** may be installed on any terrain providing access to areas having desirable wind conditions. The terrain may vary greatly and may include, but is not limited to, mountainous terrain or offshore locations. Wind turbine **100** also comprises a rotor **106** that includes one or more rotor blades **108** attached to a rotating hub **110**. Although wind turbine **100** illustrated in FIG. 1 includes three rotor blades **108**, there are no specific limits on the number of rotor blades **108** required by the present disclosure.

[0035] As shown in FIG. 2, various components are housed in nacelle **102** atop tower **104** of wind turbine **100**. For example, a variable blade pitch drive **114** may control the pitch of blades **108** (not shown in FIG. 2) that drive hub **110** as a result of wind. Hub **110** may be configured to receive three blades **108**, but other configurations may utilize any number of blades. In some configurations, the pitches of blades **108** are individually controlled by blade pitch drive **114**. Hub **110** and blades **108** together comprise wind turbine rotor **106**.

[0036] The drive train of the wind turbine **100** includes a main rotor shaft **116** (also referred to as a “low speed shaft”) connected to hub **110** via main bearing **130** and (in some configurations), at an opposite end of shaft **116** to a gear box **118**. Gear box **118**, in some configurations, utilizes a dual path geometry to drive an enclosed high-speed shaft. In other configurations, main rotor shaft **116** is coupled directly to generator **120**. The high-speed shaft (not shown in FIG. 2) is used to drive generator **120**, which is mounted on mainframe **132**. In some configurations, rotor torque is transmitted via coupling **122**. Generator **120** may be of any suitable type, for example and without limitation, a wound rotor induction generator or a direct drive permanent magnet generator. Yaw drive **124** and yaw deck **126** provide a yaw orientation system for wind turbine **100** to rotate the wind turbine to a position that faces the wind. Meteorological boom **128** provides information for a turbine control system, including wind direction and/or wind speed. In some configurations, the yaw system is mounted on a flange provided atop tower **104**.

[0037] The individual components within nacelle **102**, as discussed above, may require servicing and/or replacement from time to time, either as a part of a regular maintenance schedule or due to malfunction or damage. The present disclosure includes installing a crane assembly **300** extending through hatch **331** to install/remove and lower/raise components from the ground to the wind turbine **100**.

[0038] FIG. 3 shows a cutaway view of a wind turbine **100** with a first crane assembly **300** according to an embodiment of the present disclosure installed. As also shown in FIG. 4 and 10, the first crane assembly **300** includes a first primary support member **301** and a second primary support member **303** rotatably attached to each other. The first crane assembly **300** further includes a boom member **304** pivotably attached to the second primary support member **303**. The first primary

support member **301** and the second primary support member **301** are attached such that the second primary support member **303** is permitted to coaxially rotate with respect to the first primary support member **301**. The rotation may be facilitated by any suitable junction **302**, including, but not limited to frictional interfaces, bearing arrangements or other structures that permit rotation. The first crane assembly **300** extends through hatch **331** and provides lifting of components to/from other hatches **331** in the nacelle **102**.

[0039] The first primary support member **301** is attached to the wind turbine by attachment plate **311**. Attachment plate **311** is configured to mate, attach or otherwise fasten to a component of the wind turbine **100**. While not so limited, the attachment plate **311** may attach to or replace existing components, and utilize existing fastening locations. In one embodiment, the attachment plate **311** may be attached to existing footplates of main bearing **130**.

[0040] The first and second primary support members **301**, **303** are additionally supported by secondary support members **307**. The secondary support members **307** may be a bar, wire, cable, rope, chain, strap or any other elongated device capable of supporting the first and second primary support members **301**, **303**. Secondary support members **307** are affixed to the first primary support member **301** by collar **309**. Collar **309** attaches to first primary support member **301** and support member **307** in any suitable manner and provides support. The support member **307** attaches to wind turbine **100** by secondary support fasteners **313** and secondary support clamps **315**. While not so limited, the secondary support fasteners **313** may fasten to existing lifting eyes **513** (see e.g. FIG. 5) of the wind turbine **100**. In addition, secondary support clamps **315** may be clamped or otherwise fastened to lips, features or surfaces within the wind turbine **100** that provide a desired angle providing support for the first and second primary support members **301**, **303**. The secondary support members **307** are preferably configured at an angle and connected to the first and second primary support members **301**, **303** such that sufficient support is provided that wind turbine components of significant weight may be lifted by the lift member **305**. In one embodiment, the secondary support members **307** are configured to provide sufficient support for first and second primary support members **301**, **303** to lift components from wind turbine **100** to and/or from the surface.

[0041] Boom member **304** is pivotably attached to an end of the second primary support member **303**. A boom actuator **317** is attached to second primary support member **303** and boom member **304**. Boom actuator **317** may include a hydraulic drive or piston, electrically driven actuator or other device capable of pivoting boom member **304** to desired angles with respect to the first and second primary support members **301**, **303**. The boom actuator **317** is attached to boom member **304** by boom support **319**. However, the disclosure is not so limited and may include other arrangements, including direct attachment of the boom actuator **317** to the boom member **304**.

[0042] Boom member **304** is additionally supported by secondary boom supports **321**. The secondary boom supports **321** may be a bar, wire, cable, rope, chain, strap or any other elongated device capable of supporting the boom member **304**. Boom member extension **323** extends from boom member **304** and provides additional length for lifting. Like boom member **304**, the boom member extension **323** is supported by secondary boom supports **321**. The boom member extension

323 may be actuatable by any suitable method, including by electric or hydraulic drives or by hand. In one embodiment, the boom member extension **323** may be actuated by hand and retained in position by a pin or other fastener.

[0043] A lift member **305** is disposed at an end of boom member **304**. The lift member **305** may include a winch, lift, chain drive or any other lifting mechanism that is capable of being supported by boom member **304** and lifting wind turbine components. Line **306** extends from lift member **305** and is attachable to turbine components that require lifting. Line **306** may be a wire, cable, rope, chain or any other elongated device for lifting. In addition, the lift member **305** provides a length of line **306** sufficiently long to lower wind turbine components to the ground from above hub **110** of the wind turbine **100**. The position of lift member **305** is not limited to the end of boom member **304** and may be disposed in any location that permits lifting of components. For example, lift member **305** may be mounted on second primary support member **303** and line **306** may be guided by pulleys or other structures to the end of boom member **304**. In other embodiments, the lift member **305** may utilize auxiliary components, such as spring loaded coiling drums or similar devices for line management and deployment. First crane assembly **300** provides 360° rotation about the axis passing through the first and second primary support members **301**, **303**.

[0044] FIG. 5 shows a wind turbine servicing system **500** having a first crane assembly **300** and a second crane assembly **501** according to an embodiment of the present disclosure wherein the components within the nacelle **102** have been removed. As also shown in FIG. 6-9, the second crane assembly **501** includes a post member **503** and extendable swing member **505**. The extendable swing member **505** being extendable via a telescoping cylinder or similar structure that permits extension of the swing member **505**. The second crane assembly **501** includes a swing member actuator **507** which may drive the extendable swing member **505** in any suitable manner, including hydraulic or electric drive. The swing member **505** is rotatably attached to the post member **503** and allows the swing member **505** to lift, manipulate and move components within the nacelle **102**. The second crane assembly **501** is capable of 360° rotation, allowing swing member **505** to lift and swing a load through a full circular path. In addition, the swing member **505** may be operated to provide components to and/or from the primary crane assembly **300**. The second crane assembly **500** includes an attachment member **509** (see FIG. 8 and 9). The attachment member **509** is configured to clamp, engage, interlock or otherwise attach to a component within the nacelle **102**. As shown in FIGS. 5 and 7, the second crane assembly **501** is clamped to torque arms **511**. However, the present disclosure is not so limited and the second crane assembly **501** may be attached in any suitable location within the nacelle **102** to transfer and position components within the nacelle **102**.

[0045] FIGS. 11-13 show a first crane assembly **300** in an installed position, wherein the first crane assembly **300** extends through a hatch **331**. While not limited the particular configuration shown, hatches **331** may include a main hatch near the hub **110**, through which the primary crane assembly **300** extends and side hatches along top edges of the nacelle **102**. The present disclosure may be utilized with any configuration of hatches **331** that permit the first crane assembly **300** to extend therethrough and to which hatches **331** may access individual components for lifting. The wind turbine servicing system **500** according to the present disclosure permits installation

lation and/or removal of a variety of components. For example, the first crane assembly 300 may lift and install/remove components such as, but not limited to, blade pitch drives 114, yaw drives 124, pitch batteries, brake disks, high speed shaft couplings, oil coolers, oil filters, oil pumps, generator components, such as the generator commutator, or brush holder assembly, gearbox bearings, generator bearings, controller components, cables, and large and/or heavy service tools, such as ladders. In embodiments utilizing larger hatch openings or a removable nacelle panels, the first crane assembly 300 may lift and install/remove components such as, but not limited to, complete generator coolers, complete generator assemblies, and gearbox housings.

[0046] FIG. 14 shows a first crane assembly 300 in an unassembled configuration. The individual components of the first crane assembly 300 and the second crane assembly 501 preferably do not exceed about 30 kg and are sufficiently lightweight and sufficiently small to be handled manually. More specifically, the components of the first crane assembly 300 and second crane assembly 501 would be sufficiently disassemblable to permit the individual components to be carried by hand.

[0047] While the disclosure has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

1. A portable crane assembly for servicing a wind turbine comprising:

- a first primary support member and a second primary support member being rotatably attached to one another, the first primary support member being configured to attach to a wind turbine component, the second primary support being coaxially rotatable with respect to the first primary support member;
- a boom member being pivotably attached to an end of the second primary support member; and
- wherein the portable crane assembly is disassemblable into components that can be manually carried.

2. The portable crane assembly of claim 1, wherein the components that can be manually carried are less than about 30 kg.

3. The portable crane assembly of claim 1, wherein the second primary support member is rotatable 360° with respect to the first primary support member.

4. The portable crane assembly of claim 1, wherein the portable crane assembly is capable of lifting components selected from the group consisting of blade pitch drives, yaw drives, pitch batteries, brake disks, high speed shaft couplings, oil coolers, oil filters, oil pumps, generator components, gearbox bearings, generator bearings, controller components, cables, large and/or heavy service tools and combinations thereof.

5. The portable crane assembly of claim 1, wherein the portable crane assembly is capable of lifting components

selected from the group consisting of complete generator coolers, complete generator assemblies, gearbox housings and combinations thereof.

6. A wind turbine servicing system comprising:

- a first crane assembly and a second crane assembly arranged and disposed on a wind turbine, the first crane assembly comprising:

- a first primary support member and a second primary support member being rotatably attached to one another, the first primary support member being configured to attach to a wind turbine component, the second primary support being coaxially rotatable with respect to the first primary support member;

- a boom member being pivotably attached to an end of the second primary support member; and

- wherein the first and second crane assemblies are disassemblable into components that can be manually carried; and

- the second crane assembly is arranged and disposed to permit manipulation of components within the wind turbine.

7. The wind turbine servicing system of claim 6, wherein the components that can be manually carried are less than about 30 kg.

8. The wind turbine servicing system of claim 6, wherein the second primary support member is rotatable 360° with respect to the first primary support member.

9. The wind turbine servicing system of claim 6, wherein the portable crane assembly is capable of lifting components selected from the group consisting of blade pitch drives, yaw drives, pitch batteries, brake disks, high speed shaft couplings, oil coolers, oil filters, oil pumps, generator components, gearbox bearings, generator bearings, controller components, cables, large and/or heavy service tools and combinations thereof.

10. The wind turbine servicing system of claim 6, wherein the portable crane assembly is capable of lifting components selected from the group consisting of complete generator coolers, complete generator assemblies, gearbox housings and combinations thereof.

11. A method for servicing a wind turbine comprising:

- assembling a first crane assembly on a wind turbine, the first crane assembly comprising:

- a first primary support member and a second primary support member being rotatably attached to one another, the first primary support member being configured to attach to a wind turbine component, the second primary support being coaxially rotatable with respect to the first primary support member;

- a boom member being pivotably attached to an end of the second primary support member;

- wherein the first crane assembly is disassemblable into components that can be manually carried; and

- lifting a service load from the ground with the first crane assembly and providing the component to a hatch of the wind turbine; and

- positioning the service load into a desired position.

12. The method of claim 11, further comprising assembling a second crane assembly to permit manipulation of components within the wind turbine

13. The method of claim 12, further comprising transferring the service load from the first crane assembly to the second crane assembly prior to positioning the service load

14. The method of claim **11**, wherein the service load is a wind turbine component.

15. The method of claim **11**, further comprising dropping the service load to the ground from the hatch with the first crane assembly.

16. The wind turbine servicing system of claim **11**, wherein the wind turbine component is selected from the group consisting of blade pitch drives, yaw drives, pitch batteries, brake disks, high speed shaft couplings, oil coolers, oil filters, oil pumps, generator components, gearbox bearings, generator

bearings, controller components, cables, large and/or heavy service tools and combinations thereof.

17. The method of claim **16**, wherein the wind turbine component is a blade pitch drive or yaw drive.

18. The wind turbine servicing system of claim **11**, wherein the wind turbine component is selected from the group consisting of complete generator coolers, complete generator assemblies, gearbox housings and combinations thereof.

* * * * *