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(71) Ansøger:
VESTAS WIND SYSTEMS A/S, Hedeager 42, 8200 Århus N, Danmark

(72) Opfinder:
Henrik Petersen, Skolesvinget 13, 8700 Horsens, Danmark
Claus Overgaard, Stationsvej 31, Stevnstrup, 8870 Langå, Danmark

(74) Fuldmægtig:
Vestas Wind Systems A/S Patents Department, Hedeager 42, 8200 Århus N, Danmark

(54) Titel: **METHOD AND SYSTEM FOR LIFTING A WIND TURBINE COMPONENT**

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(57) Sammendrag:
A method of handling a component of a wind turbine includes suspending the component in a suspended orientation via a first lifting arrangement, recording a position of the first lifting arrangement relative to the component when the component is in the suspended orientation, and installing the component on the wind turbine. The method may further include recalling the recorded position, arranging a second lifting arrangement at the recorded position relative to the component, dismantling the component from the wind turbine, and suspending the component in the suspended orientation via the second lifting arrangement.

Fortsættes...

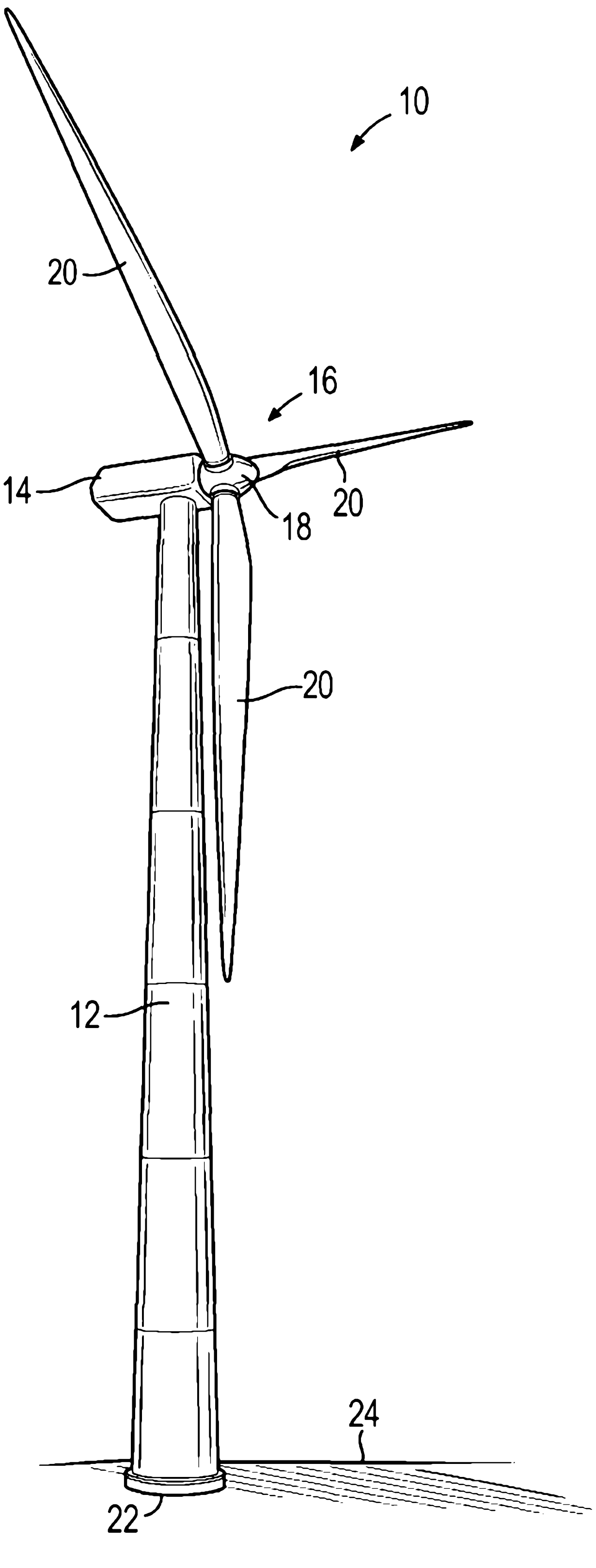

FIG. 1

METHOD AND SYSTEM FOR LIFTING A WIND TURBINE COMPONENT

Technical Field

[0001] This invention generally relates to wind turbines, and more particularly to an improved method and system for lifting a wind turbine component.

Background

[0002] Wind turbines are used to produce electrical energy using a renewable resource and without combusting a fossil fuel. Generally, a wind turbine converts kinetic energy from the wind into electrical power. A horizontal-axis wind turbine includes a tower, a nacelle located at the apex of the tower, and a rotor having a plurality of blades extending from a hub and supported in the nacelle by means of a shaft. The shaft couples the rotor either directly or indirectly, such as via a gearbox, with a generator which is housed inside the nacelle. Consequently, as wind forces the blades to rotate, electrical energy is produced by the generator.

[0003] Oftentimes, a main component of the wind turbine, such as a hub, gearbox, generator, or blade, must be detached from the nacelle and lowered by a crane for maintenance or replacement purposes. During this process, damage may be caused to the main component or other components of the wind turbine, such as during the initial stages of dismantling and, more particularly, during transfer of the weight of the main component to be removed from the tower to the crane. This damage can be caused by a discrepancy between the main component's orientation when supported by the tower and the main component's orientation when suspended from the crane. In particular, after the lifting arrangement of the crane has gripped the main component and the main component has been detached from the wind turbine, the lifting arrangement gradually draws the main component away from its mounting location. When this occurs, if there is a discrepancy between the main component's orientation when supported by the tower and the main component's orientation when suspended from the crane, then the main component may suddenly jar, jolt, swing and/or rotate out of its orientation when supported by the tower in an uncontrolled manner. This can cause damage to the main component or other components of the wind turbine, such as the connection parts or regions between the main component and the remaining fixed components of the wind turbine. The damage can be very severe, as some wind turbine components weigh in excess of 10 tons.

[0004] Discrepancies between a main component's orientation when supported by the tower and the main component's orientation when suspended from the crane can be particularly problematic for main components having non-horizontal interfaces with the wind turbine, such as the hubs of certain wind turbine designs.

[0005] Manufacturers of wind turbines and wind turbine components continually strive to improve systems and methods associated with the assembly and maintenance of wind turbines. It would therefore be desirable to provide a method and system for lifting a wind turbine component.

Summary

[0006] In one embodiment, a method of handling a component of a wind turbine includes suspending the component in a suspended orientation via a first lifting arrangement, recording a position, such as a horizontal position, of the first lifting arrangement relative to the component when the component is in the suspended orientation, and installing the component on the wind turbine. The method may further include recalling the recorded position, arranging a second lifting arrangement at the recorded position relative to the component, dismantling the component from the wind turbine, and suspending the component in the suspended orientation via the second lifting arrangement. In one embodiment, the first lifting arrangement and the second lifting arrangement are the same. In addition or alternatively, installing the component may include installing the component at an installed orientation, and the suspended orientation and the installed orientation may be the same.

[0007] The first lifting arrangement may have a vertical axis, and recording a position may include recording a position of the vertical axis relative to the component. In addition or alternatively, the component may have a center of gravity, and recording a position may include recording a position of the first lifting arrangement relative to the center of gravity. Recording a position may include projecting a laser beam from the first lifting arrangement onto the component. In addition or alternatively, recording a position may include applying a marking on the component.

[0008] In one embodiment, arranging the second lifting arrangement at the recorded position includes projecting a laser beam from the second lifting arrangement onto the component and adjusting a position of the second lifting arrangement such that the laser beam aligns with a marking on the component.

[0009] In another embodiment, a lifting arrangement for suspending a component of a wind turbine includes a hoist cable defining a vertical axis and a device configured to identify a position of the lifting arrangement relative to the component. The lifting arrangement may further include a hook, and the device may be arranged on the hook. The device may be configured to record the position of the lifting arrangement relative to the component. In addition or alternatively, the device may be configured to recall the position of the lifting arrangement relative to the component.

[0010] In one embodiment, the device includes a laser which may be configured to project a laser beam along the vertical axis of the hoist cable. In addition or alternatively, the laser may be configured to etch a marking on the component.

[0011] In another embodiment, the device includes a camera. In yet another embodiment, the device includes a plumb bob. In still another embodiment, the device includes a proximity sensor.

Brief Description of the Drawings

[0012] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description given below, serve to explain the invention.

[0013] Fig. 1 is a perspective view of a wind turbine assembled according to an aspect of the invention.

[0014] Fig. 2 is a perspective view similar to Fig. 1, showing the hub of the wind turbine suspended by a crane proximate the nacelle via a lifting arrangement.

[0015] Figs. 3A and 3B illustrate a method of installing the hub on the wind turbine.

[0016] Figs. 4A-4C illustrate a method of dismantling the hub from the wind turbine.

[0017] Fig. 5 is a perspective view similar to Fig. 1, showing a blade of the wind turbine suspended by a crane proximate the hub via a lifting arrangement.

[0018] Figs. 6A and 6B illustrate a method of installing the blade on the wind turbine.

[0019] Figs. 7A-7C illustrate a method of dismantling the blade from the wind turbine.

Detailed Description

[0020] With reference to Fig. 1, a wind turbine 10 includes a tower 12, a nacelle 14 disposed at the apex of the tower 12, and a rotor 16 operatively coupled to a generator (not shown) housed inside the nacelle 14. In addition to the generator, the nacelle 14 houses miscellaneous components required for converting wind energy into electrical energy and various components needed to operate, control, and optimize the performance of the wind turbine 10. The tower 12 supports the load presented by the nacelle 14, the rotor 16, and other components of the wind turbine 10 that are housed inside the nacelle 14 and also operates to elevate the nacelle 14 and rotor 16 to a height above ground level or sea level, as may be the case, at which faster moving air currents of lower turbulence are typically found.

[0021] The rotor 16 of the wind turbine 10, which is represented as a horizontal-axis wind turbine, serves as the prime mover for the electromechanical system. Wind exceeding a minimum level will activate the rotor 16 and cause rotation in a plane substantially perpendicular to the wind direction. The rotor 16 of the wind turbine 10 includes a central rotor hub 18 and a plurality of blades 20 that project outwardly from the central hub 18 at locations circumferentially distributed thereabout in equal intervals. In the representative embodiment, the rotor 16 includes first, second, and third blades 20, but the number may vary. The blades 20 are configured to interact with the passing air flow to produce lift that causes the rotor hub to spin about a longitudinal axis defined thereby. As shown, the tower 12 includes a foundation or base 22 for supporting the wind turbine 10 on a surface, such as a platform or the ground 24.

[0022] The wind turbine 10 may be included among a collection of similar wind turbines belonging to a wind farm or wind park that serves as a power generating plant connected by transmission lines with a power grid, such as a three-phase alternating current (AC) power grid. The power grid generally consists of a network of power stations, transmission circuits, and substations coupled by a network of transmission lines that transmit the power to loads in the form of end users and other customers of electrical utilities. Under normal circumstances, the electrical power is supplied from the generator to the power grid as known to a person having ordinary skill in the art

[0023] In accordance with an aspect of the invention, a main component of the wind turbine, such as the hub 18 or a blade 20, may be hoisted to a position proximate the nacelle 14 for mounting thereto. With reference to Fig. 2, and as set forth in further detail below, a lifting system 30 for installing and/or dismantling the main component 18, 20 includes a crane 32 and a lifting arrangement 34. The main component 18, 20 may be hoisted via the crane 32 and lifting arrangement 34, and may be suspended by the crane 32 proximate the nacelle 14 in a desired suspended orientation. A position of the lifting arrangement 34 relative to the main component 18, 20 when the main component 18, 20 is in the desired suspended orientation may be recorded. The main component 18, 20 may then be installed in a known manner so that the main component 18, 20 may be supported by the tower 12. When it is desired to dismantle the main component 18, 20 from the wind turbine 10, such as for maintenance or replacement purposes, the recorded position of the lifting arrangement 34 relative to the main component 18, 20 for achieving the desired suspended orientation may be recalled, and the lifting arrangement 34 may be positioned relative to the main component 18, 20 accordingly. The crane 32 may then suspend the main component 18, 20 in the desired suspended orientation and lower the main component 18, 20 without undesirable rotating of the main component 18, 20 when the weight of the main component 18, 20 is transferred to the crane 32 and lifting arrangement 34. Thus, dismantling of the main component 18, 20 may be achieved with a reduced risk of damage to the main component 18, 20 or other components of the wind turbine 10. The features of the improved lifting system 30 and method are set forth in further detail below to clarify each of these functional advantages and other benefits provided in this disclosure.

[0024] As shown, the hub 18 is initially hoisted by the crane 32 in a known manner toward the nacelle 14 for installation at a predetermined mounting location. Referring now to Figs. 3A and 3B, with continuing reference to Fig. 2, the illustrated lifting arrangement 34 includes a hoist cable 40, a hook 42, and a harness 44. More particularly, the hoist cable 40 is extendable and retractable by the crane 32, and the hook 42 is positioned at a distal end of the hoist cable 40 for carrying the harness 44, which may securely grip and support the hub 18 during the hoisting operation. It will be appreciated that the hook 42 may alternatively directly grip the hub 18, such as at a complementary hook thereof (not shown), such that the harness 44 may be eliminated. In any event, when suspended by the crane 32, the hoist cable 40 may define a vertical axis 46 of the lifting arrangement, i.e. the axis along which the upward force on the hub 18 (or other component) is applied by the lifting arrangement 34 as the hoist cable 40 is held taut and/or retracted by the crane 32. The lifting arrangement 34 also includes a device for identifying, recording, and/or recalling a position of the lifting arrangement 34 relative to the hub 18, such as a laser 50. In the embodiment shown, the laser 50 is arranged on the hook 42 and is configured to project a laser beam 52 in a downward direction substantially along the axis 46 of the lifting arrangement 34 when suspended by the crane 32.

[0025] When proximate the predetermined mounting location, the hub 18 is suspended by the crane 32 in a desired suspended orientation relative to horizontal. For example, the desired suspended orientation may be substantially the same as the orientation of the hub 18 when installed at the predetermined mounting location. In the embodiment shown, the illustrated hub 18 has a non-horizontal or tilted interface with the nacelle 14 when installed. In particular, when installed, the hub 18 is oriented relative to horizontal at an angle α. Thus, when proximate the predetermined mounting location, the hub 18 is suspended by the crane 32 at the angle α relative to horizontal. This may be achieved by positioning the lifting arrangement 34 such that the axis 46 of the lifting arrangement 34 is horizontally spaced apart from the center of gravity CG of the hub 18 so that the resultant torque on the hub 18 due to gravity causes the hub 18 to be oriented at the angle α relative to horizontal. It will be appreciated that by suspending the hub 18 at the angle α proximate the predetermined mounting location, the hub 18 may be readily aligned with the rotor shaft (not shown) and mounted thereto without the need to reorient the hub 18 relative to horizontal at the predetermined mounting location. It will also be appreciated that the crane 32 may suspend the hub 18 in the desired suspended orientation substantially throughout the hoisting operation, or the hub 18 may be reoriented to the desired suspended orientation as the hub 18 approaches the predetermined mounting location.

[0026] In any event, when the hub 18 is suspended in the desired suspended orientation, the laser 50 may project a laser beam 52 onto the hub 18 beneath the hook 42 and hoist cable 40 along the axis 46 of the lifting arrangement 34, and the position of the projected laser beam 52 on the hub 18 may be recorded. In this regard, the intensity of the laser 50 may be configured to etch a mark M into the hub 18 at the position of the projected laser beam 52 on the hub 18, as shown in Fig. 3A. Thus, the laser 50 may both identify and record the horizontal position of the lifting arrangement 34 relative to the hub 18. Alternatively, personnel may mark the hub 18 in response to the projected laser beam 52, such as by drilling a hole or placing a sticker at the position of the projected laser beam 52 on the hub 18. In this manner, the horizontal position of the lifting arrangement 34 relative to the hub 18 when the hub 18 is in the desired suspended orientation may be recorded. More particularly, the horizontal position of the vertical axis 46 of the lifting arrangement relative to the center of gravity CG of the hub 18 when the hub 18 is in the desired suspended orientation may be recorded.

[0027] As shown in Fig. 3B, the hub 18 may be moved into the predetermined mounting location, as indicated by the arrows A1, and subsequently installed (e.g., mounted to the rotor shaft) at the predetermined mounting location in a known manner without the need to substantially reorient the hub 18 relative to horizontal from the desired suspended orientation. After the hub 18 has been installed such that the hub 18 is supported by the tower 12 of the wind turbine 10, the harness 44 may be removed from the hub 18, and the crane 32 and/or lifting arrangement 34 may be used for installing additional components and/or may be removed from the wind turbine site.

[0028] Referring now to Figs. 4A-4C, when it is desired to dismantle the hub 18, such as for maintenance or replacement purposes, the crane 32 and lifting arrangement 34 may be returned to the wind turbine site. While the same lifting arrangement 34 is shown for both the installation and dismantling operations, it will be appreciated that a different crane 32 and/or lifting arrangement 34 may be used for each operation.

[0029] In preparation for lowering the hub 18, the crane 32 may position the lifting arrangement 34 proximate the hub 18 with the hook 42 and hoist cable 40 generally above the hub 18. The recorded position of the lifting arrangement 34 relative to the hub 18 for achieving the desired suspended orientation of the hub 18 relative to horizontal may be recalled, and the lifting arrangement 34 may be positioned relative to the hub 18 accordingly. In other words, the recorded relative position may be used to map the lifting arrangement 34 into a substantially identical lifting position to achieve the desired suspended orientation of the hub 18. In the embodiment shown, this may be achieved by horizontally aligning the axis 46 of the lifting arrangement 34 with the mark M on the hub 18. More particularly, a laser beam 52 may be projected from the laser 50 downward along the axis 46 of the lifting arrangement 34, as shown in Fig. 4A. The horizontal position of the lifting arrangement 34 relative to the hub may be adjusted, as indicated by the arrow A2, until the laser beam 52 is projected onto the mark M, as shown in Fig. 4B. Thus, the projection of the laser beam 52 onto the mark M may provide a visual indication that the lifting arrangement 34 is properly positioned for achieving the desired suspended orientation of the hub 18. In this manner, the laser 50 may also be used for recalling the recorded relative position. During this alignment operation, the intensity of the laser 50 may be configured to avoid etching additional marks into the hub 18.

[0030] When the lifting arrangement 34 is horizontally positioned such that the laser beam 52 is projected onto the mark M, the harness 44 of the lifting arrangement 34 may securely grip the hub 18 in preparation for supporting the hub 18 during the dismantling operation. As shown in Fig. 4C, the hub 18 may be detached from the rotor shaft of the wind turbine 10 in a known manner, and the crane 32 may support the hub 18 via the lifting arrangement 34 and move the hub 18 away from the nacelle 14 as indicated by the arrow A3. Due to the horizontal positioning of the lifting arrangement 34 relative to the hub 18 and, more particularly, of the axis 46 relative to the center of gravity CG being the same as when the hub 18 was previously suspended by the crane 32 proximate the nacelle 14 during the installation procedure, the orientation of the hub 18 may also be the same. Thus, the crane 32 may again support the hub 18 in the desired suspended orientation, which may be the same as the orientation of the hub 18 relative to horizontal when installed at the mounting location. In this manner, the orientation of the hub 18 relative to horizontal may remain the same as the weight of the hub 18 is shifted from the tower 12 to the lifting arrangement 34 and crane 32. In the embodiment shown, the hub 18 may remain oriented at the angle α relative to horizontal during the transfer by virtue of the axis 46 of the lifting arrangement being horizontally spaced apart from the center of gravity CG of the hub 18 so that the resultant torque on the hub 18 due to gravity causes the hub 18 to remain oriented at the angle α relative to horizontal when the hub 18 is supported by the lifting arrangement 34 and crane 32.

[0031] Therefore, the crane 32 may support and lower the hub 18 from the nacelle 14 without undesirable jarring, jolting, swinging, and/or rotating of the hub 18 between its orientation when supported by the tower 12 and its orientation when supported by the crane 32, which may otherwise apply damaging pressure against the components of the wind turbine 10, such as those at or near the interface between the nacelle 14 and the hub 18. Thus, dismantling of the hub 18 may be achieved with a reduced risk of damage to the hub 18 and/or other components of the wind turbine 10.

[0032] Referring now to Fig. 5, in another embodiment, a blade 20 is initially hoisted by the crane 32 in a known manner toward the hub 18 for installation at a predetermined mounting location. As shown in Figs. 6A and 6B, the lifting arrangement 34' for the blade 20 includes the hoist cable 40, the hook 42, a plurality of slings 60, a yoke 62, and a pair of cradles 64 suspended from the yoke 62 via one or more cables 66. More particularly, the hoist cable 40 is extendable and retractable by the crane 32, and the hook 42 is positioned at a distal end of the hoist cable 40 for carrying the slings 60 and yoke 62, which may securely grip and support the blade 20 during the hoisting operation via the cradles 64. As in the previous embodiment, when suspended by the crane 32, the hoist cable 40 may define the vertical axis 46 of the lifting arrangement 34', i.e. the axis along which the upward force on the blade 20 (or other component) is applied by the lifting arrangement 34' as the hoist cable 40 is held taut and/or retracted by the crane 32. In the embodiment shown, the slings 60 are coupled to the yoke 62 at various positions symmetrical to each other relative to the axis 46 of the lifting arrangement 34' in order to evenly distribute the weight of the blade 20 (or other component) along the yoke 62. The lifting arrangement 34' also includes a device for identifying, recording, and/or recalling a position of the lifting arrangement 34' relative to the blade 20, such as the previously described laser 50. In the embodiment shown, the laser 50 is arranged on the yoke 62 and is configured to project the laser beam 52 in a downward direction substantially along the axis 46 of the lifting arrangement 34' when suspended by the crane 32.

[0033] When proximate the predetermined mounting location, the blade 20 is suspended by the crane 32 in a desired suspended orientation relative to horizontal. For example, the desired suspended orientation may be substantially the same as the orientation of the blade 20 when installed at the predetermined mounting location. In the embodiment shown, the hub 18 is axially oriented such that the illustrated blade 20 has a substantially horizontal interface with the hub 18 when installed. In particular, when installed at the predetermined mounting location, the blade 20 is oriented substantially horizontally. Thus, when proximate the predetermined mounting location, the blade 20 is suspended by the crane 32 substantially horizontally. This may be achieved by positioning the lifting arrangement 34' such that the axis 46 of the lifting arrangement 34' is horizontally aligned with the center of gravity CG of the blade 20 so that there is no, or only negligible, resultant torque on the blade 20 due to gravity. It will be appreciated that by suspending the blade 20 substantially horizontally proximate the predetermined mounting location, the blade 20 may be readily aligned with the hub 18 and mounted thereto without the need to reorient the blade 20 relative to horizontal at the predetermined mounting location. It will also be appreciated that the crane 32 may suspend the blade 20 in the desired suspended orientation substantially throughout the hoisting operation, or the blade 20 may be reoriented to the desired suspended orientation as the blade 20 approaches the predetermined mounting location.

[0034] In any event, when the blade 20 is suspended in the desired suspended orientation, the laser 50 may project a laser beam 52 onto the blade 20 beneath the hook 42 and/or hoist cable 40 along the axis 46 of the lifting arrangement 34', and the position of the projected laser beam 52 on the blade 20 may be recorded. In this regard, the intensity of the laser 50 may be configured to etch a mark M into the blade 20 at the position of the projected laser beam 52 on the blade 20, as shown in Fig. 6A. Thus, the laser 50 may both identify and record the horizontal position of the lifting arrangement 34' relative to the blade 20. Alternatively, personnel may mark the blade 20 in response to the projected laser beam 52, such as by drilling a hole or placing a sticker at the position of the projected laser beam 52 on the blade 20. In this manner, the horizontal position of the lifting arrangement 34' relative to the blade 20 when the blade 20 is in the desired suspended orientation may be recorded. More particularly, the horizontal position of the vertical axis 46 of the lifting arrangement 34' relative to the center of gravity CG of the blade 20 when the blade 20 is in the desired suspended orientation may be recorded.

[0035] As shown in Fig. 6B, the blade 20 may be moved into the predetermined mounting location, as indicated by the arrows A4, and subsequently installed (e.g., mounted to the hub 18) at the predetermined mounting location in a known manner without the need to substantially reorient the blade 20 relative to horizontal from the desired suspended orientation. After the blade 20 has been installed such that the blade 20 is supported by the tower 12 of the wind turbine 10, the yoke 62 and cradles 64 may be removed from the blade 20, and the crane 32 and/or lifting arrangement 34' may be used for installing additional components and/or may be removed from the wind turbine site.

[0036] Referring now to Figs. 7A-7C, when it is desired to dismantle the blade 20, such as for maintenance or replacement purposes, the crane 32 and lifting arrangement 34' may be returned to the wind turbine site. While the same lifting arrangement 34' is shown for both the installation and dismantling operations, it will be appreciated that a different crane 32 and/or lifting arrangement 34' may be used for each operation. The hub 18 may be axially oriented in a manner similar to that when the blade 20 was installed. For example, the hub 18 may again be axially oriented such that the blade 20 to be removed has a substantially horizontal interface with the hub 18.

[0037] In preparation for lowering the blade 20, the crane 32 may position the lifting arrangement 34' proximate the blade 20 with the yoke 62, hook 42, and/or hoist cable 40 generally above the blade 20. The recorded position of the lifting arrangement 34' relative to the blade 20 for achieving the desired suspended orientation of the blade 20 relative to horizontal may be recalled, and the lifting arrangement 34' may be positioned relative to the blade 20 accordingly. In other words, the recorded relative position may be used to map the lifting arrangement 34' into a substantially identical lifting position to achieve the desired suspended orientation of the blade 20. In the embodiment shown, this may be achieved by horizontally aligning the axis 46 of the lifting arrangement 34’ with the mark M on the blade 20. More particularly, a laser beam 52 may be projected from the laser 50 downward along the axis 46 of the lifting arrangement 34’, as shown in Fig. 7A. The horizontal position of the lifting arrangement 34’ relative to the blade 20 may be adjusted, as indicated by the arrow A5, until the laser beam 52 is projected onto the mark M, as shown in Fig. 7B. Thus, the projection of the laser beam 52 onto the mark M may provide a visual indication that the lifting arrangement 34’ is properly positioned for achieving the desired suspended orientation of the blade 20. In this manner, the laser 50 may also be used for recalling the recorded relative position. During this alignment operation, the intensity of the laser 50 may be configured to avoid etching additional marks into the blade 20.

[0038] When the lifting arrangement 34’ is horizontally positioned such that the laser beam 52 is projected onto the mark M, the yoke 62 of the lifting arrangement 34’ may securely grip the blade 20 via the cradles 64 in preparation for supporting the blade 20 during the dismantling operation. As shown in Fig. 7C, the blade 20 may be detached from the hub 18 of the wind turbine 10 in a known manner, and the crane 32 may support the blade 20 via the lifting arrangement 34’ and move the blade 20 away from the hub 18 as indicated by the arrow A6. Due to the horizontal positioning of the lifting arrangement 34’ relative to the blade 20 and, more particularly, of the axis 46 relative to the center of gravity CG being the same as when the blade 20 was previously suspended by the crane 32 proximate the hub 18 during the installation procedure, the orientation of the blade 20 when supported by the crane 32 may also be the same. Thus, the crane 32 may again support the blade 20 in the desired suspended orientation, which may be the same as the orientation of the blade 20 relative to horizontal when installed at the mounting location. In this manner, the orientation of the blade 20 relative to horizontal may remain the same as the weight of the blade 20 is shifted from the tower 12 to the lifting arrangement 34’ and crane 32. In the embodiment shown, the blade 20 may remain substantially horizontally oriented during the transfer by virtue of the axis 46 of the lifting arrangement 34’ being aligned with the center of gravity CG of the blade 20 so that there is no, or only negligible, resultant torque on the blade 20 due to gravity when the blade 20 is supported by the lifting arrangement 34’ and crane 32.

[0039] Therefore, the crane 32 may support and lower the blade 20 from the hub 18 without undesirable jarring, jolting, swinging, and/or rotating of the blade 20 between its orientation when supported by the tower 12 and its orientation when supported by the crane 32, which may otherwise apply damaging pressure against the components of the wind turbine 10, such as those at or near the interface between the hub 18 and the blade 20. Thus, dismantling of the blade 20 may be achieved with a reduced risk of damage to the blade 20 and/or other components of the wind turbine 10.

[0040] While the hoist cable 40 has been described as defining the axis 46 of the lifting arrangement 34, 34', and the horizontal position of the lifting arrangement 34, 34' has been described in relation thereto, it will be appreciated that other points of reference on the lifting arrangement 34, 34' may be used for identifying the horizontal position of the lifting arrangement 34, 34' relative to the main component 18, 20. In this regard, the laser 50 may be positioned elsewhere on the lifting arrangement 34, 34' such that the laser beam 52 projected thereby is not coaxial with the hoist cable 40. For example, the laser 50 may be positioned proximate a longitudinal end of the yoke 62. In one embodiment, multiple lasers 50 may be positioned on the yoke 62 for providing multiple marks M on the blade 20 during the installation operation and subsequently aligning with the marks M during the dismantling operation.

[0041] While the device for identifying and/or recording a position of the lifting arrangement 34, 34' relative to the main component 18, 20 has been described as a laser 50, other devices may be used. For example, the laser 50 may be replaced by a weighted device such as a plumb bob or plummet (not shown) suspended from a position similar to that of the laser 50. More particularly, during an installation operation the weighted device may provide a visual indication of the horizontal position of the lifting arrangement 34, 34' relative to the main component 18, 20 when the main component 18, 20 is in the desired suspended orientation, and personnel may apply a mark on the main component 18, 20 in response to the position of the weighted device on or above the main component 18, 20. During a subsequent dismantling operation, the horizontal position of the lifting arrangement 34, 34' may be adjusted until the weighted device aligns with the mark in a manner similar to that described above with respect to the laser 50.

[0042] In another embodiment, the laser 50 may be replaced by a camera, such as a video camera or a photographic camera (not shown) oriented in a manner similar to the laser. The camera may record an image of the main component 18, 20 when the main component 18, 20 is in the desired suspended orientation during the installation operation. In this manner, the horizontal position of the lifting arrangement 34, 34’ relative to the main component 18, 20 when the main component 18, 20 is in the desired suspended orientation may be recorded. The image may be stored, such as at the wind turbine site, and may be retrieved during the dismantling operation. In this regard, an image comparison may be made based on the recorded image to map the lifting arrangement 34, 34’ into a substantially identical lifting position to achieve the desired suspended orientation of the main component 18, 20.

[0043] In another embodiment, the laser 50 may be replaced by a proximity sensor, such as a magnetic sensor (not shown). A magnetic field may be produced at a predetermined position on the main component 18, 20, such as at a root end of the blade 20, via one or more magnets. The magnetic sensor may detect the strength of the magnetic field when the main component 18, 20 is in the desired suspended orientation during the installation operation. The magnetic field strength reading may be stored, such as at the wind turbine site, and may be retrieved during the dismantling operation. In this regard, the horizontal position of the lifting arrangement 34, 34’ may be adjusted until the magnetic sensor detects a magnetic field strength substantially the same as the stored magnetic field strength reading. In another embodiment, the magnetic sensor and magnets may be replaced by an RF receiver and transmitter, respectively.

[0044] While the present invention has been illustrated by a description of various preferred embodiments and while these embodiments have been described in some detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The various features of the invention may be used alone or in numerous combinations depending on the needs and preferences of the user.

What is claimed is:

1. A method of handling a component of a wind turbine, comprising:
suspending the component in a suspended orientation via a first lifting arrangement;
recording a position of the first lifting arrangement relative to the component when the component is in the suspended orientation; and
installing the component on the wind turbine.

2. The method of claim 1, further comprising:
recalling the recorded position;
arranging a second lifting arrangement at the recorded position relative to the component;
dismantling the component from the wind turbine; and
suspending the component in the suspended orientation via the second lifting arrangement.

3. The method of claim 1 or 2, wherein the first lifting arrangement has a vertical axis, and wherein recording a position includes recording a position of the vertical axis relative to the component.

4. The method of any of claims 1-3, wherein the component has a center of gravity, and wherein recording a position includes recording a position of the first lifting arrangement relative to the center of gravity.

5. The method of any of claims 1-4, wherein recording a position includes projecting a laser beam from the first lifting arrangement onto the component.

6. The method of any of claims 1-5, wherein recording a position includes applying a marking on the component.

7. The method of claim 2, wherein arranging the second lifting arrangement at the recorded position includes projecting a laser beam from the second lifting arrangement onto the component and adjusting a position of the second lifting arrangement such that the laser beam aligns with a marking on the component.

8. The method of claim 2 or 7, wherein the first lifting arrangement and the second lifting arrangement are the same.

9. The method of any of claims 1-8, wherein the position is a horizontal position.

10. The method of any of claims 2, 7, or 8, wherein installing the component includes installing the component at an installed orientation, and wherein the suspended orientation and the installed orientation are the same.

11. A lifting arrangement for suspending a component of a wind turbine, comprising:

a hoist cable defining a vertical axis; and

a device configured to identify a position of the lifting arrangement relative to the component.

12. The lifting arrangement of claim 11, wherein the device is configured to record the position of the lifting arrangement relative to the component.

13. The lifting arrangement of claim 11 or 12, wherein the device is configured to recall the position of the lifting arrangement relative to the component.

14. The lifting arrangement of any of claims 11-13, wherein the device includes a laser.

15. The lifting arrangement of claim 14, wherein the laser is configured to project a laser beam along the vertical axis of the hoist cable.

16. The lifting arrangement of claim 14 or 15, wherein the laser is configured to etch a marking on the component.

17. The lifting arrangement of any of claims 11-13, wherein the device includes a camera.

18. The lifting arrangement of any of claims 11-13, wherein the device includes a plumb bob.

19. The lifting arrangement of any of claims 11-13, wherein the device includes a proximity sensor.

20. The lifting arrangement of any of claims 11-19, further comprising a hook, wherein the device is arranged on the hook.

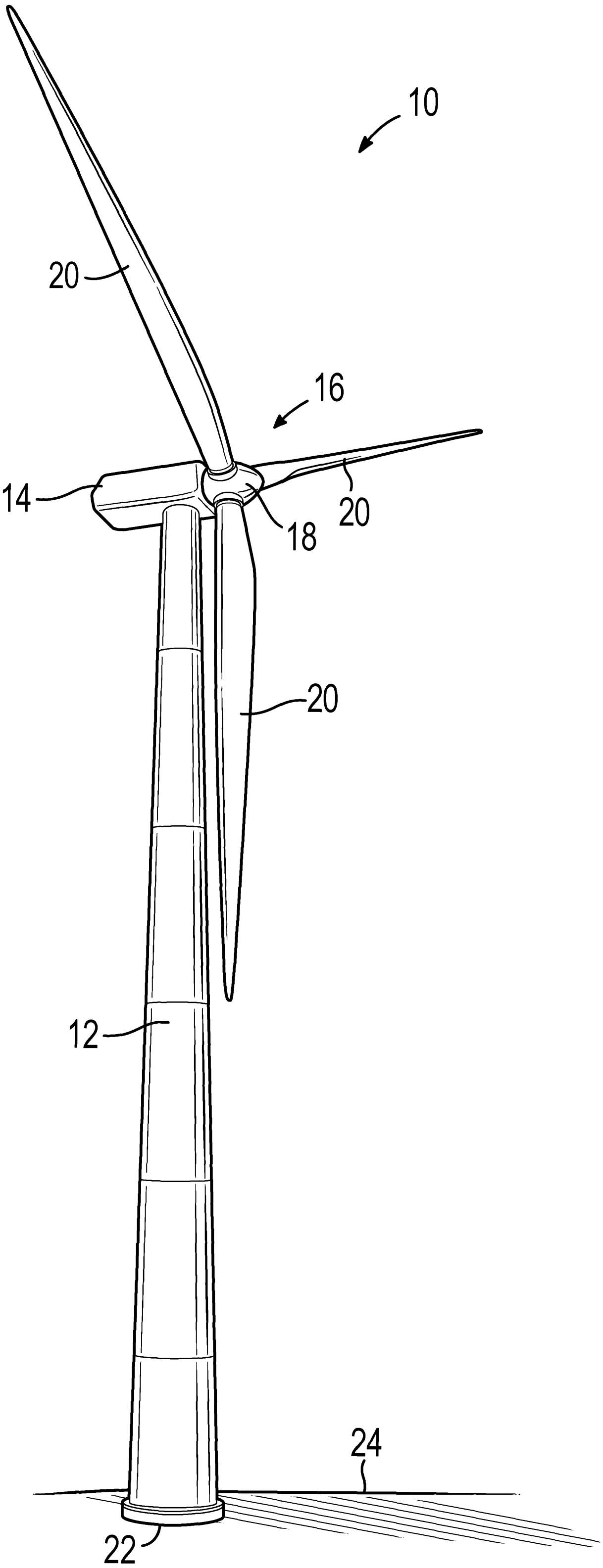

FIG. 1

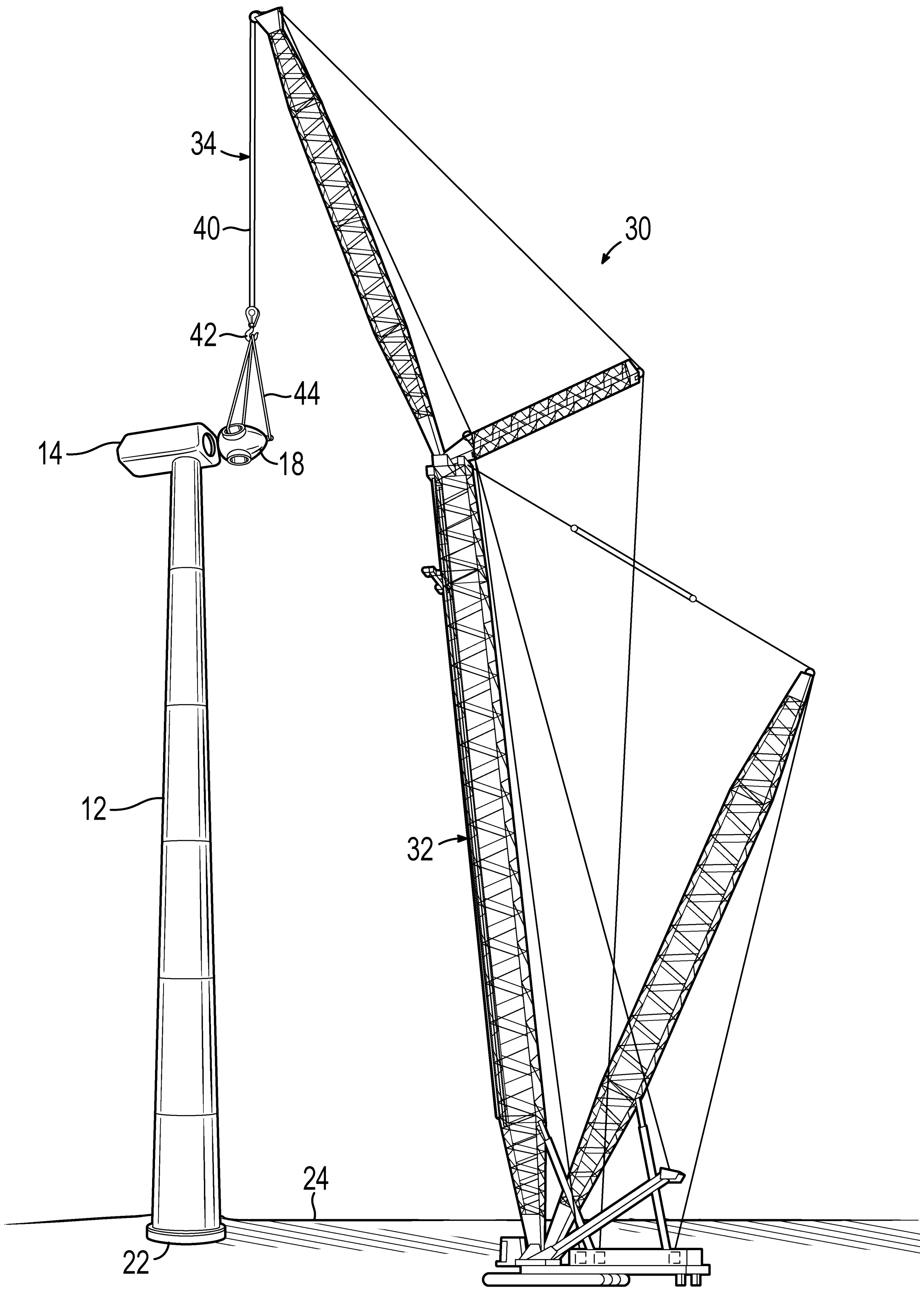

FIG. 2

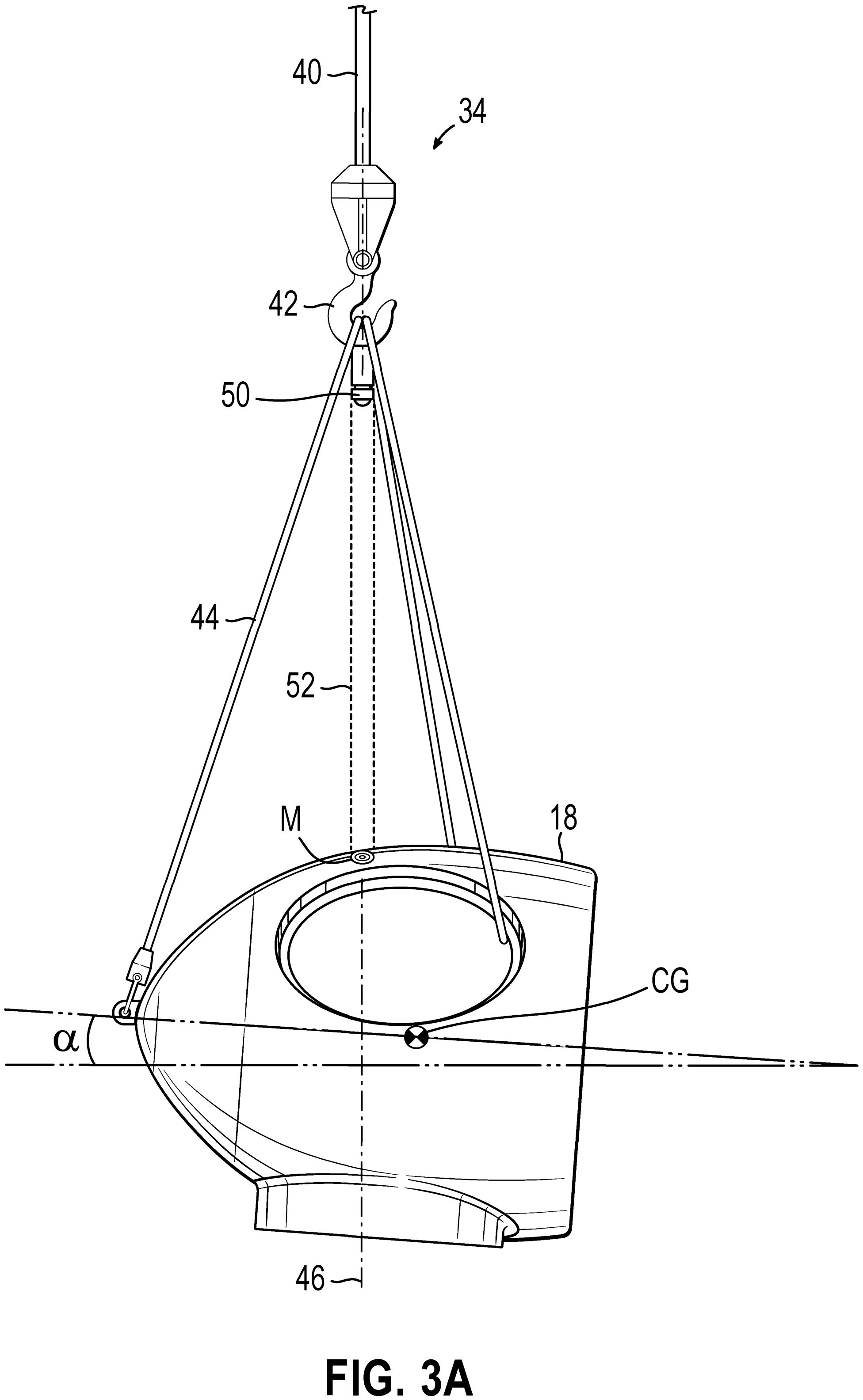

FIG. 3A

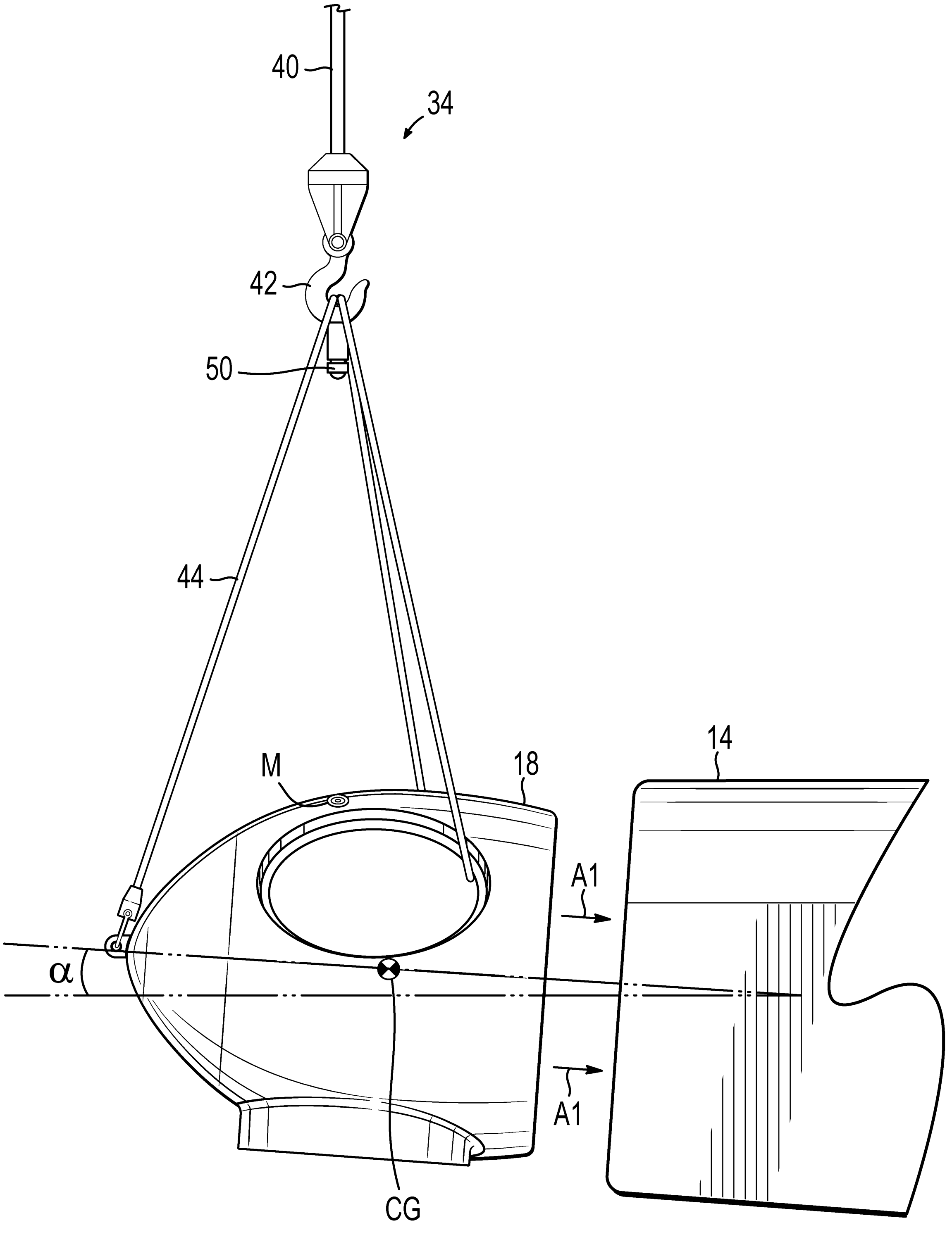

FIG. 3B

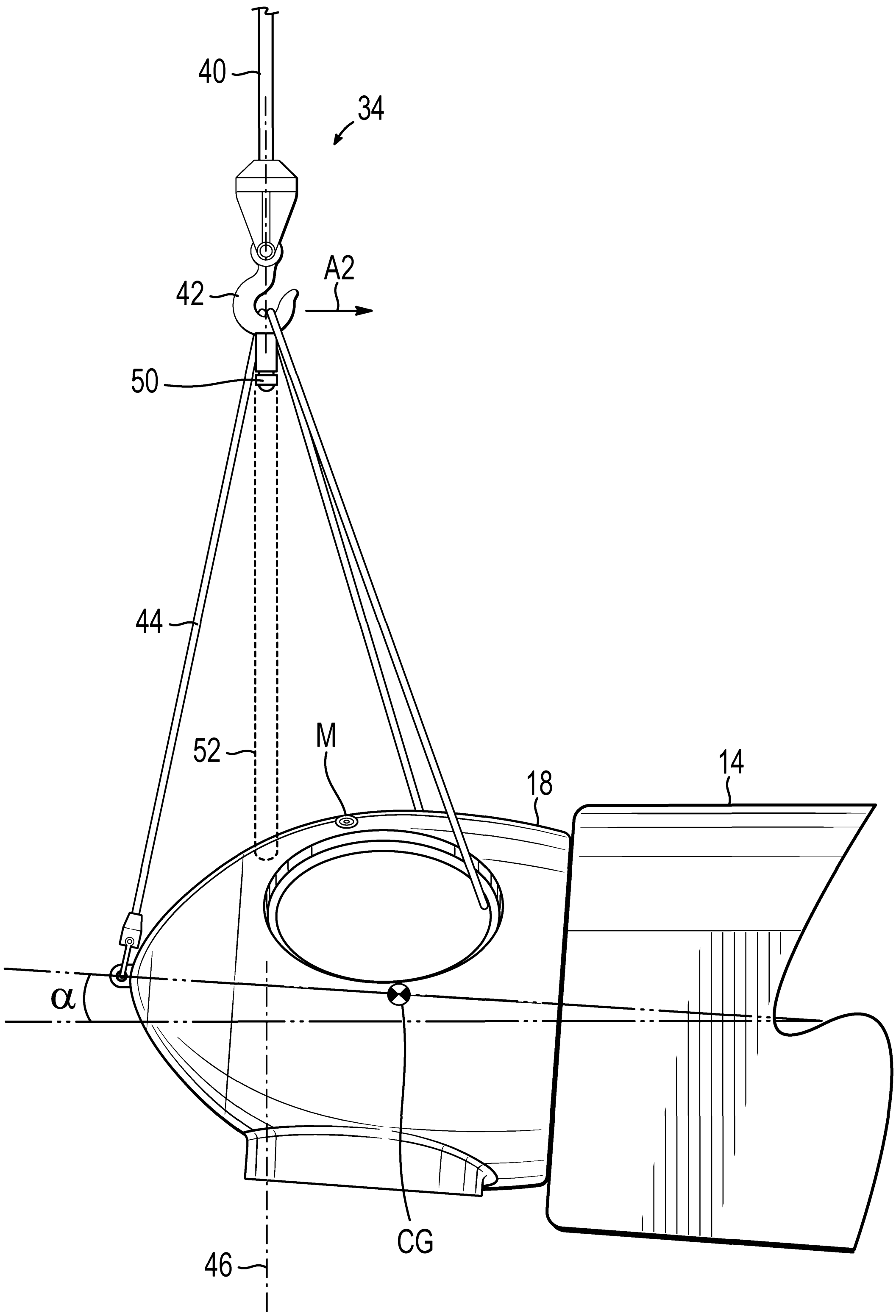

FIG. 4A

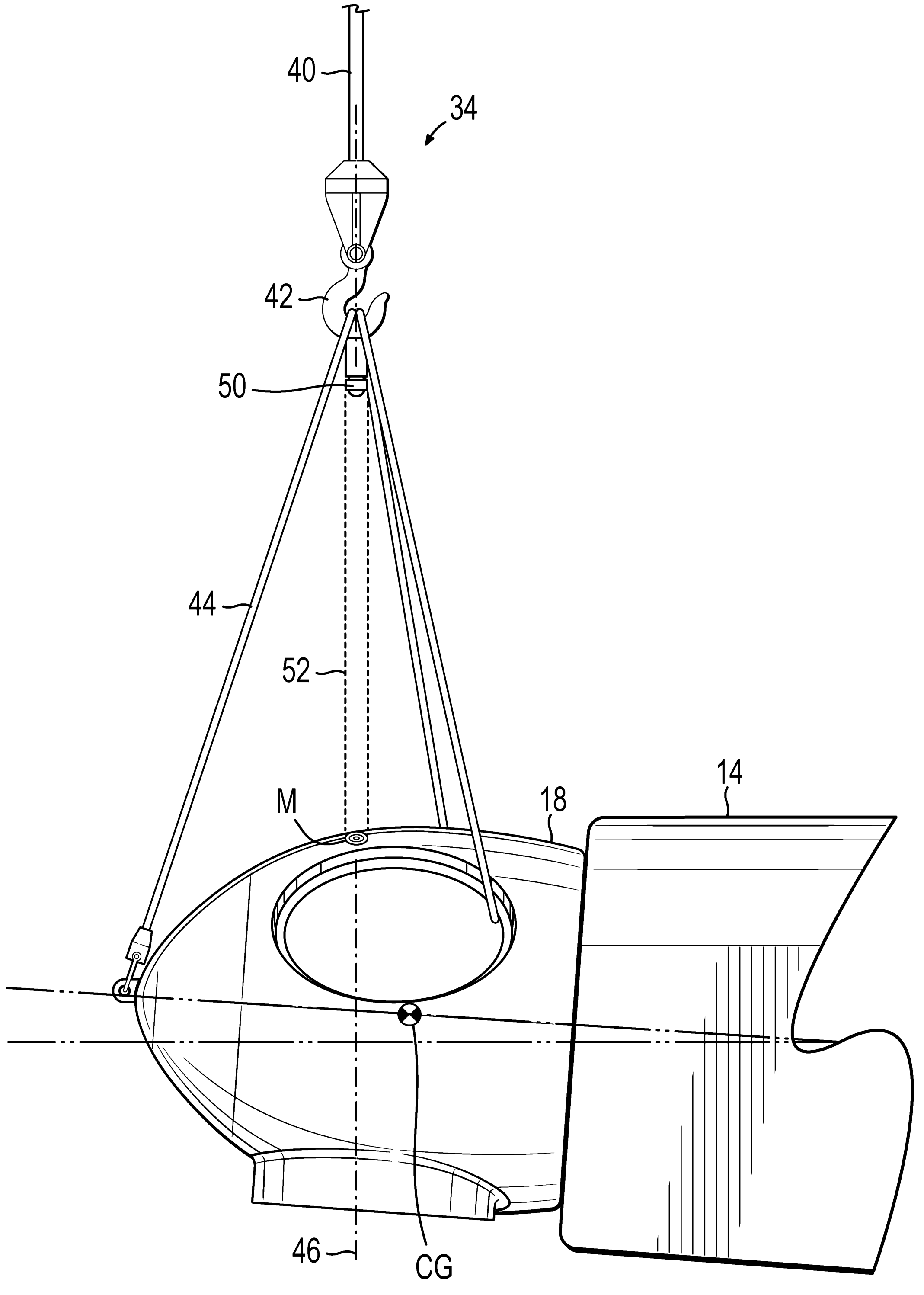

FIG. 4B

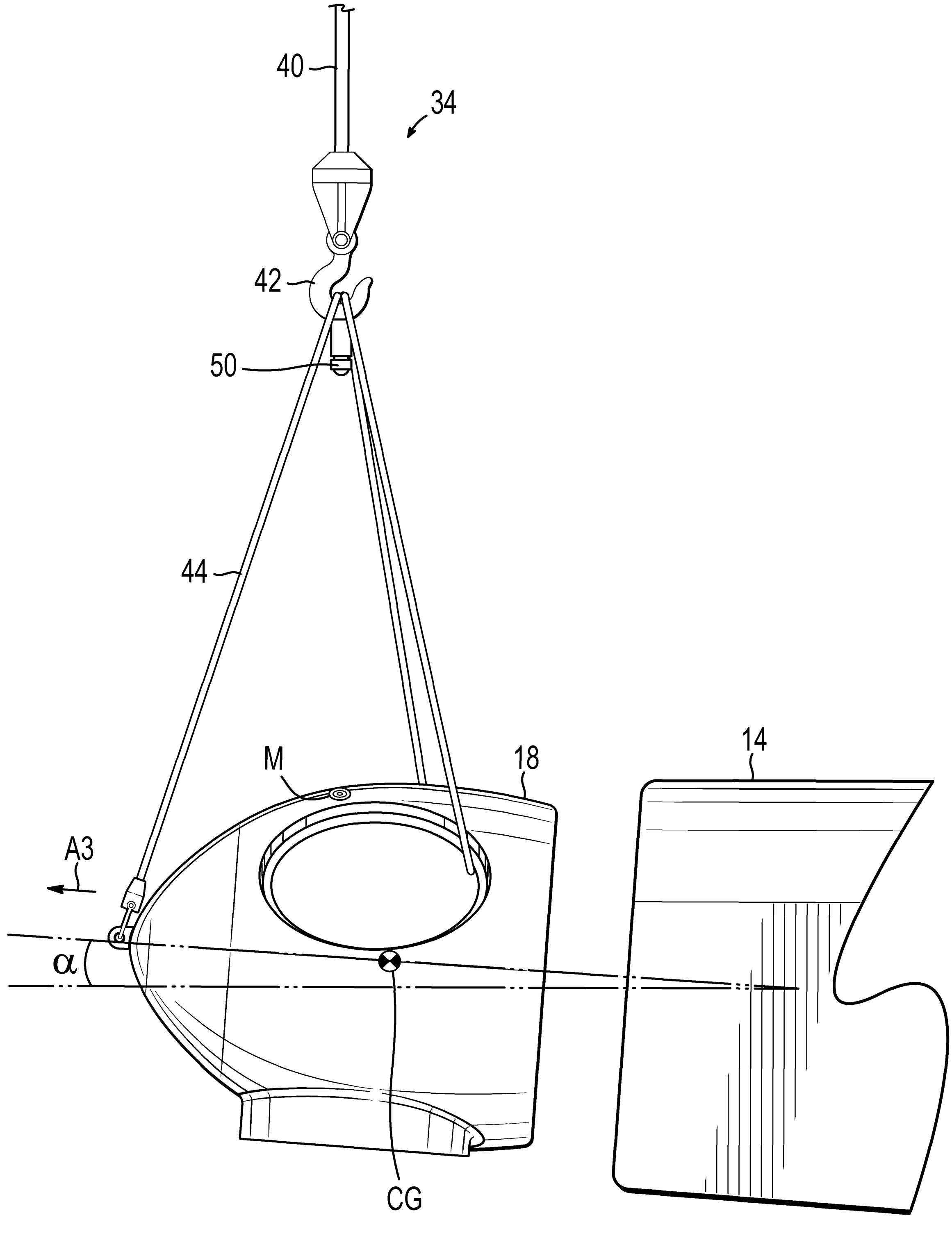

FIG. 4C

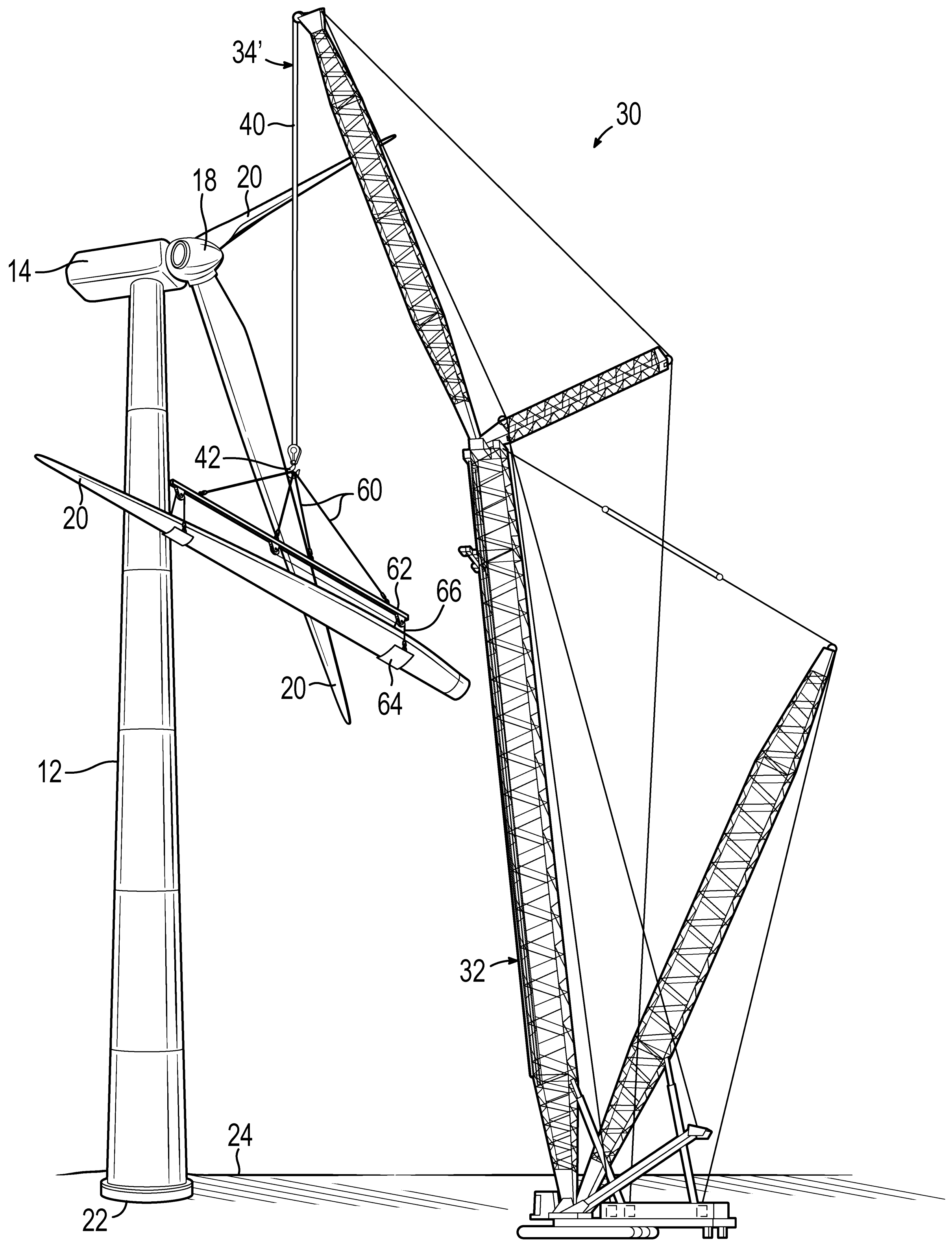

FIG. 5

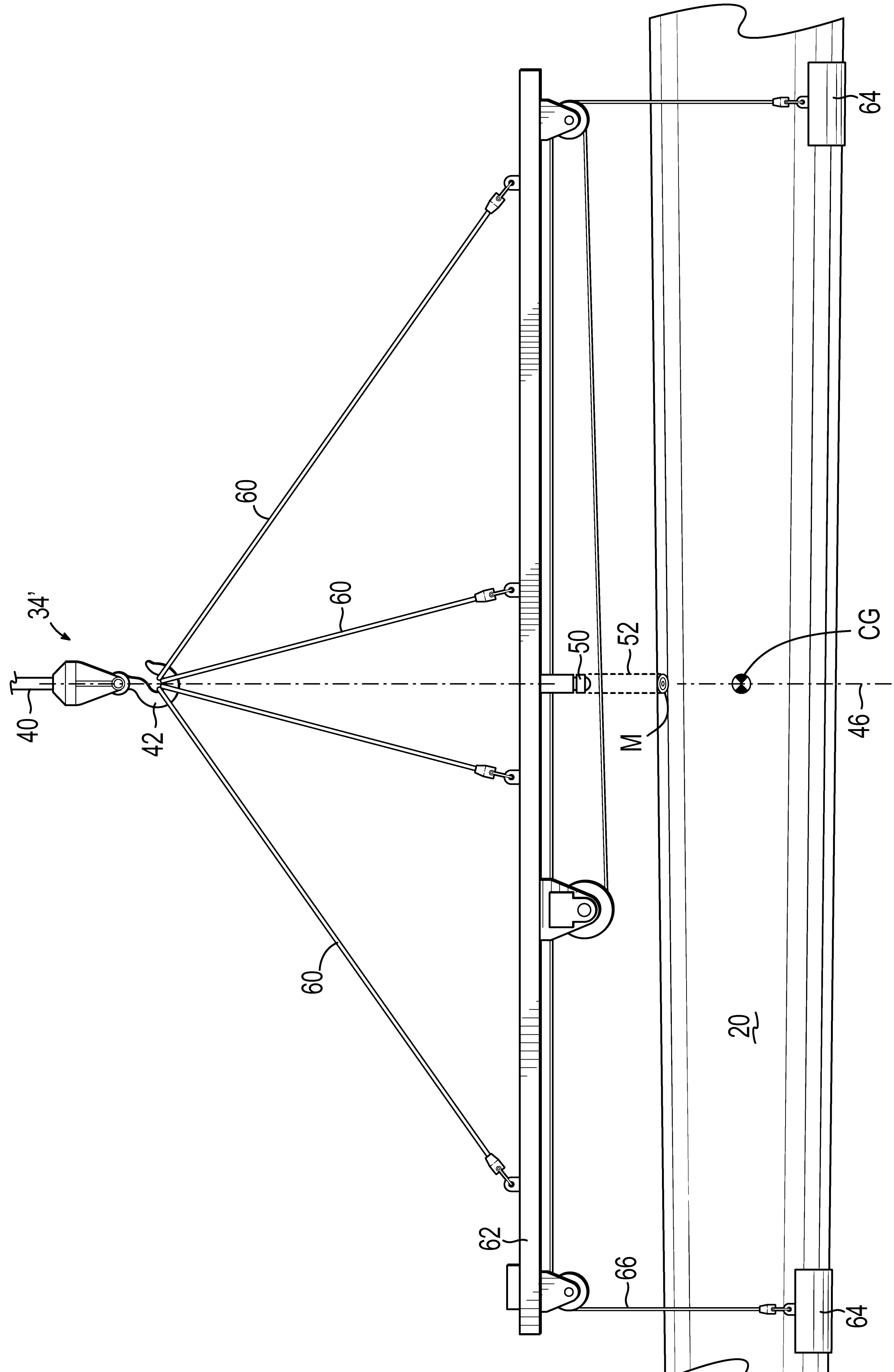

FIG. 6A

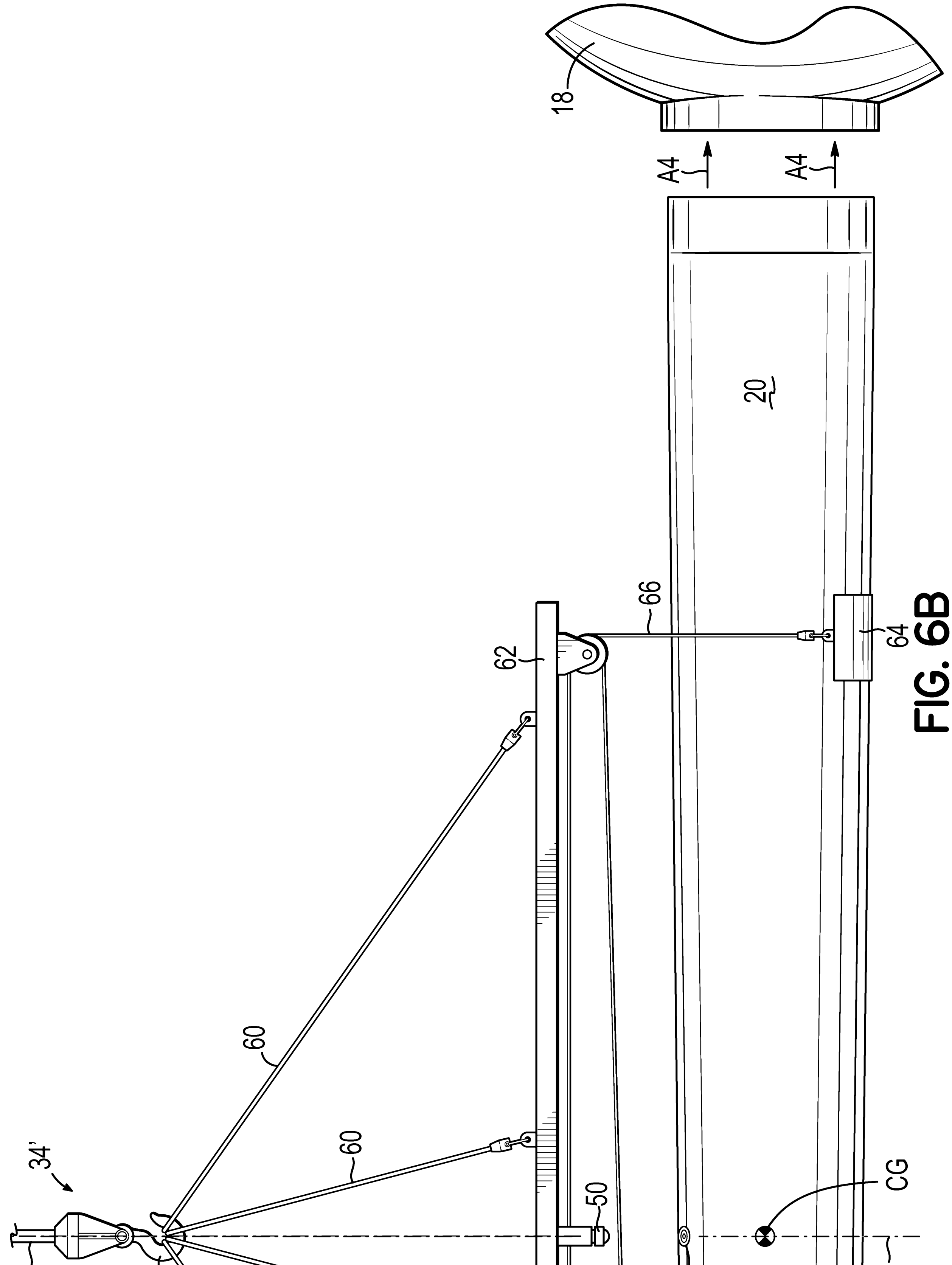

FIG. 6B

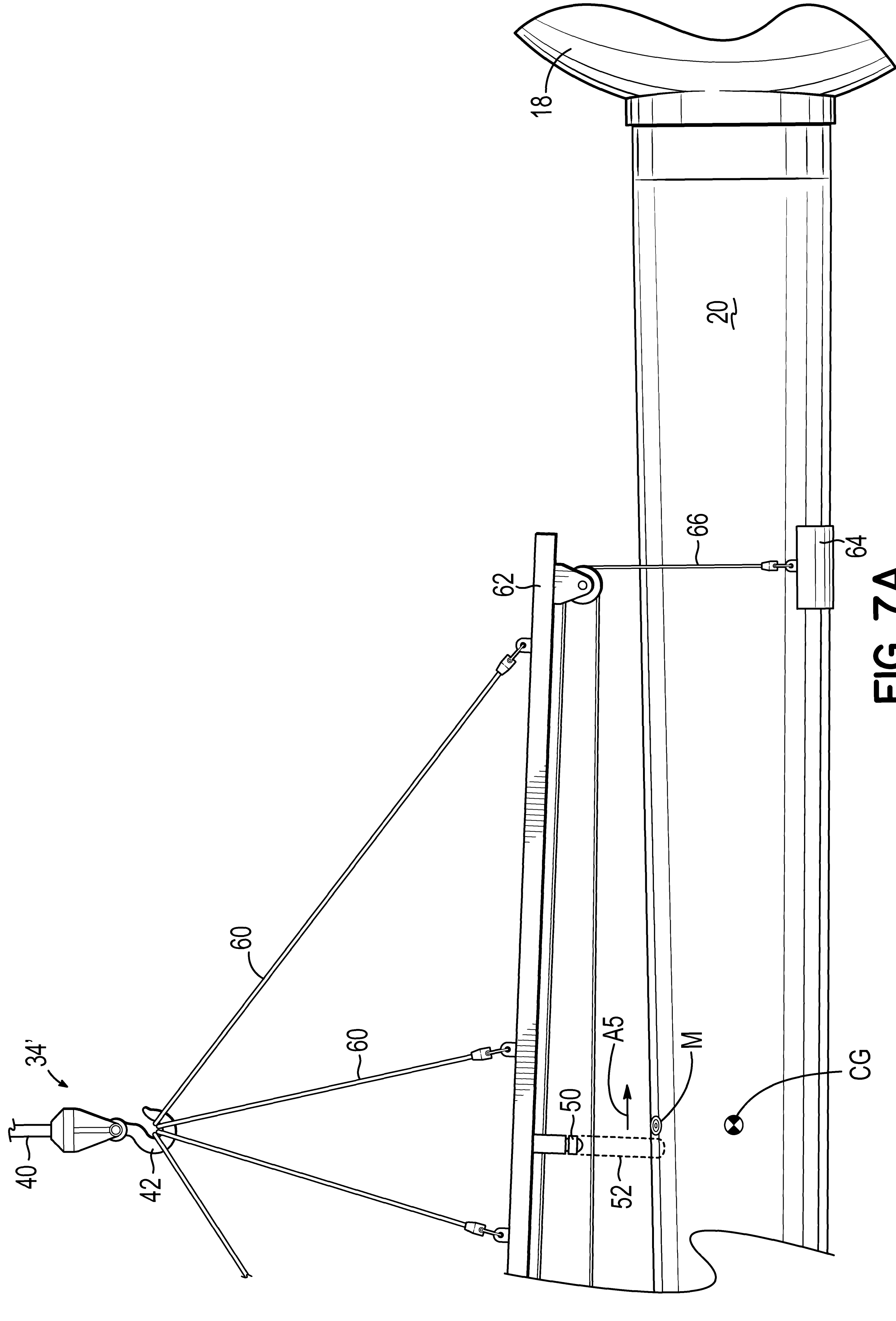

FIG. 7A

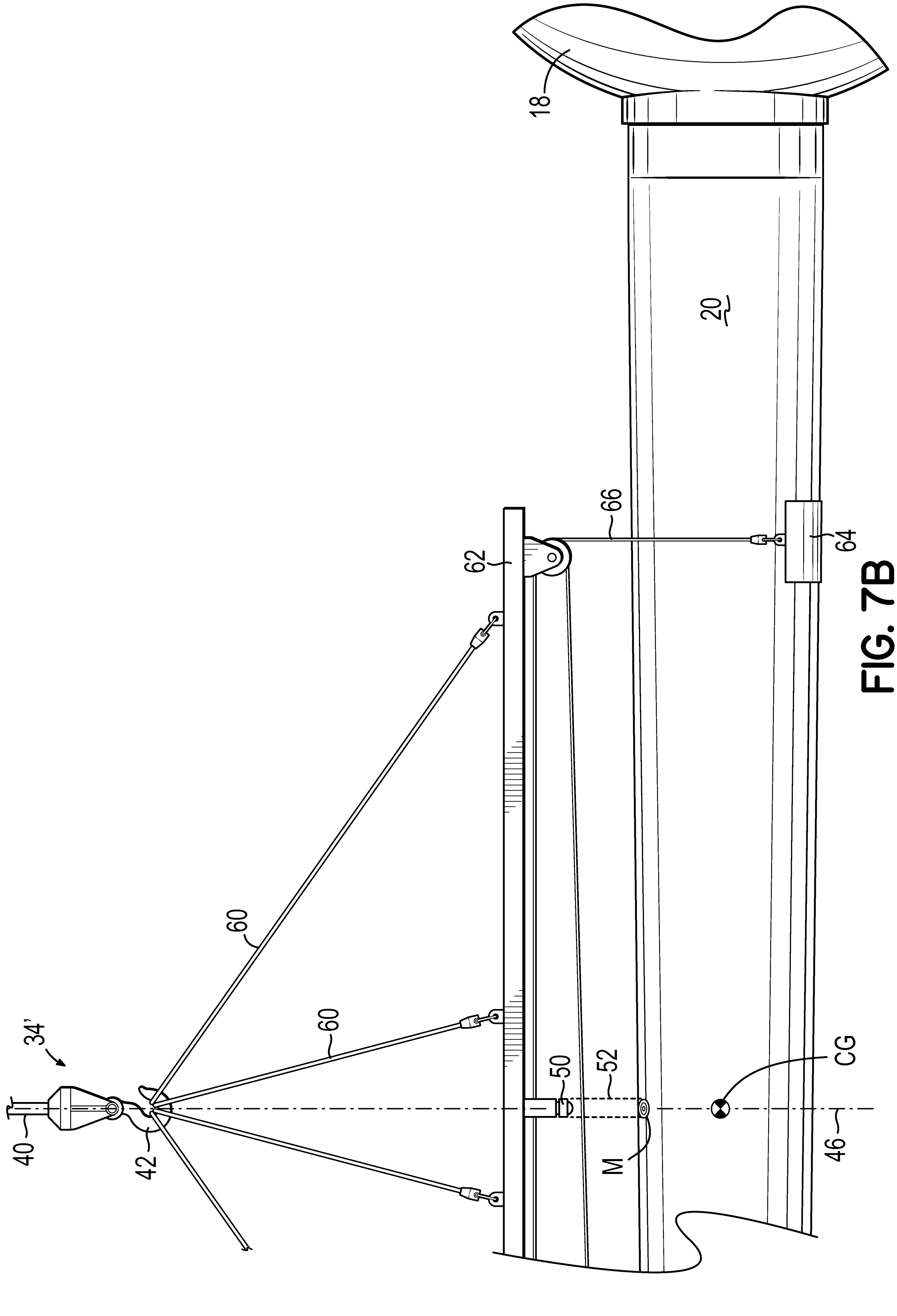

FIG. 7B

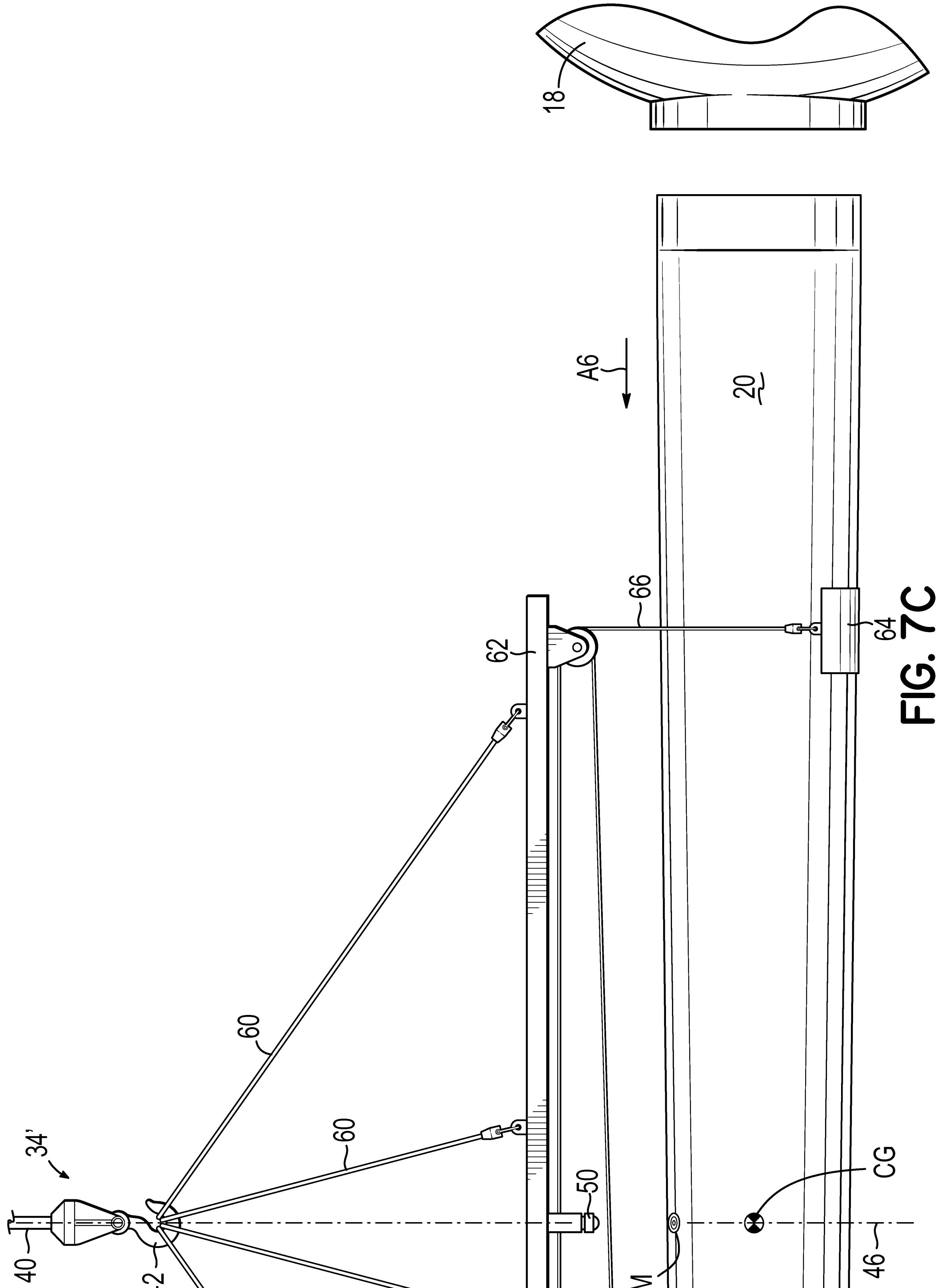

FIG. 7C