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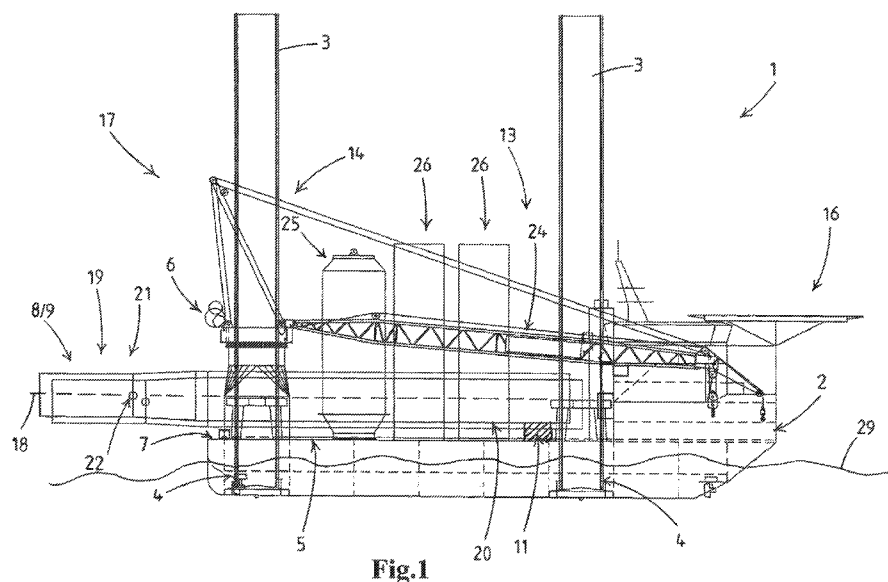


Fig.1

(57) Abstract: The invention relates to a method for installation of a pylon section of an off shore wind turbine and a jack-up vessel for performing such a method. According to the invention, the vessel comprises a pylon section installation track and an associated track cart that enable guiding the foot end of a pylon section, prior to lifting or during upending of the pylon section, over the deck of the vessel. The guide system allows for moving the pylon section without the need of a crane or with a reduced number of cranes. Thus the process can be done in less time and/or the reduced number of cranes or the smaller cranes required in the process allow for a reduction in costs.



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Title: A method for installation of a pylon section of an off shore wind turbine and a vessel for performing such a method.

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An off shore wind turbine comprises a mast supporting a nacelle and the blades of the wind turbine. The mast is mounted on a foundation in the form of a jacket, i.e. a truss or frame work installed on the sea floor, or a pile, i.e. a cylindrical foot section, part of which is driven into the sea floor. Often, a transition piece is provided between the pile and the mast of the

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The invention relates to a method for installation of a pylon section of an offshore wind turbine. Herein, a pylon section can be a pile adapted to support an offshore wind turbine or a mast of an off shore wind turbine.

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The invention thus relates to a method for installation of a pile adapted to support an offshore wind turbine and to a method for installing the mast of an offshore wind turbine. The invention further relates to vessel configured to be used in such a method, a vessel comprising a pile holding system for performing such a method, to a pile holder and to a

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In a known method for installing an offshore wind turbine, the foundation is installed first by erecting a jacket on the sea floor after which the wind turbine, comprising a mast and a nacelle, is installed on the jacket. A wind turbine can be installed as a whole at once as a whole or by assembling the wind turbine in parts on the jacket. A method for installing the

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mast of a wind turbine on a jacket is for example disclosed in CN205257825. A method for installing the wind turbine as a whole at once is for example disclosed in WO2007091042 and in WO2004070119.

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In an alternative method for installing an offshore wind turbine, the foundation, in the form of a pile, is installed first by driving the pile into the sea bottom after which the wind turbine, the wind turbine comprising a mast, nacelle and blades, is installed on the pile. Again, either by installing the wind turbine at once as a whole or by assembling the wind turbine in parts on the pile.

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There is a trend towards cost reduction in installing off shore wind turbines, in particular to increasing the efficiency of wind turbine installation. This can for example be achieved by

shortening the installation process and by enlarging the operational window, i.e. making the installation process less dependent of the circumstances, such as wind, heave, etc.

There is also a trend towards larger wind turbines and a desire to install offshore wind

5 turbines at locations with larger water depths than currently encountered. Both result in larger and heavier foundations. Hence, it is expected that in the near future piles need to be installed that are larger than 100 meters, possibly 120 meters or larger. The weight of such piles may be larger than 1000mt, possibly 1300mt or above.

10 Installation of piles is currently done using jack-up type vessel in which legs are lowered into the water to lift the vessel at least partially out of the water so that waves have a limited or minimal effect on the vessel. However, a drawback of such a jack-up type vessel is that it takes a lot of time to lower the legs and to lift the vessel out of the water and to go through the reverse process after installation of the pile. Furthermore, the jack-up vessels typically
15 are compact in size, and therefore allow for a limited amount of pay load to be carried.

It is an object of the invention to provide a faster method to install a pylon section adapted to support an offshore wind turbine. It is a further object to provide a method to install pylon sections at reduced costs.

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This object is achieved by providing a method for installation a wind turbine at a wind turbine installation site, wherein use is made of a marine jack-up type vessel, the jack-up vessel comprising:

25 - a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section

- at least three jack-up legs;

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- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level,

35 - a pylon section guide track and an associated track cart,

wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section of a wind turbine to support that bottom end of the pylon section and to guide that bottom end of the pylon

5 section over the deck and along the guide track; and

- a pylon section installation crane, which installation crane is fixed to the hull at the installation end of the guide track for lifting the pylon section of which one end is supported by the track cart, the installation crane having a boom that is slewable about a vertical slew
10 axis and pivotal up and down about a horizontal boom pivot axis,

wherein the method comprises:

- storing the pylon section on the main deck in a horizontal transport position, in which
15 horizontal transport position the longitudinal axis of the pylon section extends substantially parallel to the main deck and to the guide track, and in which horizontal transport position the bottom end of the pylon is supported by the track cart located at the support end of the track;

20 - arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which operational position the legs engage the sea floor and the hull is above water level;

- upending the pylon section, to thus bring the pylon section from the horizontal transport
25 position into a vertical installation position, in which vertical installation position the longitudinal axis of the pylon section extends in a substantially vertical direction,

the upending process comprising, at the installation end of the track, lifting the top end of the pylon section with the installation crane in an upward direction while guiding the bottom
30 end of the pylon section along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during the upending process, thereby rotating the pylon section from a horizontal orientation to a vertical orientation about a substantially horizontal rotation axis, which substantially horizontal rotation axis preferably is perpendicular to the longitudinal axis of the vessel,

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- disengaging the pile holder from the bottom end of the pylon section, lifting the pylon section with the installation crane in an upward direction, and using the installation crane,

preferably by at least slewing the jib of the crane, to position the pylon section, while supported in a vertical position, above the installation site; and

- lower the pylon section into an installed position at the installation site.

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OR

- storing the pylon section on the main deck in a vertical transport position, in which vertical transport position the longitudinal axis of the pylon section extends substantially

10 perpendicular to the main deck and to the track, and in which vertical transport position the pylon is supported by the track cart;

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position wherein the legs engage the sea floor and

15 the hull is above water level;

- optionally, moving the pylon section along the guide track towards the installation end of the track;

20 - lifting the pylon section with the installation crane in an upward direction, and using the installation crane, preferably by at least slewing the jib of the crane, to position the pylon section, while supported in a vertical position, above the installation site and

- lower the pylon section into an installed position at the installation site;

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- operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward.

The invention is based on the insight that providing a pylon section guide track and an
30 associated track cart allows for guiding the foot end of the pylon section, prior to lifting or during upending of the pylon section, over the deck of the vessel. The guide system allows for moving the pylon section without the need of a crane or with a reduced number of cranes.

Thus the process can be done in less time and/or the reduced number of cranes or the

35 smaller cranes required in the process allow for a reduction in costs.

It is submitted that in the invention is in particular advantageous for upending piles, which are large and heavy compared to masts. The vessel allows for transporting a pile in a horizontal transport position, which is beneficial since it keeps the center of gravity of the vessel plus load low, and for quickly and efficiently upending the pylon section at the
5 installation site.

The vessel and method according to the invention enable lifting the top end of the pylon section while guiding the bottom end, the bottom end being supported by the track cart, until the pylon section is fully lifted upward in an upright position. Thus the bottom end does not
10 need to be lifted during the upending process, and a smaller crane, and/or no crane at the bottom end of the pylon section is needed.

In an embodiment, the pylon section is supported in the upright transport position by the track cart
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Furthermore, the invention allows for installing large sized piles, i.e. having a length of 100 meters or more, which in turn allows for installing wind turbines in deeper waters. This is in particular the case when the vessel is provided with two pylon section installation cranes on opposite sides of the installation end of the guide track. In such a configuration, the two
20 installation cranes can be used to in unison lift the pylon section in the upright position, and subsequently lift the pile overboard and land it on the sea floor in the upright position for being driven into the sea floor.

Furthermore, the invention allows for large pylon sections, in particular foundation piles, to
25 be transported on a jack-up vessel.

In the prior art, large size pylon sections are preferably transported in a horizontal transport position to keep the centre of gravity low, i.e. close to the water surface. Furthermore, the length of these pylon sections requires large vessels. Therefore, the pylon sections are
30 typically transported on large size pontoons or vessels, while the crane for up-ending and installing the pylon sections is located on a separate, smaller sized, jack-up vessel.

The claimed combination of a crane for up-ending the pylon section with a guide track and a track cart for guiding the pylon at one end during up-ending, allows for transporting a large
35 pylon section on a jack-up vessel.

In a method according to the claimed invention, the jack-up vessel is used to transport a large pylon section, the top end of which extends beyond the contour of the vessel, while the bottom end thereof is supported by the cart on the track, the track being located in the vicinity of the support end of the guide track. To up-end the pylon section, the at least one
5 crane located at the installation end of the guide track lifts the top end of the pylon section while the cart is used to guide the bottom end of the pylon section towards the installation end of the track.

It is noted that, while upending a pylon section, the bottom end of the pylon section is
10 preferably guided by the cart up until the pylon is in the upright position. Only then is the pylon released from the cart. This to prevent a swinging movement of the pylon once it is released from the cart. Due to the large size of the pylon, swinging and other free movements are preferably kept to a minimum to provide a fully controlled
installaitonprocess.

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In a method according to the invention, the crane is connected to a part of the pylon section that is located above the track or at least near to the end of the track, when the pylon is in the horizontal transport position, such that upending the pylon only requires a lift movement of the crane. Thus, the hook of the crane is moved along a linear, vertically orientated,
20 trajectory.

In a further method according to the claimed invention, the at least one crane is connected with the top end of the pylon section at a location outside the contour of the vessel, or at least beyond the track. To enable the cart to support the bottom end of the pylon section
25 during the entire up-ending process, the crane not only lifts the top end, but also moves the top end towards the track. Thus, the hook of the crane is moved along a curved trajectory, the curved being located in a plane parallel to the track. This requires the crane to slew during the up-ending process.

30 In an embodiment, on opposite sides of the guide track are provided two cranes, one on each side of the track, to in unison lift the top end of the pylon section while the bottom end is guided along the guide track. Providing a jack up vessel with a guide track and a track cart to guide a bottom end of a pylon during the upending process in combination with setting up the crane adjacent the track and on opposite sides thereof, allows for using comparatively
35 compact and cranes for lifting a large size, more in particular comparatively heavy, pylon section. the track and cranes being located on the same vessel allows for the cranes to be set up close to the track, and on opposite sides thereof. This enables the cranes to in unison

lift the top end of a pylon section, and even to in unison lift and move the top end of a pylon section extending beyond the contour of the vessel.

Thus, the invention allows for installing large sized piles, more in particular piles having a
5 length substantially larger than the length of the guide track, more in particular having a length larger than the size of the deck, the top end of the pylon section extending beyond the contour of the vessel, for example pylon sections having a length of 100 meters or more, to be transported and installed using a jack-up vessel.

10 In a preferred embodiment, jack-up vessel has a longitudinal axis, extending between the bow and the aft of the vessel, and the guide track extends parallel to that axis. Thus, the one or more pylon sections are also supported with their longitudinal axis parallel to the longitudinal axis of the vessel. This allows for a comparatively long track, and thus enables upending of large size pylon sections.

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Typically, transport vessels are not jack up vessels. Thus, transport and installation of pylon sections using the same vessel, more in particular using a jack-up vessel, allows for a controlled up ending process, because the one or more cranes and the pylon section are located on the same vessel, eliminating relative movement of the pylon section and the
20 crane due to waves.

In a method according to the invention, the vessel is used to transport pile to the installation site and carries a pile drive unit for driving the pile into the sea floor.

25 In an embodiment, the vessel is provided with a pile guide, for engaging a pile at the top section, to keep the pile in position while the pile is driven into the sea floor. The pile guide is located at the installation side, preferably the aft, of the vessel.

In an embodiment, the pile guide is removable mounted to the hull of the vessel, and can be
30 moved, e.g. pivoted or slid, between a storage position, and an active position, in which it extends beyond the hull of the vessel. In an embodiment the pile guide is configured to be removed from the hull when not in use, and is stored for example on the deck or in a storage facility.

35 In an embodiment, the pile guide is provided in the form of a cantilever pile guide. The cantilever pile guide comprises a pile guide section for guiding a pile and a track section, which track section is mounted on a track, preferably the guide track, for supporting the pile

guide in an overboard position. The cantilever pile guide is furthermore slideable mounted on the track, such that it can be moved along the track between a storage position, in which it is located above the deck of the vessel, and an active position, in which a pile guide section of the cantilever pile guide is located outside a perimeter of the deck for guiding a
5 pile being lowered towards the sea floor.

In an embodiment, the pile guide is part of a track cart, which track cart is also to be used for supporting the bottom end of the pylon section when in the horizontal position.

- 10 In an embodiment, the pile guide is configured to engage the pylon section while it is in the horizontal transport position, preferably to secure the pylon section relative to the track cart, and to pivot with the pile while it is upended. In such an embodiment, the cart and the cart track are configured to position the pile guide over the edge of the deck, above the sea, to guide the pile while it is being lowered towards the sea floor. Thus, in such an embodiment,
15 the pile is coupled with the guide section during storage, during the upending, and during the installation process. Thus, the position of the pile can be fully controlled, and there is no need for handing over the pile from one positioning device to another, which is time consuming and above all difficult when handling very large and heavy objects such as piles.
- 20 In an embodiment, the method furthermore comprising guiding the pylon section while it is lowered into the sea, using a pile guide, and driving the pylon section into the sea floor using a pile drive.

In a further embodiment, the pile guide is part of the track cart and the track cart is used to
25 move the pile guide from a storage position, in which the pile guide is located above the deck of the vessel, into an active position, in which the pile guide is located outside a perimeter of the deck for guiding a pile being lowered towards the sea floor.

In a method for installing a pylon section of a wind turbine at a wind turbine installation site,
30 use is made of a marine jack-up type vessel, the jack-up vessel comprising:

- a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;

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- at least three jack-up legs;

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;

5 - a pylon section guide track and an associated track cart, wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pile guide, which pile guide is configured to engage the bottom end of the pylon section when in the horizontal transport position, to position the pylon section relative to the cart, to support that bottom
10 end of the pylon section, and to guide the bottom end of the pylon section over the deck and along the guide track, and wherein the pile guide is pivotably mounted on the track cart to pivot with the pylon section while the pylon section is upended from the horizontal transport position into the vertical installation position; and

15 - a pylon section installation crane, which installation crane is fixed to the hull at the installation end of the guide track for lifting the pylon section, of which one end is supported by the track cart, the installation crane having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

20 wherein the method comprises:

- storing the pylon section on the main deck in a horizontal transport position, in which horizontal transport position the longitudinal axis of the pylon section extends substantially parallel to the main deck and to the guide track, and in which horizontal transport position
25 the bottom end of the pylon is supported by the track cart located at the installation end of the track;

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which operational position the legs
30 engage the sea floor and the hull is above water level;

- using the cart to move the pile guide from a storage position, in which the pile guide is located above the deck of the vessel, into an active position, in which the pile guide is located outside a perimeter of the deck for guiding a pile being lowered towards the sea
35 floor, and upending the pylon section using the pylon section installation crane, to thus bring the pylon section from the horizontal transport position into a vertical installation position, in

which vertical installation position the longitudinal axis of the pylon section extends in a substantially vertical direction;

the upending process comprising:

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- at the support end of the track, lifting the top end of the pylon section with the installation crane in an upward direction and along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during the upending process, thereby rotating the pylon section from a horizontal orientation to a vertical orientation about
10 a substantially horizontal rotation axis, which substantially horizontal rotation axis preferably is perpendicular to the longitudinal axis of the vessel;

- supporting the pylon section with the installation crane in an vertical position, and using the installation crane to lower the pylon section, while supported in a vertical position, above the
15 installation site; and

- lowering the pylon section into an installation position at the installation site and guiding the pylon section, using a pile guide, while it is lowered into the sea,

20 - driving the pylon section into the sea floor using a pile drive; and

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward.

25 Thus, transport of large size pylon sections in a horizontal transport position is possible on a smaller sized, jack-up vessel. The combination of a crane for up-ending the pylon section with a guide track and a track cart for guiding the pylon at on end during up-ending, allows for controlled movement of the pylon section during up-ending, and thus allows for transporting a large pylon section on a jack-up vessel.

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Furthermore, the invention is in particular advantageous for transporting the mast of the wind turbine in the upright position, and allows for doing so with the nacelle and blades already mounted on the mast. Thus, the mast, preferably as part of a preassembled wind turbine, i.e. a combination of a mast, nacelle and blades, can be lifted and mounted on a
35 base, i.e. a jacket or pile, with a single lifting action.

In an embodiment for installing a pylon section of a wind turbine at a wind turbine installation site, use is made of a marine jack-up type vessel, the jack-up vessel comprising:

- a buoyant hull with a main deck for storing the pylon section during transport, the pylon
5 section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;
- at least three jack-up legs;
- 10 - a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;
- a pylon section guide track and an associated track cart,
15 wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section to support that bottom end of the pylon section and to guide the bottom end of the pylon section over the
20 deck and along the guide track; and
- two pylon section installation cranes, preferably two around the leg pylon section installation cranes, located on opposite sides of the installation end of the guide track, to in unison lift the pylon section at a top end thereof, which installation cranes are each fixed to
25 the hull of the vessel at the installation end of the guide track for lifting the pylon section, of which a bottom end is supported by the track cart, the installation cranes each having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,
- 30 wherein the method comprises:
 - storing the pylon section on the main deck in a vertical transport position, in which vertical transport position the longitudinal axis of the pylon section extends substantially perpendicular to the main deck and to the guide track, and in which vertical transport
35 position the pylon is supported by the track cart;

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which position the legs engage the sea floor and the hull is above water level;

5 - optionally, moving the pylon section along the guide track towards the installation end of the track;

- lifting the pylon section with the installation cranes in an upward direction, and using the installation cranes, preferably by at least slewing the jib of the cranes, to position the pylon
10 section, while supported in a vertical position, above the installation site; and

- lowering the pylon section into an installed position at the installation site; and

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract
15 the jack-up legs upward.

The guide track allows for moving a mast, preferably the mast already carrying a nacelle and blades, over the deck, for example from a transport position away from the pylon section installation crane, to a position adjacent the pylon section installation crane, to enable that
20 crane to lift the mast from the vessel.

Furthermore, the guide track extending over the deck of the vessel allows for transporting multiple masts, preferably all provided with a nacelle and blades, preferably each mast being supported by a track cart on the guide track, and move the masts one after another, i.e. at
25 subsequent installation sites, into a position in which they can be engaged by the pylon section installation crane to be installed on a wind turbine installation base, e.g. a jacket or pile, at an installation site adjacent the vessel. Thus the deck space can be optimally used for the transport of masts, and the vessel can be used to visit multiple sites to install the masts, before it needs to be provided with new masts.

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In an embodiment, the vessel is provided with two pylon section installation cranes for lifting the pylon section, preferably a preassembled wind turbine, from the vessel onto the installation site, i.e. onto a pile or a jacket. It is submitted that masts preferably are free of protrusion that may negatively influence wind flow during use. Therefore, preferably a mast is
35 provided with a temporarily mounted yoke, located at the top of the mast for coupling the mast with the travelling blocks of the pylon section installation cranes.

The invention furthermore provides a method for installing a mast, wherein the mast is part of a preassembled wind turbine, the wind turbine further comprising a nacelle, blades and a rotational axis, wherein the method comprises:

- 5 - supporting the preassembled wind turbine in an vertical transport position using the track cart, the nacelle of the preassembled wind turbine facing the aft of the vessel and the blades of the wind turbine extending in a direction essentially perpendicular to the guide track;
- coupling the installation cranes with the mast of the preassembled wind turbine on opposite
10 sides of the nacelle, and lifting the preassembled wind turbine in an upright position from the track cart;
- moving the preassembled wind turbine towards the installation site by both slewing the installation cranes and pivoting the jibs downward; and
15 - lowering the preassembled wind turbine onto the jacket or pile.

In an embodiment, the vessel is provided with two pylon section installation cranes for lifting the mast off the vessel, and the mast is to be provided with a temporarily yoke at a top
20 section of the mast for guiding the wires of the crane, and with a temporarily foot clamp at a bottom section of the mast for coupling with the respective travelling blocks of the pylon section installation cranes. In such an embodiment, the wires of the crane extend from the travelling blocks located at the bottom section of the mast, along the mast and to the top section thereof, where the wires are guided to the crown of the respective pylon section
25 installation cranes are guided by the yoke at the top section of the mast. This provides the mast with additional stability while it is supported, i.e. while being lifted, by the installation cranes.

In an embodiment, the foot clamp engages the outer circumference of the mast only, and
30 leaves the bottom end of the mast, in particular any fastening devices, such as a flange with apertures for mounting bolts, provided at the bottom end of the mast free, such that the fastening device can be used to mount the mast onto the base, i.e. a pile or jacket while the foot clamp is mounted on the mast.

35 In a further embodiment, the foot clamp is part of the track cart and can be coupled with, and uncoupled from, the track cart. When the foot clamp is coupled with the cart, it can

support the pylon section, i.e. the mast, preferably the preassembled wind turbine, in an upright position.

When the cart has been used to move the mast in a position for lifting it, the foot clamp can be used to couple the mast with the wires, more in a particular the travelling blocks, of the pylon section installation crane, and the mast is lifted including the foot clamp, from the track cart.

By providing the track cart with a foot clamp that can be used for supporting the mast in a vertical storage position on the guide track and while lifted by the pylon section installation cranes, the mast is coupled with the foot clamp during storage and during the installation process. Thus, the position of the pylon section can be fully controlled, and there is no need for handing over the mast from one positioning device to another, which is time consuming and above all difficult when handling very large and heavy objects such as a preassembled wind turbine.

The invention furthermore provides a jack-up vessel for installation of a pylon section of an off shore wind turbine.

In an embodiment of a marine jack-up type vessel according to the invention, the jack-up vessel comprises:

- a buoyant hull with a main deck for storing a pylon section, during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;
- at least three jack-up legs;
- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level,
- a pylon section guide track and an associated track cart,

wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section,

- a pylon section installation crane, which installation crane is fixed to the hull of the vessel at the installation end of the track, for lifting a pylon section of which one end is at least partially supported by the track cart, the installation crane having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis.

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The vessel has a pylon section guide track and an associated track cart that enable guiding the foot end of the pylon section, prior to lifting or during upending of the pylon section, over the deck of the vessel. The guide system allows for moving the pylon section without the need of a crane or with a reduced number of cranes. Thus the process can be done in less
10 time and/or the reduced number of cranes or the smaller cranes required in the process allow for a reduction in costs.

In an embodiment, the pylon holder is configured to guide the bottom end of the pylon section along the guide track while the pylon section is upended from the horizontal
15 transport position into an installation position, in which installation position the pylon section has a vertical orientation and is at least partially supported by the pylon holder.

Such a jack-up vessel is configured for transporting a pylon section, in particular a pile for forming the base of a wind turbine, in a horizontal transport position, and for upending the
20 pylon section at an installation site, using the installation crane, into an installation position in which the pile has a vertical orientation.

It is submitted that in the invention is in particular advantageous for upending piles, which are large and heavy compared to masts. The vessel allows for transporting a pile in a
25 horizontal transport position, which is beneficial since it keeps the center of gravity of the vessel plus load low, and for quickly and efficiently upending the pile at the installation site.

The vessel enables lifting the top end of the pylon section while guiding the bottom end, the bottom end being supported by the track cart, until the pylon section is fully lifted upward in
30 an upright position. Thus the bottom end does not need to be lifted during the upending process, and a smaller crane, and/or no crane at the bottom end of the pylon section is needed.

Furthermore, the invention allows for a vessel for installing large sized pylon sections, i.e.
35 having a length of 100 meters or more, which in turn allows for installing wind turbines in deeper waters. This is in particular the case when the vessel is provided with two pylon section installation cranes on opposite sides of the installation end of the guide track. In

such a configuration, the two installation cranes can be used to in unison lift the pylon section in the upright position, and subsequently lift the pylon section overboard and land it on the sea floor in the upright position for being driven into the sea floor.

- 5 In an embodiment, the pylon holder is configured to move, preferably pivot, between a first position, for at least partially supporting the pylon section at the bottom end thereof, when the pylon section is in the horizontal transport position, and a second position, for at least partially supporting the pylon section at the bottom end thereof, when the pylon section is in the installation position, in which horizontal transport position the pylon section has an
10 essentially horizontal orientation.

Thus, the pylon holder can pivot with the pylon section while the pylon section is upended, and thus continuously support and guide the bottom end of the pylon section. In an embodiment, the pylon holder is a cradle shaped holder, which fully supports the bottom end
15 of the pylon section when the pylon section is in the horizontal transport position, but which does not support or engage the pylon section in a direction parallel to the longitudinal axis of the pylon section. Thus, when the pylon section has been upended, it functions as a stop, preventing movement in a direction perpendicular to the longitudinal axis of the pylon section, and thus prevents swinging of the pylon section, at least in one direction, while
20 supported by an installation crane.

In an embodiment, the vessel furthermore comprises a pylon section top end support, which top end support is located at the installation end of the guide track for engaging the top end of the pylon section when the pylon section is in a horizontal transport position, in which
25 horizontal transport position the longitudinal axis of the pylon section extends substantially parallel to the main deck and the guide track.

The pylon section top end support can be configured in the form of a rack or frame, that forms a cradle type support for engaging the pylon section at the top end thereof. The main object of the pylon section top end support is to support the top end of the pylon section
30 such that the longitudinal axis of the pylon section extends in a substantially horizontal direction, when the bottom end of the pylon section is supported by the track cart in the horizontal transport position.

In an embodiment, the pylon section top end support is removably mounted on the deck of the vessel or on the guide track,
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In an embodiment, the pylon top section support is mounted on the guide track at the installation end thereof. In such an embodiment, the pylon section top end support is

preferably removed when the pylon section is upended and the bottom end of the pylon section, supported by the track cart, moves towards the installation end of the track section.

In an alternative embodiment, the pylon section top end support is mounted on part of the deck located between the installation end of the guide track and the edge of the deck. In

5 such an embodiment, the pylon section top end support does not need to be removed during the upending of the pylon section.

In an alternative embodiment, the pylon section top end support is part of a pylon section lifting device, which lifting device is removably mounted around the pylon section near the

10 top end thereof to provide the pylon section with engagement sections to be coupled with the pylon section installation crane.

In an embodiment, the track cart is provided with a cart drive for controlled movement of the cart during the upending process, e.g. wherein the cart comprises a drive with a sprocket

15 that cooperates with a rack extending along the guide track.

Thus, the cart drive can be used to position the cart, during the upending process, such that the wires of the installation crane lifting the top end of the pylon section keep a substantially vertical orientation.

20 In an embodiment, the jack-up vessel comprises a pylon section storage location on at least one side of the guide track, for supporting a pylon section in a horizontal storage position in which a longitudinal axis of the pylon section extends parallel to the guide track and parallel to a pylon section in the horizontal transport position on the transport track, and the vessel comprises a pylon section transfer device, e.g. one or more cranes or a transfer track with a

25 track cart, for transferring a pylon section from the horizontal storage position into the horizontal transport position.

Thus, in such an embodiment multiple pylon sections can be transported by the vessel. The vessel can therefore install multiple pylon sections before it has to be resupplied. This allows for a more efficient installation process, in particular when used to install a windfarm, i.e.

30 multiple installation sites grouped close together.

In an embodiment, the vessel further comprises at least a top transfer track and a bottom transfer track, the top transfer track and the bottom transfer track extending substantially perpendicular to the guide track, and the top transfer track and the bottom transfer track

35 comprising at least one top transfer cart and at least one bottom transfer cart respectively for supporting a pylon section at the top and at the bottom respectively, for moving the pylon section into and out of the horizontal transport position on the guide track.

In an embodiment, the guide track and the track cart are configured to support the pylon section in the horizontal transport position such that the longitudinal axis of the pylon section extends parallel to a longitudinal axis of the vessel and preferably is located at the centre of the vessel.

In an embodiment, the guide track and the track cart are configured to support the pylon section, when in the horizontal transport position, with the top end located near the installation crane and an installation edge of the deck, i.e. the edge of the deck over which the pylon section will be lifted off the vessel, and with the bottom end located away from the installation crane and the installation edge of the vessel.

In embodiment the invention provides a vessel of which the pylon holder is configured to engage the bottom end of the pylon section when in the vertical transport position, and wherein the cart can move the supported pylon section along the guide track while the pylon section is free standing, i.e. without additional supports, in vertical transport position.

Such an embodiment is in particular advantageous for transporting the mast of a wind turbine in the upright position, and allows for doing so with the nacelle and blades already mounted on the mast. Thus, the mast, preferably as part of a preassembled wind turbine, i.e. a combination of a mast, nacelle and blades, can be lifted and mounted on a base, i.e. a jacket or pile, with a single lifting action.

Furthermore, the guide track allows for moving a mast, preferably the mast already carrying a nacelle and blades, over the deck, for example from a transport position away from the pylon section installation crane, to a position adjacent the pylon section installation crane, to enable that crane to lift the mast from the vessel.

In an embodiment, the vessel is configured to be supplied with pylon sections by an extended guide track from another vessel or from land, for example a quay. In such an embodiment, for example a supply track is provided on a barge, preferably a jack-up barge, or a quay, the supply track comprising one or more track carts supporting a pylon section in the upright position, bridge section can be used to connect the supply track with the guide track, to enable the track carts to be moved along the track from the supply track onto the guide track.

The vessel being a jack-up type vessel allows for the legs to be extended, and at least partially lift the vessel out of the water, to stabilise the vessel and preferably level the vessel with the supply track to thus facilitate the transfer of a cart from the supply track onto the guide track while supporting a pylon section, in particular while supporting a preassembled
5 wind turbine. In an embodiment, the track cart is provided with a cart drive configured for controlled movement of the cart along the supply track and onto the guide track. In an alternative embodiment, the tracks can be skid tracks and the cart skid carts, to be moved skidded along the track using a skid device, e.g. hydraulic cylinders. Alternative drive systems, e.g. a winch for pulling the cart along the track can also be used.

10

The invention also provides a method for supplying a jack-up vessel, the jack-up vessel comprising a guide track for supporting and moving a preassembled wind turbine along the deck of the vessel using a track cart, the method comprising:

15 providing a track cart with a preassembled wind turbine on a supply track;

aligning the jack-up vessel, more in particular the guide track of the jack-up vessel, with the supply track;

20 lowering the legs of the jack-up vessel to stabilise the vessel, and preferably to at least partially lift the vessel out of the water and level the guide track of the vessel with the supply track;

connect the supply track with the guide track, for example by providing a bridge track

25 between the supply track and the jack-up vessel, more in particular the guide track of the jack-up vessel, such that the supply track and the guide track are both part of a single linear guide track;

move the track cart with the preassembled wind turbine from the supply track onto the guide
30 track, thus passing the preassembled wind turbine between two legs of the Jack-up vessel; and

after thus moving one or more preassembled wind turbines onto the jack up vessel, raising the legs of the jack up vessel and moving the jack up vessel to an installation site.

35

A further method according to the invention comprises the steps:

prior to moving the preassembled wind turbine onto the jack-up vessel, orientate the preassembled wind turbine with its front facing sideways on the supply track, i.e. with the rotational axis of the wind turbine at an angle with the supply track; and

- 5 move the track cart with the preassembled wind turbine from the supply track onto the guide track with the turbine having this orientation, such that the preassembled wind turbine, when on the guide track, is orientated with its front facing sideways on the guide track, i.e. with the rotational axis of the wind turbine at an angle with the guide track.
- 10 In a further method, the angle between the rotational axis and the guide track is at least 70 degrees, preferably is at least 75 degrees, for example is 78,5 degrees.

In a further method, the angle between the rotational axis and the guide track is less than 90 degrees, preferably is less than 85 degrees, for example is 80 degrees.

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A further method according to the invention comprises the steps:

aligning the jack-up vessel, more in particular the guide track of the jack-up vessel, with an installation site;

- 20 lowering the legs of the jack-up vessel to stabilise the vessel, and to at least partially lift the vessel out of the water;

orientate the preassembled wind turbine with its front facing the installation site and with the rotational axis of the wind turbine parallel with the supply track, preferably by rotating the

- 25 pylon section, more in particular the mast, of the preassembled wind turbine about its longitudinal axis, and if needed, move the preassembled wind turbine along the guide track into a position in which it can be lifted by one, preferably two, installation cranes; and

lift the preassembled wind turbine from the vessel onto a wind turbine installation base, e.g.

- 30 a jacket or pylon, using an installation crane, preferably using two installation cranes in unison.

With a vessel according to the invention, the guide track extending over the deck of the vessel allows for transporting multiple preassembled wind turbines, i.e. wind turbines

- 35 comprising a mast, a nacelle and blades, aligned on the guide track over the vessel.

In a preferred embodiment, the vessel is configured to orientate a preassembled wind turbine, i.e. rotate the pylon section, more in particular the mast, of the preassembled wind turbine along its longitudinal axis to thus adapt the orientation of the nacelle and blades relative to the guide track. In an embodiment, the track cart is configured to rotate the pylon section. in an alternative embodiment, a separate pylon section orientation device is provided, e.g. a clamp that can engage the pylon, lift it, e.g. lift it from a track cart on the guide track, rotate it around its longitudinal axis and lower it, for example lower it onto a track cart on the guide track

- 10 Such a vessel allows for transporting multiple preassembled wind turbines, the preassembled wind turbines all having an orientation in which the rotational axis of the wind turbine extend at an angle with the supply track, and the blades of the different turbines overlap when seen in a view perpendicular to the guide track. This configuration allows for positioning multiple preassembled wind turbines close together and between the raised legs
15 of the jack up vessel, and thus enables a comparatively small vessel to transport and install multiple relatively large preassembled wind turbines.

The preassembled wind turbines can be moved one after another, at subsequent installation sites, into a position in which they can be engaged by the pylon section installation cranes to
20 be installed on a base at an installation site adjacent the vessel. Thus the deck space can be optimally used for the transport of masts, and the vessel can be used to visit multiple sites to install the masts, before it needs to be provided with new masts.

In an embodiment of a vessel according to the invention the track cart is configured for
25 supporting a pylon section in the vertical transport position and in the horizontal transport position, e.g. wherein the cart comprises a pylon section holder for engaging the bottom end of a pylon section, and which pylon section holder can be pivoted between a horizontal support position for engaging the bottom end of a pylon section having a horizontal orientation and
30 a vertical support position for engaging the bottom end of a pylon section having a vertical orientation. Such an embodiment is in particular advantageous for transporting a pile, i.e. a pylon section configured to form a base of a wind turbine, which are relatively large and heavy, compared to a mast of a wind turbine that is to be mounted onto such a pile, or on a transition piece mounted onto such a pile.

35 In an embodiment, the track cart has a pylon section holder, which pylon section holder is configured to engage both the larger piles and relative smaller mast sections. In an

embodiment, the pylon section holder comprises an adaptable gripper, clamp or cradle, that can be adapted to fit the size and/or shape of the pylon section to be engaged. Also, a track cart can be provided with multiple, differently sized interchangeable pylon section holders, thus, the cart can be provided with a couple element that fits the pylon section to be

5 handled.

In an embodiment, the track cart is provided with a pylon section holder for supporting pylon sections in the horizontal transport position, and allowing for upending the pylon section while supporting it, and with a pylon section holder for supporting pylon sections in the
10 vertical transport position, which pylon section holders can be interchanged.

Thus, one pylon section holder is used for transporting a pylon section in a horizontal transport position, and during upending that pylon section, which pylon section holder is replaced with a different pylon section holder for transporting a pylon section in the vertical
15 transport position. As an alternative, one pylon section holder can be used for both transportation modes, i.e. can be set in a fixed in a first position relative to the cart for transporting a pylon section in the vertical transport position and be fixed in a second position for transporting a pylon section in the horizontal transport position, and can be driven between these positions during the upending process.

20 Typically, the horizontal transport position is to be used for piles, while mast sections, preferably with the nacelle and blades already mounted, are transported in the upright position, the pile typically having a larger diameter and being of more weight than the mast. Thus, in an embodiment, one pylon section holder is configured to engage large diameter pylon sections and another pylon section holder is provided for engaging small diameter
25 pylon sections. As an alternative, and as already explained above, an adaptive pylon section holder can be provided to engage both a pylon section of a large and of a small diameter, or an adapter piece can be provided to enable the a pylon section holder fit for small diameter pylon sections to also receive pylon sections having a large diameter.

30 In an embodiment, the pylon section holder is configured to receive the bottom end of a pylon section in the vertical transport position, e.g. comprises a cone for inserting in the bottom end of the pylon section and/or a hollow section for receiving the bottom end and for engaging the outside circumferential surface of the bottom end of the pylon section. In an embodiment, the pylon section holder comprises one or more clamping devices for engaging
35 the bottom end of the pylon section to secure the pylon section in the vertical transport position.

In an embodiment, the guide track is provided with multiple track carts for each supporting a pylon section in the vertical transport position. In such an embodiment, the multiple pylon sections can be supported next to each other, each mounted in a track cart.

- 5 In an embodiment, the track cart is configured to be fixed to the guide track and/or to the deck of the jack-up vessel, to provide additional support for a pylon section supported in the upright transport position.

- 10 In an embodiment, the vessel is provided with a pylon section support system for providing pylon sections with support while the vessel is in transit, i.e. is travelling between a pylon section supply site, for example a harbour or dock, and an installation site.

- In an embodiment, the pylon support system is configured to provide support for pylon sections in the vertical transport position,
- 15 In embodiment, the pylon section support system comprises a support mount, which support mount can be attached to the pylon section, for example by way of clamping, bolts or welding, at the lower end thereof, to provide the pylon section with an enlarged footprint on the deck, and thus stabilise the pylon section in the vertical transport position during transit.
- 20 The support mount for example is a frame work or comprises multiple legs, with supports or feet positioned away from the center of the pylon section, and which supports or feet can rest on the deck to provide the pylon section with support. In an embodiment, the supports are temporarily fixed to the deck, for example using clamps or by welding.

- 25 In an embodiment, the pylon support system comprises a deck mounted support frame with pylon engagement devices, e.g. clamps or slots, for engaging the pylon section, which engagement devices are located at a height above the main deck for engaging the pylon section at a distance away from the bottom end of the pylon section, for example at 15 or 20 meters above the lowest end of the pylon section.

- 30 In an embodiment, the track cart is configured to pick up a pylon section and drop off a pylon section, and the pylon section can be supported in the vertical transport position by the pylon section support system only, for example by a support mount fixed to the lower end of the pylon section or by a deck mounted support frame. Thus a single cart can be
- 35 used to transport pylon sections, one at the time, along the guide track. In an alternative embodiment, each pylon section in the vertical transport position is provided with a track cart,

which track supports the pylon section, either alone or in combination with a pylon support system, in the vertical transport position during transit.

In an embodiment, the vessel is provided with two pylon section installation cranes for lifting the pylon section, preferably a preassembled wind turbine, from the vessel onto the installation site. It is submitted that masts preferably are free of protrusion that may negatively influence wind flow during use. Therefore, preferably a mast is provided with a temporarily mounted YOKE, located at the top of the mast for coupling the mast with the travelling blocks of the pylon section installation cranes.

In an embodiment, the vessel is provided with two pylon section installation cranes for lifting the mast off the vessel, and the mast is to be provided with a temporarily yoke at a top section of the mast for guiding the wires of the crane, and with a temporarily foot clamp at a bottom section of the mast for coupling with the respective travelling blocks of the pylon section installation cranes. In such an embodiment, the wires of the crane extend from the travelling blocks located at the bottom section of the mast, along the mast and to the top section thereof, where the wires are guided to the crown of the respective pylon section installation cranes are guided by the yoke at the top section of the mast. This provides the mast with additional stability while it is supported, i.e. while being lifted, by the installation cranes.

- providing a temporarily mounted yoke, located at the top of the mast for coupling the mast with the travelling blocks or the wires of the pylon section installation cranes; and

- optionally providing a temporarily mounted foot clamp, which foot clamp preferably is part of the track cart which can be connected to and disconnected from the cart, at the bottom of the mast for coupling the mast with the travelling blocks of the pylon section installation cranes.

In an embodiment, the deck of the jack-up vessel has an installation side, the installation crane, preferably both installation cranes, being mounted to the hull of the vessel at the installation side of the vessel, and the installation end of the guide track is located at the installation side. Furthermore, preferably the guide track extends perpendicular to the installation side of the deck of the vessel.

In an embodiment, the vertical slew axis of the respective installation cranes define a virtual plane, and an installation side of the main deck of the vessel is located at an installation side of the virtual plane and the main deck is located at a deck side of the virtual plane.

- 5 In a further embodiment, the guide track passes between two installation cranes and between the two legs of the vessel located at the installation side of the main deck of the vessel, and the guide track extends in a direction perpendicular to the virtual plane.

In an embodiment of a vessel according to the invention, the vessel comprises a second
10 installation crane and the two installation cranes are fixed to the hull on opposite sides of the guide track at the installation end thereof, for in unison lifting a pylon section of which one end is supported by the track cart, and for lifting the pylon section from the vessel onto an installation site. Providing the jack-up with two installation cranes on opposite sides of the guide track allows for the installation cranes to support a pylon section on opposite sides
15 thereof, and thus to, in unison, lift a pylon sections having a length similar to or larger than the length of the jib. In this context it is submitted that because of installation cranes typically being provided with a travelling block and often with spreaders and similar devices, a single installation crane is not able to lift a pylon section in an upright position, the pylon section having a height similar to having the height of the jib.

20

In a further embodiment, each crane has a storage configuration, in which the jib is located at the deck side of the virtual plane, and an installation configuration in which the jib is located at the installation side of the virtual plane.

- 25 In an embodiment, the pylon section installation crane is an around the leg crane, i.e. is mounted around a leg of the jack-up vessel, preferably the two pylon section installation cranes are both around the leg cranes, i.e. are each mounted around a leg of the jack-up vessel.

This allows for a compact configuration of the jack-up vessel, and , the latter for an extra
30 stabile installation configuration due to the cranes being located around the legs supporting the vessel, and on opposite sides of the guide track, more in particular the installation end of the guide track.

In an embodiment, the jack-up vessel has four legs, the four legs comprising two front legs
35 and two rear legs, wherein the two rear legs are spaced farther away from each other than the two front legs, to thus create additional deck space between the two rear legs, preferably between the two around the leg cranes mounted on said rear legs.

In an embodiment, the jack-up vessel furthermore comprises a cantilever, e.g. for performing well bore operations, and the guide track is adapted to cooperate with the cantilever to move the cantilever relative to the hull at least in longitudinal direction of the guide track between a retracted position and an extended position, in which extended position an operational end of the cantilever structure extends beyond an installation side of the main deck of the vessel.

In an embodiment, the guide track and/or the installation crane is/are adapted to move the cantilever into a deck clearing position wherein a clear deck area of the main deck is present between said cantilever and the installation side of the main deck of the vessel, wherein the clear deck area extends at least 20 meters in a direction perpendicular to said installation side and at least 10 meters transverse to the guide track direction, e.g. to allow for placing a topsides on said clear deck area.

In an embodiment, the jack-up vessel comprises a cantilever motion assembly, which cantilever motion assembly preferably comprises the guide track, which guide track preferably comprises one or more rails mounted on said main deck, e.g. in an axial direction of the hull perpendicular to the second axial side, and wherein said one or more rails extend towards or to a side of the hull so as to allow for the cantilever motion assembly to move the cantilever relative to the vessel between extended positions wherein an operational end of the cantilever extends beyond the side of the hull, a retracted position wherein said operational end is before the side of the hull and the entire cantilever is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs.

Upending a pylon section is a complicated process, in particular when the upending involves both lifting and slewing with the up ending crane, or cranes, to keep the pylon section aligned with the track during the upending process. Furthermore, the increasing pile sizes requires larger cranes as well. To allow for a crane driver to safely utilise the full operational window of the crane, the crane preferably should be able to support loads up to or above twice the size of the load actually being hoisted. This is in particular the case with piles, which due to their weight and length may potentially cause extreme loads on the crane and other upending equipment. Thus, typically large sized cranes are used for the installation of piles.

According to a further aspect the invention therefore also provides an offshore wind turbine installation vessel capable of efficiently, i.e. fast and/or with comparatively small cranes, upending a wind turbine foundation pile.

The invention therefore provides an offshore wind turbine installation vessel that comprises:

- a hull having a storage deck configured for storage thereon of one or more wind turbine foundation piles, e.g. monopiles, in horizontal orientation thereof, said foundation piles each having a lower end configured to be driven into the seabed and a top end,
- a crane, e.g. a pylon section installation crane, comprising:
 - a crane base secured to the hull,
 - 10 - a slewable superstructure mounted on the crane base and slewable about a vertical slew axis relative to the crane base,
 - a slew drive configured to cause slew motion of the superstructure about the slew axis,
 - a boom structure comprising a boom that is pivotally connected to the
 - 15 superstructure about an inner pivot axis,
 - a luffing mechanism comprising a luffing drive and configured to cause luffing motion of the boom structure,
 - a hoisting assembly comprising a hoisting winch and a hoisting winch driven cable,
 - a load connector, wherein the winch driven cable extends in a multi-fall
 - 20 arrangement between a sheave set on the boom structure and a sheave set on the load connector,
 - a computerized crane control system linked to the slew drive, the luffing drive, and the hoisting winch, which computerized crane control system is programmed to perform a
 - 25 foundation pile installation routine providing a coordinated pattern of slew motion of the superstructure and of luffing motion of the boom structure, as well as operation of the hoisting winch so that the load connector moves from a foundation pile pick up position thereof where the load connector is connected to the top end of a horizontally oriented foundation pile stored on the deck to a foundation pile overboarding position thereof wherein
 - 30 the foundation pile is in vertical suspended from the load connector, outside of the hull, and preferably is aligned with a pile gripper configured to maintain the wind turbine foundation pile in vertical orientation during a pile driving operation wherein the foundation pile is driven into the seabed.
 - 35 The vessel comprises a computerized crane control system, which computerized crane control system is programmed to perform a foundation pile installation routine providing a

coordinated pattern of slew motion of the superstructure of the crane, of luffing motion of the boom structure of the crane, and of hoisting by the hoisting winch of the crane.

Thus, the computerized crane control system is capable of moving the load connector, and
5 thus the load supported by the load connector, from a foundation pile pick up position to a foundation pile over boarding position, along a predefined trajectory. Using the computerized crane control system, this trajectory can be programmed, and the upending process can be run by the crane control system.

10 For example, when upending a pylon section, the load connector, and thus the top end of the pylon section, moves along an arc shaped trajectory, or, if the pylon section is supported by a cart that moves along the track during the upending a more complicated trajectory. During the upending process, the pylon section is to be kept aligned with the track to not exert unwanted stresses on the cart supporting the pylon section. Also, the distance
15 between the load connector and the cart should be controlled, to prevent the upending of the pylon section to result in forces pulling or pushing the cart along the track. When two cranes are used, both cranes furthermore have to move simultaneously. This makes the upending process difficult to manage. Providing the computerized crane control system helps the crane driver in managing this process.

20

The crane running an installation routine reduces the workload of the crane driver, who can now fully concentrate on monitoring the process, and who may intervene if that is deemed necessary. Thus, the crane driver is able to better monitor the overall process. Also, because the load connector is moved along an optimal path, the crane movement can be
25 optimised and the load can be moved efficiently. This may also reduce the time required for hoisting the load to its destination.

Thus, an offshore wind turbine installation vessel is capable of efficiently, i.e. fast and/or with comparatively small cranes, upending a wind turbine foundation pile.

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In a preferred embodiment, the computerized crane control system is provided with one or more input devices, e.g. sensors or cameras, to track the position of the load and/or to monitor the environment, for example the relative position of the vessel, and is configured to dynamically amend the installation routine using the information provided by the one or more
35 input devices. For example, the computerised crane control system may adjust the position of the boom and hoisting winch to compensate for titling of the vessel due to a change in load distributed over the working deck.

The crane control system may for example also be used to control the position of the load connector relative to an object, for example a cart or pylon holder or gripper, during the upending or installation of a pylon section. Thus the crane drive is allowed to control a
5 limited number of parameters, while the system handles another set of parameters of the hoisting process. The control system for example keeps the pylon section aligned with the track, while the crane driver controls the position of the load connector relative to the track, and the speed with which the load connector moves along the predefined trajectory.

- 10 In an embodiment, the invention provides a crane comprising computerized crane control system that allows for running sub routines in a hoisting process. For example, the installation routine may comprises the actual upending process, ending in the pile being supported in the upright position, after which the crane driver takes over and hoists the pile into a position for landing the pile in the pile gripper, after which a pile gripper landing routine
15 is run that moves the pile into the pile gripper, after which the crane driver again takes over and lowers the pile towards the sea floor.

The predefined trajectory can for example be obtained by running a simulation on shore, and transferring the movements of the load connector from the simulator to the
20 computerized crane control system, after running a successful installation procedure. Alternatively, a crane driver may program an ideal trajectory into the computerized crane control system. Also, the computerized crane control system may be configured to record the trajectory of movement of the load connector during a first installation, which recorded movements can subsequently be used as installation routine in subsequent installations.

25 Because the trajectory of the load connector can be controlled using the computerized crane control system, the installation routine can be set up to move the load connector along the ideal path for handling a load, i.e. an optimal combination of a path that allows for quickly moving the load to its destination and the path that is least taxing to the crane structure and
30 capacity. Thus, the operational window of the crane can be used optimally, and it is no longer required to use for example a crane that can handle at least two times the load that is actually being hoisted.

In an embodiment, the vessel further comprises a pile gripper, preferably arranged in
35 proximity of the crane, configured to maintain a wind turbine foundation pile in vertical orientation during a pile driving operation wherein the foundation pile is driven into the

seabed. Thus, the vessel can be used for the full installation process, i.e. also during the pile driving.

In an embodiment, the invention provided a crane with a computerized crane control system
5 that is capable of running one or more routines, for example a load lifting routing, or a load landing routing, in which a basic routine of movements is dynamically adjusted to compensate for changes in the environment.

For example, in addition to the computerized crane control system, a crane may be provided
10 with a multiple scanners that provide spatial information on objects located in the crane working area, e.g. the top end of a pile. A basic routine of movements for landing a pile driver onto the top end of the pile may be adjusted based on this real time spatial information to compensate for movements of the vessel supporting the crane relative to the pile supported by the sea floor.

15 In an embodiment, the vessel comprises an upending cradle configured to support the lower end or a lower section of the foundation pile during upending of the foundation pile during the foundation pile installation routine.

20 Such an upending cradle is configured to assist in the upending process by keeping the lower end of the pile at a substantially fixed, or controlled, position, and by guiding the pivoting movement of the lower end of the pile.

In an embodiment, the computerized crane control system is programmed to perform a
25 foundation pile installation routine that is configured to move the top end of the pile along a fixed trajectory relative to the upending cradle. It is submitted that an optimal trajectory of the load connector allows for minimizing the loads exerted on the upending cradle in the horizontal plane.

30 This is in particular the case when the upending cradle comprises a pivotably supported clamp, to secure the bottom section of the pile relative to an upending pivot axis. Moving the top end of the pile along a curved trajectory having the pivot point at its centre minimises loads on the upending cradle. Preferably, the curved trajectory of movement of the load connector lies within a plane that is perpendicular to the pivot axis. Thus, forces directed
35 perpendicular to that plane, i.e. for example parallel to the pivot axis, can be kept to a minimum.

However, performing such an exact hoisting movement is difficult for a crane driver, because it involves a combination of slewing, luffing and hoisting movements. The programmable computerized crane control system enables a fully controlled movement of the load connector, and thus for a minimal load on the upending cradle. The latter can thus
5 be of a compact, low weight design.

In an embodiment, the vessel is a jack up vessel provided with an upending cradle track, and the upending cradle is mounted on that cradle track and is configured to move along a track, during the upending of the foundation pile. By thus moving the cradle, the top end of
10 the pile can be lifted in a purely vertical direction, which facilitates the lifting process. The installation routine may be used to adjust the hoisting speed such that it keeps up with the movement of the upending cradle along the track. In an embodiment, the cradle is provided with a drive, for enabling controlled movement of the cradle along the track, and the computerized crane control system is configured to at least monitor the movement of the
15 cradle, preferably control the drive and thus control the movement of the cradle along the track.

In a further embodiment, the upending cradle is configured to support the foundation pile at the lower end thereof, when the pile has been upended.
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In an embodiment, the upending cradle is configured to guide the foundation pile, while the pile, in an upended position, is lowered towards the sea floor. In such an embodiment, the upending cradle is configured to be used as a pile gripper.

25 In an embodiment, the vessel, preferably the crane of the vessel, further comprises an observation system linked to the computerized crane control system, for tracking movement of the load connector and/or the top end of the wind turbine foundation piles during the foundation pile installation routine, which observation system comprises:

30 - at least one camera, preferably mounted to the boom, to register a crane working area view, preferably a crane working area top view, of the working area of the crane,

- an augmentation system, linked with the at least one camera and with the crane control system, and configured to combine graphic crane information, e.g. hoisting speed, wind
35 direction, with the real time view registered by the camera into an augmented crane working area view; and

- a display, e.g. a monitor or a head up display, linked to the augmentation system to present the augmented working area view to a crane driver.

The observation system enables the crane driver to monitor the movement of the load connector, and thus the load supported thereby. In a preferred embodiment, the display projects the programmed trajectory of the load connector according to the installation routine and the actual position, preferably the actual trajectory, of the load connector to facilitate monitoring the routine by the crane driver. The crane driver may stop or overrule the routine if the discrepancy between the actual track and the predetermined track becomes too large.

10 In a further preferred embodiment, the computerized crane control system allows for the crane driver to adjust the routine to keep the load connector on track, without having to stop the routine.

In an embodiment, the computerized crane control system comprises an input device, e.g. a key pad, a slot for connecting an information carrier, a wireless connection, etc, that is configured to receive a foundation pile installation routine, to enable the computerized crane control system to perform said foundation pile installation routine.

20 In an embodiment, the computerized crane control system comprises a control device that is configured to receive a command to start the foundation pile installation routine of the computerized crane control system.

In a further embodiment, the computerized crane control system comprises a control device that is configured to receive a command to stop the foundation pile installation routine of the computerized crane control system.

In an embodiment, the crane is a first pylon section installation crane and the vessel further comprises a second pylon section installation crane, which second pylon section installation crane is similar to the first pylon section installation crane, for in addition to the first crane support a foundation pylon section, wherein the computerized crane control system is linked to a slew drive, a luffing drive, and a hoisting winch of the first crane and the second crane, and wherein the computerized crane control system is programmed to perform the foundation pile installation routine providing a coordinated pattern of slew motion of the superstructure and of luffing motion of the boom structure, as well as operation of the hoisting winch of both the first crane and the second crane so that the load connector of the first crane and the load connector of the second crane each move from a foundation pile pick up position thereof where the load connector is connected to a horizontally oriented

foundation pile stored on the deck to a foundation pile upended position thereof wherein the foundation pile is in vertical position and is suspended from at least the load connector of the first crane.

- 5 The invention furthermore provides a crane for providing a vessel according to the invention.

It is submitted that the invention, in particular the crane according to the invention, can also be used for lifting pylon sections, e.g. piles or mast sections, that have been transported to the installation site in an upended position. For example, the piles can be stored on the

- 10 storage deck with a vertical orientation, requiring one or more cranes to lift the upended pile from the vessel onto the installation site, for example lower the pile into a pile gripper configured to maintain a wind turbine foundation pile in vertical orientation during a pile driving operation wherein the foundation pile is driven into the seabed.

- 15 The invention allows for using a comparatively light crane, or to use two cranes in unison, for hoisting the pile because the computerised control system, more in particular the foundation pile installation routine, allows to optimally utilise the cranes capacity. Thus there is no need for large cranes, for example cranes mounted on a dedicated crane vessel.

- 20 Furthermore, the pylon section, e.g. masts or mast sections, can be part a completed wind turbine, further comprising a nacelle and blades mounted thereon. Hoisting these completed masts or mast section is a difficult process, due to the blades of the wind turbine possibly colliding with the boom or other objects during the hoisting process. This is in particular the case when the vessel is a jack up vessel, of which the legs, even if they are in an extend
- 25 position raising the vessel above the water, may limit the movement of the completed mast during the hoisting process. Hoisting the completed mast with a crane according to the invention allows for using an installation routine, comprising a coordinated pattern of slew motion of the superstructure and of luffing motion of the boom structure as well as operation of the hoisting winch so that the load connector, and thus the completed mast, moves from a
- 30 location on the deck of the vessel to a location at the installation site, for example on top of a pile or a jack up located at the installation site.

In an embodiment, an installation routine comprises only part of the hoisting process. For example, when installing a completed mast section, i.e. with nacelle and blades mounted,

- 35 the load connector is fixed to the mast section or nacelle, and the completed mast section is lifted from the deck into a routine start position, from which the installation routine is run. The installation routine controls the hoisting of the crane and moves the completed mast into a

routine end position above for example a pile section at the installation site. During the installation routine, the crane driver monitors the process, preferably using a display presenting an augmented view of the working area of the crane, and may intervene if deemed necessary. Once the completed mast section has arrived at the routine end
5 position, the crane driver takes over to lower the mast section onto the pile.

The invention furthermore provides a pile upending system, comprising at least one crane with a computerized crane control system programmed to run a foundation pile installation routine, and an upending cradle configured to support the lower end or a lower section of a
10 foundation pile during upending of the foundation pile during the foundation pile installation routine.

The invention furthermore provides an offshore vessel comprising a crane, the crane having a computerized crane control system configured to run a load hoisting routine. The invention
15 furthermore provides a crane for providing such a vessel.

In an embodiment, the computerized crane control system can be linked in a master-slave configuration for hoisting a single load with both cranes. In the master-slave configuration, a crane driver runs the first crane and the computerized crane control systems are linked to
20 make the second crane move with the first crane, more in particular to keep the load connector of the second crane in a fixed position relative to the load connector of the first crane during the hoisting process.

The invention furthermore provides an offshore vessel comprising a crane, the craning having an observation system comprising an augmentation system. The invention
25 furthermore provides a crane for providing such a vessel.

According to the invention, such an offshore vessel comprises:

- a hull having a storage deck configured for storage thereon of one or more loads, e.g.
30 containers, monopoles;
- a crane comprising:
 - a crane base secured to the hull;
 - a slewable superstructure mounted on the crane base and slewable about a vertical slew
35 axis relative to the crane base;
 - a slew drive configured to cause slew motion of the superstructure about the slew axis;

- a boom structure comprising a boom that is pivotably connected to the superstructure about an inner pivot axis;
- a luffing mechanism comprising a luffing drive and configured to cause luffing motion of the boom structure;
- 5 - a hoisting assembly comprising a hoisting winch and a hoisting winch driven cable;
- a load connector, wherein the hoisting winch driven cable extends between a sheave on the boom structure and a sheave on the load connector, preferably extends in a multi-fall arrangement between a sheave set on the boom structure and a sheave set on the load connector, and driving the hoisting winch moves the load connector up or down at a
- 10 crane working area;
- a computerized crane control system linked to the slew drive, the luffing drive, and the hoisting winch,
- an observation system, which observation system comprises:
- 15 - at least one camera, preferably mounted to the boom, to register a crane working area view, preferably a crane working area top view, of the working area of the crane,
- an augmentation system, linked with the at least one camera and with the crane
- 20 control system, and configured to combine graphic crane information, e.g. hoisting speed, wind direction, with the real time view registered by the camera into an augmented crane working area view;
- display, e.g. a monitor or a head up display, linked to the augmentation system to present
- 25 the augmented working area view to a crane driver.

Thus, the crane provides a crane driver with a real time overview of the crane working area. The overview combines a digital representation and/or actual picture of the crane working area, combined with graphic crane information.

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In an embodiment, the observation system allows for the crane driver to adapt the augmented crane working area view, e.g. to select which crane information is to be shown, or, in case of multiple camera's, which viewing angle of the crane working area.

In an embodiment, the observation system comprises multiple camera's that provide

35 different viewing angle of the crane working area, or may provide views of different areas.

For example, in an embodiment one camera is set up to monitor the location of origin of a load to be lifted, one camera is set up to monitor the location of destination of the load to be

lifted, and three cameras are set up to monitor the crane working area, with two mounted to the boom of the crane and one mounted to the super structure of the crane, such that they move with the crane when the load is moved from the one location to the other.

Also, views of multiple camera's may be combined. For example, a first camera may register

5 a person, which person is blocked from view by a container in the view of a second camera.

When the crane driver is present with the view of the second camera, a graphical representation of the person may be projected on the container to indicate to the crane driver a person is located behind the container.

The spatial information can for example also be used to project a digital image of an object
10 onto the display, when that object is not, or is not fully visible. For example, due to poor visibility conditions, for example caused by fog or poor lighting conditions, or an obstructed direct view from the crane driver's cabin, important objects, such as a load carried by the crane or a potential collision object such as another crane mounted on the vessel, may not be fully visible to the crane driver. The augmented view can thus provide the crane driver
15 with a digital representation. e.g. a line drawing or a fully rendered drawing, of an object such as another crane mounted on the vessel, that is projected on the display to indicate the presence and location of the object.

In an embodiment, computerized crane control system and/or the observation system may
20 be provided with sensors and camera's to obtain additional information, such as an infrared camera, a night view camera, a camera that allows for substantial magnification of the picture to enable zooming in on the view provided, object detection sensors, scanners such as laser scanners or ultra sound scanners, lidar, etc.

25 The term 'crane information' may refer to any type of information relevant to the hoisting process, and may comprise information on the load to be lifted, on the vessel on which the load is located, wind direction, logistic planning information, etc.

In an embodiment, the augmentation system comprises spatial information of the vessel and
30 the crane, for example comprises a 3D model of the vessel and the crane, and is configured to use this spatial information to present the crane driver with potential collision objects, e.g. a control station located adjacent the storage deck of the vessel. Also, the spatial information may be combined with functional information, such as areas that are designated 'storage area' and are thus accessible for landing loads, and areas that are designated
35 'personnel area' and are thus off limits to the crane.

In an embodiment, the observation system comprises one or more spatial sensors, for example laser scanners or ultrasonic scanners, to register, preferably continuously register, the surroundings of the crane. Thus, the spatial information available to the augmentation system can be updated. Changes in the environment, for example due to stacking objects
5 on the storage deck, can be incorporated in the augmented view.

The spatial sensors can be located on the crane. In an embodiment, the sensors are located on the super structure of the crane and/or the boom of the crane, such that the area scanned by the sensors moves with the crane when the latter is slewed by the slew drive. In
10 an embodiment, the sensors can be mounted on the vessel, for example along different positions along a storage deck, to provide spatial information of an area from different angles. This is in particular beneficial when the area comprises fixed or temporarily obstacles, such as containers stacked on the storage deck. For example, in an embodiment, the vessel is provided with multiple sonar sensors to register container positions on the
15 storage deck from several angles.

In addition, or as an alternative, one or more spatial sensors can be mounted on the boom of the crane, e.g. at the top of the boom, to provide a top down view of the crane working area. In an embodiment, the load connector can be provided with sensors and/or camera's
20 to scan the crane working area and/or provide information, e.g. a real time top down view of the working area, to the crane driver.

In an embodiment, mobile sensors are temporarily mounted to the load itself, for example to a container, to register the surroundings of the container, and for example the proximity of other objects and/or the load connector, or to register the location of the load relative to the
25 spatial information present in the augmentation system. In an embodiment, the augmented view displays the position of the load connector relative to the boom, more in particular relative to the position at which the hoisting cable is supported by the boom. Thus, the augmented view may in a top view of the crane working area indicated the side lead and/or the offlead of the load connector. In an embodiment, the augmented view may show the
30 crane operator information on the speed of the load connector and the position of the load connector relative to the storage deck or relative to a load located on the storage deck.

In an embodiment, the augmentation system is configured to project a path for the crane driver to follow the hoisted load, e.g. the pylon section during the up-ending process. In an
35 embodiment, the crane driver enters a start location and an end location, and the computerized crane control system or the augmentation system generates the optimal path between those locations.

The path can for example be projected in the form of three dimensional line which is to be followed with the hoisted load, or in the form of a virtual tunnel, marked by subsequent rectangular frames, the tunnel defining the boundaries within which the load should be kept to obtain an optimal transfer from one location to the other.

5 In a further embodiment, the computerized crane control system linked to the slew drive, the luffing drive, and the hoisting winch, and computerized crane control system is configured to automatically hoist a load along a pre-programmed path, the path being generated by the augmentation system, the computerized crane control system or the crane driver.

In an embodiment, the augmentation system is configured to display both the position of the
10 load connector and the path to be followed, preferably at least in a top view, such that the augmented view displays the difference between the path and the position of the load connector, and thus the side lead and/or the offlead of the load connector relative to the path. This allows the crane driver to adjust the position of the load connector, by controlling the luffing mechanism and/or the hoisting mechanism and/or the slew drive, to keep the
15 offset between the path and the actual load minimal. In a further embodiment, the computerised crane control system is configured to make the adjustments to thus automatically keep the load on the pre-set trajectory.

In an embodiment, the augmentations system comprises mobile spatial scanners, to provide
20 spatial information. For example a person or a drone can be equipped with a mobile spatial scanner to register spatial information on a supply vessel, for example on the location and relative position of equipment located on the storage deck of the supply vessel, and provide this information to the augmentation system. In an embodiment, the load connector is provided with a mobile spatial scanner, and is moved over the storage deck to map the
25 storage deck and the loads stacked on it, prior to starting any hoisting action.

In an embodiment, the observation system is configured to track the load trajectory, i.e. the trajectory followed by the load while being hoisted by the crane, and preferably to project potential load trajectory, and to present this information to the crane driver in the augmented
30 view display.

In a further embodiment, the observation system is configured to sound an alarm when it detects a possible collision between the load trajectory data and the three dimensional area data.

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In an embodiment, the observation system is configured to alert the crane driver if the potential trajectory of the boom, or of a load hoisted by the crane collides with an object. In a

further embodiment, the observation system is linked to the computerized crane control system, and the latter is configured to stop the movement, or adjust the trajectory, of the boom or load to prevent a collision from occurring.

- 5 In an embodiment, the observation system comprises a camera and optical recognition software, to monitor presence of personal in the crane working area, and the augmentation system is configured to signal and indicate the presence of personal in the crane working area to the crane driver. In a further embodiment, the observation system is linked to the computerized crane control system, and the latter is configured to stop the movement, or
10 adjust the trajectory, of the load connector to prevent a collision from occurring or to prevent a load from being moved in a position above personal detected by the observation system.

The invention furthermore provides an offshore vessel comprising a crane, the craning having a collision prevention system. The invention furthermore provides a crane for
15 providing such a vessel. According to the invention, such an offshore vessel comprises:

- a hull having;
- a crane comprising:
 - a crane base secured to the hull;
 - 20 - a slewable superstructure mounted on the crane base and slewable about a vertical slew axis relative to the crane base;
 - a slew drive configured to cause slew motion of the superstructure about the slew axis;
 - a boom structure comprising a boom that is pivotably connected to the
25 superstructure about an inner pivot axis;
 - a luffing mechanism comprising a luffing drive and configured to cause luffing motion of the boom structure;
 - a hoisting assembly comprising a hoisting winch and a hoisting winch driven cable;
 - a load connector, wherein the winch driven cable extends, preferably in a multi-fall
30 arrangement, between a sheave set on the boom structure and a sheave set on the load connector;
- a computerized crane control system linked to the slew drive, the luffing drive, and the hoisting winch; and
35
- a collision prevention system, comprising multiple proximity detectors, e.g. camera's with object recognition software or laser scanners, which proximity detectors are located along at

least a top section of the boom structure to scan a collision safety zone extending adjacent the at least the top section of the boom structure, to detect an object entering the collision safety zone during a slew motion and/or a luffing motion and to subsequently present a crane driver with a warning signal and/or stop the slew motion and/or luffing motion of the boom to prevent a collision with the detected object.

By providing crane with a collision prevention system, the invention allows for simplifying crane operation.

It will be apparent to the skilled person that features and embodiments described in relation to one device, system, vessel, or method can also be applied to other described devices, systems, vessels or methods, where applicable. For instance, the features and embodiments described in relation to the jack-up vessel according to the invention can also be applied to the method as this method also includes the use of a jack-up vessel.

The examples described above are presented with reference to providing a jack-up vessel comprising a crane, or a crane for providing such a vessel. However, as will be understood by one skilled in the art, the devices and techniques described herein may be applied to provide cranes for any suitable off shore vessel.

Advantageous embodiments of the vessel according to the invention and the method according to the invention are disclosed in the sub claims and in the description, in which the invention is further illustrated and elucidated on the basis of a number of exemplary embodiments, of which some are shown in the schematic drawing. In the figures, components corresponding in terms or construction and/or function are provided with the same last two digits of the reference numbers.

Whilst primarily presented for illustrative purposes with reference to one or more of the figures, any of the technical features addressed below may be combined with any of the independent claims of this application either alone or in any other technically possible combination with one or more other technical features.

The invention will now be described in a non-limiting way by reference to the accompanying drawings in which like parts are indicated by like reference symbols, and in which:

Fig. 1 depicts a side view in partial see through of a jack-up vessel according to an embodiment of the invention with two pylon sections on deck and legs in a lifted position; Fig. 2 depicts a top view of the vessel of Fig. 1;

Fig. 3 depicts a side view of a jack-up vessel according to an embodiment of the invention in a first working position upending a pylon section;

Fig. 4 depicts a side view of the jack-up vessel of Fig. 3 in a second working position upending the pylon section;

5 Fig. 5 depicts a side view of the jack-up vessel of Fig. 3 in a third working position upending the pylon section;

Fig. 6 depicts a side view of the jack-up vessel of Fig. 3 supporting the pylon section above an installation site;

10 Fig. 7 depicts a rear view of the jack-up vessel of Fig. 3 supporting the pylon section above an installation site, with additional objects on a deck;

Fig. 8 depicts a side view of the jack-up vessel of Fig. 7 with a PILE DRIVE mounted on the pylon section for driving the pylon into the sea floor;

15 Fig. 9 shows a top view of a jack-up vessel shown in fig. 8, with the PILE DRIVE mounted on the pylon section, with one of the two cranes depicted, and with a pylon section in a horizontal storage position on the deck and the pylon section;

Fig. 10 depicts a side view of the jack-up vessel of Fig. 7 with the pylon section driven into the sea floor while an intermediate section is mounted on the pylon section;

Fig. 11 shows a rear view of a jack-up vessel showing a crane position with a one crane configuration left and a crane position with a two crane configuration right;

20 Fig. 12 shows a side view in partial see through of a jack-up vessel according to an embodiment of the invention with multiple pylon sections, in the form of preassembled wind turbines, supported on a guide track;

Fig. 13 shows a partial close up of the vessel of Fig. 12;

25 Fig. 14 shows a side view of the vessel of Fig 12 while mounting the preassembled wind turbine on a pile at an installation site;

Fig. 15 shows a rear view of a jack-up vessel according to an embodiment of the invention with two installation cranes coupled via a yoke to a nacelle of a preassembled wind turbine;

Fig. 16 shows a rear view of the jack-up vessel of fig. 15 with two installation cranes coupled in an alternative way with a mast of a preassembled wind turbine;

30 Fig. 17 shows a side view of the vessel of Fig. 16;

Fig. 18 shows a perspective view of a jack-up vessel according to an embodiment of the invention supporting a pile guide;

Fig. 19 shows a perspective view of a jack-up vessel according to an embodiment of the invention being supplied with pylon sections from a barge;

35 Fig. 20 shows a perspective view of a jack-up vessel according to an embodiment of the invention with an alternative vessel layout;

Fig. 21 shows a perspective view of an exemplary embodiment of a vessel similar to the vessel shown fig. 15 installing a preassembled wind turbine in a way similar to the one depicted in figure 15;

Fig 22 shows a perspective view of an embodiment of a vessel according to the invention

5 and a set of preassembled wind turbines to be loaded on said vessel;

Fig. 23 shows a perspective view of the preassembled wind turbines of Fig. 22 loaded on the vessel of fig. 22;

Fig. 24 shows a perspective view at a different angle of the vessel of Fig 22;

Fig. 25 shows a perspective view at a different angle of the vessel of Fig 22, with one of the
10 preassembled wind turbines pivoted about its longitudinal axis to allow for it to be lifted by the two installation cranes in unison;

Fig. 26 shows the vessel of Fig 25, with the pivoted preassembled wind turbine being lifted by the two installation cranes in unison;

Fig. 27-30 show a jack up vessel for installing pylon sections according to the invention
15 provided with a cantilever; and

Fig. 31 depicts a side view of the jack-up vessel similar to the vessel of Fig. 3 in a working position during the upending of the pylon section which working position follows the second working position and precedes the third working position, shown in respectively Fig. 4 and Fig. 5.

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Figure 1 shows a marine jack up vessel 1 for installing a pylon section of a wind turbine at a wind turbine installation site, according to the claimed invention.

The jack-up vessel 1 comprises a buoyant hull 2, four jack up legs 3, a plurality of elevating
25 units 4, a pylon section guide track 5, and two pylon section installation cranes 6.

A marine jack-up vessel according to the claimed invention comprise at least three jack-up legs, in the preferred embodiment shown, the vessel comprises four legs. Such a vessel furthermore comprises a plurality of elevating units, each associated with a respective jack-
30 up leg. The elevation units 4 are adapted to move the respective jack-up leg 3 vertically relative to the hull 2 and to bring the vessel 1 in an operational position wherein the legs engage the sea floor and the hull is above water level. The legs 3 are moved in the opposite direction to bring the vessel 1 in a transport position, shown in figure 1, wherein, wherein a lower end of the legs is retracted into the hull. This configuration enables the vessel to travel
35 between locations.

In the embodiment shown, the jack-up vessel 1 has a longitudinal axis 15, a front or bow 16, with a structure comprising amongst others personnel quarters, and a rear or aft 17, at which the two pylon section installation cranes 6 are located.

- 5 According to the invention, the buoyant hull 2 has a main deck 7 for storing a pylon section 8 during transport, which deck is provided with a pylon section guide track 5 and an associated track cart 11. The pylon section guide track is located on or in the main deck and extends between a support end of the guide track.
- 10 In the embodiment shown, the pylon section guide track 5, comprising two parallel rails 12, is located on the main deck 7 and extends between a support end 13 of the guide track and an installation end 14 of the guide track.

The exemplary jack-up vessel 1 shown supports two pylon sections, in the example piles 9, one of which is shown in a horizontal transport position on the pylon section guide track and one is shown in a horizontal storage position.

In the embodiment shown, furthermore a pile drive 25, e.g. an air hammer, for driving the pylon sections into the seafloor, and two intermediate sections 26, to be mounted on the pylon sections, and a located on the main deck 7.

The pylon sections 8 have a longitudinal axis 18 extending between a top end 19 of the pylon section and a bottom end 20 of the pylon section. In the embodiment shown, the pylon sections are piles provided with a partially tapered top section 21, which top section is furthermore provided with two lifting pins 22 for coupling with the pylon section installation crane.

The track cart 11 is provided with a pylon holder 23 for engaging the bottom end 20 of the pylon section 8. The track cart is configured to move along the pylon section guide track 5, and thus guide the pylon section 8, or at least the bottom end 20 thereof, along the guide track as well.

At the installation end 14 of the guide track 5, the two pylon section installation cranes 6 are located on opposite sides of the guide track. The installation cranes are fixed to the hull 2 of the vessel 1 at the installation end of the track, for lifting a pylon section of which one end is at least partially supported by the track cart.

The installation cranes 6 each have a boom 24 that is slewable about a vertical slew axis 25 and pivotal up and down about a horizontal boom pivot axis 26. In figures 1 and 2, the cranes are depicted in their storage position, in which the booms 24 are lowered and with their top end are supported on a boom rest 27 located near the bow of the vessel.

5

In the preferred embodiment shown, the boom rest is located at the outside of the vessel, to support the top end of the booms outside the contour of the hull, we seen in top view, and above the water. This enables the booms to extend along the front legs, when in the legs are in the lifted position, and furthermore allows for objects, in the embodiment shown the pile drive 25 and the two intermediate sections 26, to be stored on the main deck, which objects extend up to or even above the booms.

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In a preferred embodiment of a jack-up vessel according to the invention, these boom rests are retractable boom rests, and can be moved between a support configuration, in which they extend beyond the contour of the hull, when seen in top view, and can be used to support a boom rest, and storage configuration, in which they are located within the contour of the hull. Such a storage configuration allows for a reduced width of the vessel, compared to the width of the vessel with the boom vessel in the support configuration.

15

The jack up vessel allows for a method for installation a wind turbine at a wind turbine installation site. More in particular, the jack up vessel shown in figures 1 and 2 allows for a method for installation of a pylon section at an installation site, the method comprising driving the pylon section into the sea floor, an example of which is shown in figures 3-10, and a method for mounting a mast, preferably as part of a preassembled wind turbine, on a pile or jacket at an installation site, an example of which is shown in figures 12-14.

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In an embodiment, the method for installation a pylon section of a wind turbine at a wind turbine installation site comprises:

- storing the pylon section 8 on the main deck 7 in a horizontal transport position, in which horizontal transport position the longitudinal axis 18 of the pylon section 8 extends substantially parallel to the main deck and the pylon section guide track 5, and in which horizontal transport position the bottom end 20 of the pylon is supported by the track cart 11 located at the support end 13 of the guide track 5, see figures 1 and 2;

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- arranging the vessel 1 adjacent the wind turbine installation site 27 and operating the elevating units 4 to bring the vessel 1 in an operational position wherein the legs 3 engage the sea floor 28 and the hull 2 is above water level 29;

- 5 - upending the pylon section 6, to thus bring the pylon section from the horizontal transport position into a vertical installation position, in which vertical installation position the longitudinal axis 18 of the pylon section 8 extends in a substantially vertical direction.

The upending process comprises, at the installation end of the track, lifting the top end of
10 the pylon section with the installation crane, in the embodiment shown installation cranes, in an upward direction while guiding the bottom end of the pylon section along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during the upending process, thereby rotating the pylon section from a horizontal orientation to a vertical orientation about a substantially horizontal rotation axis, which
15 substantially horizontal rotation axis preferably is perpendicular to the longitudinal axis of the vessel,

The upending the pylon section ends with the pylon section installation cranes supporting the pylon section in the vertical installation position, follows the condition shown in figure 5,
20 and precedes the condition shown in figure 6, in which the pylon section has been lifted of the vessel and is supported above the installation site.

It is submitted that when the pylon section is a pile, it is to be used as a base onto which a, preferably preassembled wind turbine, is to be installed. A pile is a large and heavy pylon
25 section compared to for example a mast, which is to be mounted on a pile for supporting a nacelle. Because of the weight and size, a pile preferably is first fully upended, while the bottom end of the pile is guided by the track cart, and only after it has been upended is lifted upwards and overboard to be correctly positioned at the installation site for being driven into the sea floor.

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Thus, the pile is upended such that it is located above the installation end of the guide track once in the vertical installation position, in which in which vertical installation position the longitudinal axis of the pylon section extends in a substantially vertical direction, which allows the track cart to guide the bottom end of the pylon section during the upending
35 process, and thus prevent the bottom end of pylon section to swing. Guiding the bottom end of the pylon section thus allows for a controlled upending process, in which the position of

the pylon section is controlled, the top end by the pylon section installation cranes and the bottom end by the track cart.

After the upending of the pylon section, the pile holder is disengaged from the bottom end of the pylon section, for example by lifting the pylon section in an upwards direction, and using the installation cranes, preferably by at least slewing the jib of the cranes, to position the pylon section, while supported in a vertical position, above the installation site, which condition is shown in figure 6. Figure 7 shows a rear view of the vessel with the pylon section supported by both the pylon installation cranes.

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In the embodiment shown, the vessel 1 comprises a first installation crane 6 and a second installation crane 6'. The two installation cranes are fixed to the hull 12 of the vessel on opposite sides of the guide track 5 at the installation end 14 thereof,

15 In the embodiment shown, the pylon section installation cranes are around the leg cranes, i.e. are each mounted on the hull of the vessel and around the leg of the jack-up vessel. Furthermore, the cranes are located on opposite sides of the guide track, more in particular the installation end of the guide track for in unison lifting a pylon section of which one end is supported by the track cart, and for lifting the pylon section from the vessel onto an
20 installation site.

Providing the jack-up vessel with two installation cranes on opposite sides of the guide track allows for the installation cranes to support a pylon section on opposite sides thereof, and thus to, in unison, lift a pylon sections having a length similar to or larger than the length of
25 the jib. Figure 11 shows how a two crane configuration allows for upending larger pylon sections above the guide track. The figure shows on the left a pylon section installation crane configured for solo lifting a pylon section, i.e. without assistance of a second installation crane, and on the right a pylon section installation crane configured for in unison lifting a pylon section, i.e. with the assistance of a second installation crane located on the
30 opposite site of the guide track. In the figure a left half of a relatively short pylon section is shown on the left and half of a relatively large pylon section is shown on the right, both halves being separated by a dotted line.

When the pylon section has to be upended by a single installation crane, the jib of the crane
35 has to be positioned such that the jib, more in particular the top end of the jib, supports the main load above the centre of the pylon section. Thus, the single installation crane is not

able to lift a pylon section having a height similar to having the height of the jib into an upright position.

When the pylon section is to be upended by two installation cranes in unison, the jib of the
5 crane can be set a steeper angle, because the top end of the jib can be located alongside the pylon section.

Thus, by providing the vessel with two pylon section installation cranes on opposite sides of the installation end of the guide track, the two installation cranes can be used to in unison lift
10 the pylon section in the upright position, i.e. upend the pylon section out of the horizontal storage position into the vertical storage position, and subsequently lift the pylon section overboard and land it on the sea floor in the upright position for being driven into the sea floor.

15 In an embodiment, the pylon section installation cranes are used to lower the pylon section onto the sea floor.

In an embodiment the, pylon section is mounted on a pre installed base, for example a subsea template or preinstalled concrete base. In a preferred embodiment, the pylon section
20 is driven into the sea floor, preferably using a pile drive provided by the vessel.

In the embodiment shown, the pylon section 8 is driven into the sea floor 28, using the pile drive 25 stored on the deck of the vessel, which is depicted in figure 8, after which an intermediate pylon section 26 is mounted on top of the pile, which is shown in figure 10.
25

In a further embodiment of a vessel 1, which vessel is provided with a pile guide 30 for positioning the pylon section, more in particular the pile, and for guiding the pile while it is being driven into the sea floor. Figure 18 shows a perspective view of a jack-up vessel 1 comprising a pile guide 30 for guiding the pylon section 8 while it is lowered into the sea
30 and/or while the pylon section is driven into the seafloor using a pile drive.

the pile guide is removable mounted to the hull of the vessel, and can be moved, e.g. pivoted or slid, between a storage position, and an active position, in which it is shown. In the active position, the pile guide extends beyond the hull of the vessel. Preferably, the pile
35 guide is substantially ring shaped for securing the pylon section along its circumference. In a further embodiment, the pile guide can be opened to allow the pylon section to be inserted

in the pile guide in a lateral direction, instead of the pile being lowered in a axial direction into the pile guide.

In an alternative embodiment, the pile guide is part of the track cart and the track cart is
5 used to move the pile guide from a storage position, in which the pile guide is located above the deck of the vessel, into an active position, in which the pile guide is located outside a perimeter of the deck for guiding a pile being lowered towards the sea floor.

The jack up vessel 1 furthermore allows for a method for installation of a wind turbine at a
10 wind turbine installation site. In an embodiment, the mast of the wind turbine is installed first, after which the nacelle is mounted on the mast and the blades are subsequently mounted on the nacelle. The vessel according to the claimed invention however allows for transporting and installing preassembled wind turbines, i.e. a combination of a mast, nacelle and blades, the nacelle and blades being mounted on the mast already.

15

A method of the invention for installing a wind turbine is depicted in figures 12-14. Figure 12 shows a side view in partial see through of a jack-up vessel 1 according to an embodiment of the invention with multiple pylon sections 8, which pylon sections are part of preassembled wind turbines 31, supported on a guide track on the deck of the vessel.

20 Figure 13 shows a partial close up of the vessel of figure 12. Figure 14 shows a side view of the vessel of figure 12 while mounting one of the preassembled wind turbines 31 onto a pylon section 8, more in particular onto an intermediate section 26 mounted on a pile 8, at a wind turbine installation site 27.

25 The method for installation of a wind turbine comprises the steps:

- storing the pylon section 8, in the embodiment shown the preinstalled wind turbine 31, on the main deck 7 in a vertical transport position, which is depicted in figure 12, in which vertical transport position the longitudinal axis of the pylon section 8 extends substantially
30 perpendicular to the main deck 7 and to the guide track 5, and in which vertical transport position the pylon section is supported by the track cart 11;

- arranging the jack-up vessel 1 adjacent a wind turbine installation site 27 and operating the elevating units to bring the vessel in an operational position wherein the legs 3 engage the
35 sea floor 28 and the buoyant hull 2 is above water level 29;

- optionally, moving the pylon section 8 along the guide track 5 towards the installation end 14 of the guide track 5;

- lifting the pylon section 8 with the pylon section installation crane, in the embodiment

5 shown with the two pylon section installation cranes 6, 6', in an upward direction, and using the installation cranes, preferably by at least slewing the jib of the crane, to position the pylon section 8, while supported in a vertical position, above the wind turbine installation site 27 and

10 - lower the pylon section 8 into an installed position at the installation site 27, which is shown in figure 14;

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward.

15

In the embodiment shown, each of the two pylon sections, of the two respective preassembled wind turbines, is supported in a track cart 11, which track cart 11 can be used to move the respective preinstalled wind turbine along the guide track. Once the first preassembled wind turbine has been installed, the cart that supported it is removed from the

20 track, to thus allow for the second track cart to be used to move the second preassembled wind turbine into a installation position in which it can be lifted by the installation cranes in an upward direction out of the cart, and onto a pylon section, or other installation base.

In an alternative embodiment, the guide track is provided with a single track cart, and the

25 pylon sections are supported in a support mount that can be engaged by the track cart to enable the track cart to support the pylon section, and to move the pylon section along the guide track. When the support mount is not coupled with the track cart, it can be mounted to the deck to provide additional support for the pylon section during transit, i.e. the vessel travelling for example between installation sites.

30

In an embodiment, the track cart is configured to pick up a pylon section and drop off a pylon section, and the pylon section can be supported in the vertical transport position by the pylon section support system only, for example by a support mount fixed to the lower end of the pylon section or by a deck mounted support frame. Thus a single cart can be

35 used to transport pylon sections, one at the time, along the guide track. In an alternative embodiment, each pylon section in the vertical transport position is provided with a track cart,

which track supports the pylon section, either alone or in combination with a pylon support system, in the vertical transport position during transit.

In the embodiment shown, the vessel 1 is provided with two pylon section installation cranes 5 6 for lifting the pylon section 8, preferably in the form of a mast 10 that is part of a preassembled wind turbine 31, from the vessel 1 onto the installation site 27.

It is submitted that masts preferably are free of protrusion that may negatively influence wind flow during use. Therefore, preferably a mast is provided with a temporarily mounted YOKE, 10 located at the top of the mast for coupling the mast with the travelling blocks of the pylon section installation cranes.

Figure 15 shows a rear view of a jack-up vessel according to an embodiment of the invention with two installation cranes 6 coupled via a yoke 32 with the nacelle of the 15 preassembled wind turbine.

Figure 16 shows a rear view of the jack-up vessel of figure 15 with two installation cranes coupled in an alternative way with a mast of a preassembled wind turbine. In this embodiment, the yoke 32 engages a top end of the mast of the preassembled wind turbine, 20 but wires 33 extend between the yoke 32 and a temporarily foot clamp 34 that engages the mast 10 at a bottom section thereof for lifting the preassembled wind turbine. In the embodiment shown, the travelling blocks of the cranes are coupled with the yoke 32, and additional wires extend between the yoke and the foot clamp. In an alternative embodiment, the yoke only guides the hoisting wires of the installation cranes and the traveling blocks are 25 coupled with the foot clamp.

Furthermore, in the embodiment shown, foot clamp 34, is a transition piece that is part of the track cart and that can be connected to and disconnected from the track cart, for guiding the mast along the guide track and for lifting the mast from the guide track respectively. 30

Figure 17 shows a side view of the vessel of figure 16, the two installation cranes lowering the mast onto the pile section, the mast section being supported at its lower end via the foot clamp and being balanced by the yoke located at the top end of the mast.

35 Figure 19 shows a perspective view of a jack-up vessel 1 according to an embodiment of the invention being supplied with pylon sections 8 from a barge 35.

The invention provides a method for loading a wind turbine installation vessel, the vessel having two pylon section installation cranes, with one or more pylon sections, which one or more pylon sections are presented by another vessel, e.g. a barge, or on the main land, e.g. a quay, using the two pylon section installation cranes to lift the pylon section onto the vessel, while the legs of the vessel are in the lifted position. a step of such a method, using a barge for supplying the wind turbine installation vessel, is shown in figure 19.

The method comprises the steps:

- 10 - lifting the pylon section 8 into a substantially horizontal position, using the first installation crane 6 to lift the pylon section 8 at the bottom end thereof and the second installation crane 6' to lift the pylon section 8 at the top end thereof, which is depicted in figure 19;
- moving the pylon section 8 onto the vessel by pivoting the first installation crane 6 and the second installation crane 6', such that the bottom end of the pylon section 8 is moved between the installation cranes first, and:
- positioning the pylon section 8 above a pylon section guide track provided on or in the deck of the vessel and lowering the pylon section into the horizontal transport position;
- 20 or
- lowering the bottom end of the pylon section 8 onto a track cart located at the installation end of the guide track, using the second installation crane and the track cart to move the pylon section above the guide track and lowering the top end of the pylon section, and thus the pylon section, into the horizontal transport position.

The invention also provides a method for supplying a jack-up vessel, the jack-up vessel comprising a guide track for supporting and moving a preassembled wind turbine along the deck of the vessel using a track cart, with pylon sections, preferably with pylon sections that are masts that are part of a preassembled wind turbine.

a method for supplying the jack up vessel with preassembled wind turbines is shown in figures 22-26, the method comprising:

providing a track cart with a preassembled wind turbine on a supply track, which is depicted in figure 22, the wind turbines being supported by a track cart on a supply track located on a quay;

- 5 aligning the jack-up vessel, more in particular the guide track of the jack-up vessel, with the supply track;

lowering the legs of the jack-up vessel to stabilise the vessel, and preferably to at least partially lift the vessel out of the water and level the guide track of the vessel with the supply
10 track;

connect the supply track, in the embodiment the supply track on the quay, with the guide track on the vessel, for example by providing a bridge track between the supply track and the jack-up vessel, more in particular the guide track of the jack-up vessel, such that the
15 supply track and the guide track are both part of a single linear guide track;

move the track cart with the preassembled wind turbine from the supply track onto the guide track of the vessel, thus passing the preassembled wind turbine between two legs of the Jack-up vessel; and
20

after thus moving one or more preassembled wind turbines onto the jack up vessel, raising the legs of the jack up vessel and moving the jack up vessel to an installation site. Figures 23 and 24 show the jack up vessel 1 with the three preassembled wind turbines mounted on the deck of the vessel.
25

In the exemplary method shown, prior to moving the preassembled wind turbines onto the jack-up vessel, they have been orientated with their front facing sideways on the supply track, i.e. with the rotational axis of the wind turbine at an angle with the supply track.

30 Thus, when the preassembled wind turbines are moved from the supply track onto the guide track the turbines, when on the guide track, are orientated with their front facing sideways, i.e. with the rotational axis of the wind turbine at an angle with the guide track.

In the exemplary method shown in the figures, after the vessel 1, more in particular the
35 guide track of the jack-up vessel, has been aligned with an installation site, depicted in figure 24, the legs of the jack-up vessel are lowered to stabilise the vessel, and to at least partially lift the vessel out of the water, which is depicted in figure 25.

Subsequently, the preassembled wind turbine to be installed at the installation site is orientated, more in particular is pivoted about its longitudinal axis, such that its front faces the installation site and the rotational axis of the wind turbine is parallel with the supply track,

5

In the method shown, the preassembled wind turbine is pivoted about its longitudinal axis by rotating the pylon section, more in particular the mast, of the preassembled wind turbine about its longitudinal axis, using the track cart having a slew bearing supported pylon section support. Thus the track cart is configured for supporting and for pivoting the mast of the preinstalled wind turbine.

10

In an alternative embodiment, a pylon section pivoting device can be provided at the installation end of the guide track, for receiving the mast supported by a guide track, supporting that mast and pivoting that mast about its longitudinal axis.

15

Once the preinstalled wind turbine faces the installation side, it is lifted from the vessel onto a wind turbine installation base, e.g. a jacket or pylon, using the two installation cranes in unison, which is depicted in figure 26.

20 Fig. 20 shows a perspective view of a jack-up vessel according to an embodiment of the invention with an alternative vessel layout.

In an embodiment of a vessel according to the invention, at least three piles can supported between the two cranes, the pile preferably each having a cross section of at least 10 meters, for example each having a cross section of at least 12 meters.

25

In an embodiment of a vessel according to the claimed invention, the guide track and track cart are configured to support a pylon section in the horizontal transport position with the top end of the pylon section extending over the installation side of the jack up.

30

In an embodiment, the guide track comprises two parallel rails and the track cart is supported by both rails.

In an embodiment, the jack up vessel has a central longitudinal axis, and the guide track extends parallel to and above that longitudinal axis.

35

In an embodiment, the pylon section holder comprises a support device for supporting the bottom end of a pylon section in the horizontal transport position, e.g. comprises a cradle for receiving the bottom end of the pylon section and or a clamping device for engaging the bottom end of the pylon section from the inside and/or outside, which preferably is a

5 pivotable support device, that maintains engagement with the bottom end of the pylon section while the pylon section is lifted into the vertical installation position.

In an embodiment, - wherein the pylon holder engages with a circumference of the pylon section at the bottom end thereof to hold the pylon section in order to limit movement of the

10 bottom end of the pylon section in a direction perpendicular to a longitudinal axis of the pylon section, and wherein the pylon section holder engages with the bottom end of the pylon section in order to limit movement of the pylon section in a direction parallel to the longitudinal axis of the pylon section.

15 In an embodiment, the vessel is furthermore provided with a pylon section lifting device, which lifting device is to be removable mounted around the pylon section near the top end thereof to provide the pylon section with engagement sections to be coupled with the pylon section installation crane.

20 When in the horizontal transport position, the pylon section has a horizontal orientation parallel to a longitudinal axis of the vessel,

When a pylon section is in the transport position, it is located on the track to be moved by the cart. A pylon section that is in the storage position is not located on the guide track.

25

A preassembled wind turbine is a combination of a mast, nacelle and blades, the nacelle and blades being mounted on the mast already. Thus, the transportation and installation of a preassembled wind turbine allows for mounting the nacelle and blades off site, for example on shore, and subsequently loading the preassembled wind turbine onto the vessel. Offsite

30 assembly of the wind turbine into a preassembled wind turbine is more efficient compare to doing it on site, i.e. from a vessel.

Fig. 21 shows a perspective view of an exemplary embodiment of a vessel similar to the vessel shown fig. 15 installing a preassembled wind turbine in a way similar to the one

35 depicted in figure 15. The vessel shown in figure 21 comprises legs at the rear of the vessel which are spaced wider apart than the legs at the front of the vessel, to thus create extra deck space between the pylon section installation cranes

In an embodiment, the jack-up vessel furthermore comprises a cantilever, e.g. for performing well bore operations, and the guide track is adapted to cooperate with the cantilever to move the cantilever relative to the hull at least in longitudinal direction of the guide track between a retracted position and an extended position, in which extended position an operational end of the cantilever structure extends beyond an installation side of the main deck of the vessel.

In an embodiment, the guide track and/or the installation crane is/are adapted to move the cantilever into a deck clearing position wherein a clear deck area of the main deck is present between said cantilever and the installation side of the main deck of the vessel, wherein the clear deck area extends at least 20 meters in a direction perpendicular to said installation side and at least 10 meters transverse to the guide track direction, e.g. to allow for placing a topsides on said clear deck area.

In an embodiment, the jack-up vessel comprises a cantilever motion assembly, which cantilever motion assembly preferably comprises the guide track, which guide track preferably comprises one or more rails mounted on said main deck, e.g. in an axial direction of the hull perpendicular to the second axial side, and wherein said one or more rails extend towards or to a side of the hull so as to allow for the cantilever motion assembly to move the cantilever relative to the vessel between extended positions wherein an operational end of the cantilever extends beyond the side of the hull, a retracted position wherein said operational end is before the side of the hull and the entire cantilever is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs.

Figures 27-30 show an exemplary embodiment of a vessel 1 provided with a cantilever 10.

In the situation of fig. 27 the elevating units have been operated and brought the vessel 1 in an operational position wherein the vessel is not afloat but wherein the jack-up legs 4a, 4b, 4c, 4d engage the seabed B. In the shown embodiment, the feet of the jack-up legs are partly buried in the bottom of the sea B. The hull 2 is above water level W at a height such that a cantilever 10 is movable in an extended position above the topsides 51 of the offshore platform 50.

The vessel further comprises a cantilever 10 having a cantilever structure 11 with an operational end 11a, wherein said operational end supports a wellbore activities station 12, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure 11 having an inner end 11b longitudinally

opposite the operational end 11a, wherein the cantilever is movably mounted on the main deck 3 of the hull.

A cantilever motion assembly 13 is provided and adapted to move the cantilever relative to the hull 3 at least in longitudinal direction CL thereof between a retracted position and extended positions wherein the operational end 11a of the cantilever extends beyond a cantilever deployment side of said sides of the hull. In the vessel of fig. 27, the cantilever deployment side of the hull is the second axial side 2b.

In fig. 27, the cantilever motion assembly has moved the cantilever 10 into an extended position wherein the operational end 11a of the cantilever extends beyond the cantilever deployment side 2, and above the topsides 51. The wellbore activities station 12 is aligned with a wellbore 55 of the offshore platform 50.

This configuration of fig. 27 allows the performance of wellbore activities such as drilling and plug and abandonment operations, involving the use of the wellbore activities station.

In fig. 28, the cantilever 10 is shown in a retracted position. In the shown position, the operational end 11a of the cantilever no longer extends beyond the hull of the vessel.

Here, the cantilever motion assembly comprises the pylon section guide track 5, the guide track having two parallel rails 13, mounted on the main deck 3 allowing movement of the cantilever 10. The rails 13 are mounted in an axial direction A of the hull, perpendicular to the second axial side 2b, and extend in the longitudinal direction CL of the cantilever.

Said one or more rails 13 extend towards or to the first axial side 2a of the hull so as to allow for the cantilever motion assembly to move the cantilever 10 relative to the vessel at least in said longitudinal direction CL between extended positions wherein the operational end 11a of the cantilever extends beyond the second axial side 2b of the hull, a retracted position wherein said operational end 11a is before the second axial side of the hull 2b and the entire cantilever 10 is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs.

In addition, also a rail 14 is mounted on said main deck 3 in the lateral direction L of the hull, parallel to and adjacent the second axial side, allowing a lateral movement of the cantilever between multiple extended positions.

Two pylon section installation cranes 20, 21 are fixed to the hull and having a boom 20b, 21b that is slewable about a vertical slew axis 20s, 21s and pivotal up and down about a horizontal boom pivot axis 20h, 21h.

- 5 In particular, crane 20 is a first leg encircling crane comprising a foot 20f fixed to the hull, a slew bearing supported on the foot and extending about a jack-up leg 4c of the second pair of jack-up legs of the vessel, a slewable crane member 20sb which is supported by said slew bearing, a boom 20b pivotally mounted to said slewable crane member 20sb about a horizontal boom pivot axis 20h so that the boom is pivotal up and down. The slewable crane
10 member 20sb comprises a protruding superstructure 20c.

Analogously, crane 21 is a second leg encircling crane comprising a foot fixed to the hull, a slew bearing supported on the foot and extending about the other jack-up leg 4d of the second pair of jack-up legs of the vessel, a slewable crane member which is supported by
15 said slew bearing, a boom 21b pivotally mounted to said slewable crane member about a horizontal boom pivot axis 21h so that the boom is pivotal up and down.

In fig. 29, and in fig. 30, according to the second and third aspect of the invention, the cantilever 10 has moved into a deck clearing position wherein a deck area of the main deck
20 is cleared to form a clear deck area 3C between said cantilever 10 and said second axial side 2b.

Figure 30 is a side view of the operational situation of figure 29, with the cantilever 10 in the deck clearing position.

25

Figure 31 depicts a side view of a jack-up vessel similar to the one of figure 3, shown in a working position during the upending of the pylon section which working position is after the second working position and prior the third working position, shown in respectively figure 4 and figure 5.

30

The upending process of the pylon section 8 comprises, at the installation end of the track, lifting the top end of the pylon section 8 with the installation cranes in an upward direction while guiding the bottom end of the pylon section along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during
35 the upending process, which is shown in figures 3-5. Thereby rotating the pylon section from a horizontal orientation to a vertical orientation about a substantially horizontal rotation axis,

which substantially horizontal rotation axis preferably is perpendicular to the longitudinal axis of the vessel.

It is submitted that with a preferred upending process according to the invention, the pylon section is upended into an upright position while the lower end of the pylon section is supported by the cart. Once in the upright position, the pylon section is lifted upwards from the cart, such that it is fully supported by the cranes. Subsequently, the cranes move the pylon section from its position above the track cart into the vertical installation position, in which the pylon section has been lifted off the vessel and is supported above the installation site. This is depicted in figure 6.

In the embodiment shown in fig. 31 the pylon section installation cranes are provided with a computerized crane control system 120.

Figure 31 depicts the marine jack up vessel 1 according to the invention. The vessel comprises a buoyant hull 2 and pylon section installation cranes 6. The jack up vessel is furthermore provided with pylon section guide track 5 and a track cart 11.

The hull 2 is provided with a main deck 7 configured for storage thereon of the one or more pylon sections 5, in horizontal orientation thereof.

The crane 6 comprises a crane base 109, which crane base 109 is secured to the hull 2, and a slewable superstructure 110 mounted on the crane base 109, and slewable about a vertical slew axis relative to the crane base.

The crane 6 further comprises a slew drive 111, a boom structure 112, a luffing mechanism 113, a hoisting assembly 114 and a load connector 115.

The slew drive 111 is configured to cause slew motion of the superstructure 110 about the slew axis.

The boom structure 112 comprises a boom 116 that is pivotally connected to the superstructure 110, such that it can pivot about a horizontal inner pivot axis.

The luffing mechanism 113 comprising a luffing drive 117 and is configured to cause a luffing motion of the boom structure 112. Thus, the luffing mechanism can be used to pivot the boom upwards or downwards.

The hoisting assembly 114 comprises a hoisting winch 118 and a hoisting winch driven cable 119. In the embodiment shown, the winch driven cable 119 extends in a multi-fall arrangement between a sheave set on the boom structure 112 and a sheave set on the load connector 115.

The crane 6 comprises a computerized crane control system 120 linked to the slew drive 111, the luffing drive 117, and the hoisting winch 118.

10 The computerized crane control system 120 is programmed to perform a pylon section upending routine providing a coordinated pattern of slew motion of the superstructure 110 and of luffing motion of the boom structure 112, as well as operation of the hoisting winch 118 so that the load connector 115 moves from a foundation pile pick up position 21 thereof, as depicted in figure 3, where the load connector 15 is connected to the top end of a
15 horizontally oriented pylon section stored on the main deck 4, to a position wherein the pylon section is vertically suspended from the load connector 15, outside of the hull 2, which is depicted in figure 6.

The offshore wind turbine installation vessel thus enables a method for installation of a pile
20 adapted to support an offshore wind turbine, according to the invention.

The method comprising the following steps:

- a. transporting a pile in a horizontal orientation to an offshore installation site;
25
 - b. lifting an upper end portion of the pylon section, with the lower side supported by a cart on the cart track, thereby rotating the pile from a horizontal orientation to a vertical orientation about a substantially horizontal rotation axis perpendicular to the longitudinal axis of the vessel;
30
- after rotating the pile from the horizontal orientation to the vertical orientation, and the pylon section being moved outside the contour of the vessel seen from above to be lowered into the water, or mounted on a jacket.
- In the preferred embodiment shown, the computerized crane control system 120 is provided
35 with multiple input devices 100, to track the position of the pylon section.

The crane control system 120 can be used to control the position of the load connector relative to the guide track and the cart during the upending or installation of a pylon section. Thus the crane drive is allowed to control a limited number of parameters, while the system handles another set of parameters of the hoisting process. The control system for example
5 keeps the pylon section aligned with the track, while the crane driver controls the position of the load connector relative to the track, and the speed with which the load connector moves along the predefined trajectory.

The computerized crane control system allows for running sub routines in a hoisting
10 process. For example, the installation routine may comprises the actual upending process, ending in the pile being supported in the upright position, after which the crane driver takes over and hoists the pile into a position for landing the pile in the pile gripper, after which a pile gripper landing routine is run that moves the pile into the pile gripper, after which the crane driver again takes over and lowers the pile towards the sea floor.

15 Because the trajectory of the load connector can be controlled using the computerized crane control system, the installation routine can be set up to move the load connectors of the pylon section installation cranes along the ideal path, depicted in figure 31 with line 101. Thus, the operational window of the cranes can be used optimally, and it is no longer
20 required to use for example a crane that can handle at least two times the load that is actually being hoisted.

In the preferred embodiment shown, the cranes are provided with a multiple scanners 102 that provide spatial information on objects located in the crane working area, e.g. the top
25 end of a pile or a leg of the jack up vessel.

In the embodiment shown, the cart of the vessel comprises an upending cradle configured to support the lower end of the pylon section during the upending process. More in particular, the upending cradle is configured to assist in the upending process by guiding the pivoting
30 movement of the lower end of the pile along the track during the upending process.

The computerized crane control system is programmed to perform a pylon section up-ending routine that is configured to move the top end of the pile along a fixed trajectory relative to the upending cradle. It is submitted that an optimal trajectory of the load connector allows for
35 minimizing the loads exerted on the upending cradle in the horizontal plane.

This is in particular the case when the upending cradle comprises a pivotably supported clamp, to secure the bottom section of the pile relative to an upending pivot axis. Moving the top end of the pile along the curved trajectory 101 having the pivot point at its centre minimises loads on the upending cradle. The curved trajectory of movement 101 of the load connector lies within a plane that is perpendicular to the pivot axis. Thus, forces directed perpendicular to that plane, i.e. for example parallel to the pivot axis, can be kept to a minimum.

However, performing such an exact hoisting movement is difficult for a crane driver, because it involves a combination of slewing, luffing and hoisting movements. The programmable computerized crane control system enables a fully controlled movement of the load connector, and thus for a minimal load on the upending cradle. The latter can thus be of a compact, low weight design.

In the embodiment shown, the jack up vessel provided with an upending cradle track, and the upending cradle is mounted on that cradle track and is configured to move along a track, during the upending of the foundation pile. By thus moving the cradle, the top end of the pile can initially be lifted in a purely vertical direction, which facilitates the lifting process. The installation routine is used to adjust the hoisting speed such that it keeps up with the movement of the upending cradle along the track. In an embodiment, the cradle is provided with a drive, for enabling controlled movement of the cradle along the track, and the computerized crane control system is configured to at least monitor the movement of the cradle, preferably control the drive and thus control the movement of the cradle along the track. Once the crat reaches the installation end of the guide track, the top end of the pylon section is moved along a curved trajectory to fully up end the pylon section. In an alternative method, the cart is moved during the entire upending process, and the load connector follows a curved trajectory.

CLAIMS

1. Method for installing a pylon section of a wind turbine at a wind turbine installation site, wherein use is made of a marine jack-up type vessel, the jack-up vessel comprising:

5 - a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;

- at least three jack-up legs;

10

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;

15 - a pylon section guide track and an associated track cart,

wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section to support that
20 bottom end of the pylon section and to guide the bottom end of the pylon section over the deck and along the guide track; and

- a pylon section installation crane, which installation crane is fixed to the hull at the installation end of the guide track for lifting the pylon section, of which one end is supported
25 by the track cart, the installation crane having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

wherein the method comprises:

30 - storing the pylon section on the main deck in a horizontal transport position, in which horizontal transport position the longitudinal axis of the pylon section extends substantially parallel to the main deck and to the guide track, and in which horizontal transport position the bottom end of the pylon is supported by the track cart located at the support end of the track;

35

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which operational position the legs engage the sea floor and the hull is above water level;

- 5 - upending the pylon section, to thus bring the pylon section from the horizontal transport position into a vertical installation position, in which vertical installation position the longitudinal axis of the pylon section extends in a substantially vertical direction;

the upending process comprising, at the installation end of the track, lifting the top end of
 10 the pylon section with the installation crane in an upward direction while guiding the bottom end of the pylon section along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during the upending process, thereby rotating the pylon section from a horizontal orientation to a vertical orientation about a substantially horizontal rotation axis, which substantially horizontal rotation axis preferably is
 15 perpendicular to the longitudinal axis of the vessel;

- disengaging the pile holder from the bottom end of the pylon section, lifting the pylon section with the installation crane in an upward direction, and using the installation crane, preferably by at least slewing the jib of the crane, to position the pylon section, while
 20 supported in a vertical position, above the installation site; and

- lower the pylon section into an installed position at the installation site; and

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract
 25 the jack-up legs upward.

2. Method for installing a pylon section of a wind turbine at a wind turbine installation site, wherein use is made of a marine jack-up type vessel, the jack-up vessel comprising:

30 - a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;

- at least three jack-up legs;

35

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;

5 - a pylon section guide track and an associated track cart,

wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section to support that
10 bottom end of the pylon section and to guide the bottom end of the pylon section over the deck and along the guide track; and

- two pylon section installation cranes, preferably two around the leg pylon section installation cranes, located on opposite sides of the installation end of the guide track, to in
15 unison lift the pylon section at a top end thereof, which installation cranes are each fixed to the hull of the vessel at the installation end of the guide track for lifting the pylon section, of which a bottom end is supported by the track cart, the installation cranes each having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

20

wherein the method comprises:

- storing the pylon section on the main deck in a vertical transport position, in which vertical transport position the longitudinal axis of the pylon section extends substantially
25 perpendicular to the main deck and to the guide track, and in which vertical transport position the pylon is supported by the track cart;

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which position the legs engage the sea
30 floor and the hull is above water level;

- optionally, moving the pylon section along the guide track towards the installation end of the track;

35 - lifting the pylon section with the installation cranes in an upward direction, and using the installation cranes, preferably by at least slewing the jib of the cranes, to position the pylon section, while supported in a vertical position, above the installation site; and

- lowering the pylon section into an installed position at the installation site; and

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract

5 the jack-up legs upward.

3. Method for installing a pylon section of a wind turbine at a wind turbine installation site, wherein use is made of a marine jack-up type vessel, the jack-up vessel comprising:

10 - a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;

- at least three jack-up legs;

15

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;

20 - a pylon section guide track and an associated track cart, wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pile guide, which pile guide is configured to engage the bottom end of the pylon section when in the horizontal transport position, to position the pylon section relative to the cart, to support that bottom
25 end of the pylon section, and to guide the bottom end of the pylon section over the deck and along the guide track, and wherein the pile guide is pivotably mounted on the track cart to pivot with the pylon section while the pylon section is upended from the horizontal transport position into the vertical installation position; and

30 - a pylon section installation crane, which installation crane is fixed to the hull at the installation end of the guide track for lifting the pylon section, of which one end is supported by the track cart, the installation crane having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

35 wherein the method comprises:

- storing the pylon section on the main deck in a horizontal transport position, in which horizontal transport position the longitudinal axis of the pylon section extends substantially parallel to the main deck and to the guide track, and in which horizontal transport position the bottom end of the pylon is supported by the track cart located at the installation end of

5 the track;

- arranging the vessel adjacent the wind turbine installation site and operating the elevating units to bring the vessel in an operational position, in which operational position the legs engage the sea floor and the hull is above water level;

10

- using the cart to move the pile guide from a storage position, in which the pile guide is located above the deck of the vessel, into an active position, in which the pile guide is located outside a perimeter of the deck for guiding a pile being lowered towards the sea floor, and upending the pylon section using the pylon section installation crane, to thus bring

15 the pylon section from the horizontal transport position into a vertical installation position, in which vertical installation position the longitudinal axis of the pylon section extends in a substantially vertical direction;

the upending process comprising:

20

- at the support end of the track, lifting the top end of the pylon section with the installation crane in an upward direction and along the guide track towards the installation end of the track, the cart supporting the bottom end of the pylon section during the upending process, thereby rotating the pylon section from a horizontal orientation to a vertical orientation about

25 a substantially horizontal rotation axis, which substantially horizontal rotation axis preferably is perpendicular to the longitudinal axis of the vessel;

- supporting the pylon section with the installation crane in an vertical position, and using the installation crane to lower the pylon section, while supported in a vertical position, above the

30 installation site; and

- lowering the pylon section into an installation position at the installation site and guiding the pylon section, using a pile guide, while it is lowered into the sea,

35 - driving the pylon section into the sea floor using a pile drive; and

- operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward.

4. Method according to claim 1 or claim 2, the method furthermore comprising guiding the
5 pylon section while it is lowered into the sea, using a pile guide, and driving the pylon section into the sea floor using a pile drive.

5. Method according to claim 4, wherein the pile guide is part of the track cart and the track
cart is used to move the pile guide from a storage position, in which the pile guide is located
10 above the deck of the vessel, into an active position, in which the pile guide is located outside a perimeter of the deck for guiding a pile being lowered towards the sea floor.

6. Method according to one or more of the preceding claims, wherein the vessel has two,
preferably substantially similar, pylon section installation cranes, located on opposite sides
15 of the installation end of the guide track, to in unison upend and/or lift the pylon section at a top end thereof.

7. Method according to claim 1 and claim 6, wherein the method furthermore comprises
loading the vessel with one or more pylon sections, which one or more pylon sections are
20 presented by another vessel, e.g. a barge, or on the main land, e.g. a quay, using the two pylon section installation cranes to lift the pylon section onto the vessel, while the legs of the vessel are in the lifted position, the method comprising the steps:

- lifting the pylon section into a substantially horizontal position, using the first installation
25 crane to lift the pylon section at the bottom end thereof and the second installation crane to lift the pylon section at the top end thereof;

- moving the pylon section onto the vessel by pivoting the first installation crane and the
second installation crane, such that the bottom end of the pylon section is moved between
30 the installation cranes first, and

- positioning the pylon section above guide track and lowering the pylon section into the horizontal transport position.

35 8. Method according to claim 1, wherein the cart is provided with a pivotable cradle, for engaging a bottom end of the pylon section, and for pivoting with the pylon section while it is

upended, to continuously guide and support the pylon section at the bottom end during the upending process.

9. Method according to one or more of the preceding claims, the method comprising storing
5 at least one pile on the deck of the vessel, which at least one pile is stored in the horizontal transport position, in which it is located above the guide track, the pile having a length of at least 90 meters, more preferably having a length of at least 100 meters.

10. Method according to claim 9, wherein the bottom end of the pile in the transport position
10 is located at the support end of the guide track and the top end of the pile extends overboard at the installation end of the guide track.

11. Method for installing a mast according to claim 2, wherein the mast is part of a
preassembled wind turbine, the wind turbine further comprising a nacelle, blades and a
15 rotational axis, wherein the method comprises:

- supporting the preassembled wind turbine in an vertical transport position using the track
cart, the nacelle of the preassembled wind turbine facing the aft of the vessel and the blades
of the wind turbine extending in a direction essentially perpendicular to the guide track;

20

- coupling the installation cranes with the mast of the preassembled wind turbine on opposite
sides of the nacelle, and lifting the preassembled wind turbine in an upright position from the
track cart;

25 - moving the preassembled wind turbine towards the installation site by both slewing the
installation cranes and pivoting the jibs downward; and

- lowering the preassembled wind turbine onto the jacket or pile.

30 12. Method according to claim 11, the method further comprising the step:

- moving the preassembled wind turbine towards the installation end of the guide track, and
thus moving the blades of the preassembled wind turbine from one side of two legs at the
installation end of the guide track to an opposite side of the legs at the installation side, the

35 legs being in the lowered position; and

- raising the jibs of the installation cranes into a position for lifting the preassembled wind turbine.

13. Method according to claim 11 or claim 12, wherein the method furthermore comprises

5 loading the vessel with one or more preassembled wind turbines, which one or more preassembled wind turbines are presented by another vessel, e.g. a barge, or on the main land, e.g. a quay, using the two mast installation cranes to lift the one or more preassembled wind turbine onto the vessel, while the legs of the vessel are in the lifted position, the method comprising the steps:

10

- coupling the mast installation cranes with the mast of the preassembled wind turbine on opposite sides of the nacelle, and lifting the preassembled wind turbine in an upstanding position;

15 - moving the preassembled wind turbine onto the vessel by pivoting the first installation crane and the second installation crane;

- positioning the mast above the guide track and lowering the mast onto the track cart; and

20 - optionally, use the track cart to move the preassembled wind turbine to a vertical transport position away from the installation cranes.

14. Method according to one or more of the preceding claims, the method furthermore comprising the steps:

25

- providing a temporarily mounted yoke, located at the top of the mast for coupling the mast with travelling blocks or wires of the mast installation cranes; and

30 - optionally providing a temporarily mounted foot clamp, which foot clamp preferably is part of the track cart which can be connected to and disconnected from the cart, at the bottom of the mast for coupling the mast with travelling blocks of the pylon section installation cranes.

15. Method for supplying a jack-up vessel, the jack-up vessel comprising a guide track for supporting and moving a preassembled wind turbine along the deck of the vessel using a

35 track cart, the method comprising:

- providing a track cart with a preassembled wind turbine on a supply track;

- aligning the jack-up vessel, more in particular the guide track of the jack-up vessel, with the supply track;

5 - lowering the legs of the jack-up vessel to stabilise the vessel, and preferably to at least partially lift the vessel out of the water and level the guide track of the vessel with the supply track;

- connect the supply track with the guide track, for example by providing a bridge track

10 between the supply track and the jack-up vessel, more in particular the guide track of the jack-up vessel, such that the supply track and the guide track are both part of a single linear guide track;

- move the track cart with the preassembled wind turbine from the supply track onto the

15 guide track, thus passing the preassembled wind turbine between two legs of the Jack-up vessel; and

- after thus moving one or more preassembled wind turbines onto the jack up vessel, raising the legs of the jack up vessel and moving the jack up vessel to an installation site.

20

16. Method according to claim 15, the method further comprising the steps:

- prior to moving the preassembled wind turbine onto the jack-up vessel, orientate the preassembled wind turbine with its front facing sideways on the supply track, i.e. with the

25 rotational axis of the wind turbine at an angle with the supply track; and

- move the track cart with the preassembled wind turbine from the supply track onto the

guide track with the turbine having this orientation, such that the preassembled wind turbine, when on the guide track, is orientated with its front facing sideways on the guide track, i.e.

30 with the rotational axis of the wind turbine at an angle with the guide track.

17. Method according to claim 16, wherein the angle between the rotational axis and the guide track is at least 70 degrees, preferably is at least 75 degrees, for example is 78,5 degrees.

35

18. Method according to claim 16 or claim 17, wherein the angle between the rotational axis and the guide track is less than 90 degrees, preferably is less than 85 degrees, for example is 80 degrees.

5 19. Method according to any of the claim 15-18, the method further comprising the steps:

- aligning the jack-up vessel, more in particular the guide track of the jack-up vessel, with an installation site;

10 - lowering the legs of the jack-up vessel to stabilise the vessel, to at least partially lift the vessel out of the water;

- orientate the preassembled wind turbine with its front facing the installation site and with the rotational axis of the wind turbine parallel with the supply track, preferably by rotating the pylon section, more in particular the mast, of the preassembled wind turbine about its longitudinal axis, and if needed, move the preassembled wind turbine along the guide track into a position in which it can be lifted by one, preferably two, mast installation cranes; and

15 - lift the preassembled wind turbine from the vessel onto a wind turbine installation base, e.g. a jacket or pylon, using an installation crane, preferably using two installation cranes in unison.

20 20. Marine jack-up type vessel for installing a pylon section of a wind turbine at a wind turbine installation site, the jack-up vessel comprising:

25

- a buoyant hull with a main deck for storing the pylon section during transport, the pylon section having a longitudinal axis extending between a top end of the pylon section and a bottom end of the pylon section;

30 - at least three jack-up legs;

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the sea floor and the hull is above water level;

35

- a pylon section guide track and an associated track cart,

wherein the guide track is located on or in the main deck and extends between a support end of the guide track and an installation end of the guide track, and wherein the track cart comprises a pylon holder for engaging the bottom end of the pylon section; and

- 5 - a pylon section installation crane, which installation crane is fixed to the hull of the vessel at the installation end of the track for lifting the pylon section, of which one end is at least partially supported by the track cart, the installation crane having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis.
- 10 21. Vessel according to claim 20, wherein the pylon holder is configured to guide the bottom end of the pylon section along the guide track, preferably from the support end to the installation end, while the pylon section is upended from a horizontal transport position into an installation position, in which installation position the pylon section has a vertical orientation and is at least partially supported by the pylon holder, and/or
- 15 is configured to guide the bottom end of the pylon section along the guide track prior to the pylon section being upended.

22. Vessel according to claim 21, wherein the pylon holder is configured to move, preferably pivot, between

- 20 a first position, for at least partially supporting the pylon section at the bottom end thereof, when the pylon section is in the horizontal transport position, in which horizontal transport position the pylon section has an essentially horizontal orientation and
- a second position, for at least partially supporting the pylon section at the bottom end thereof, when the pylon section is in the installation position.

25

23. Vessel according to one or more of the claims 20-22, wherein the vessel furthermore comprises a pylon section top end support, which top end support is located at the installation end of the guide track for engaging the top end of the pylon section when the pylon section is in a horizontal transport position, in which horizontal transport position the
- 30 longitudinal axis of the pylon section extends substantially parallel to the main deck and the guide track.

24. Vessel according to claim 23, wherein the pylon section top end support is removable mounted on the deck of the vessel or on the guide track.

35

25. Vessel according to one or more of the claims 20-24, wherein the track cart is provided with a cart drive for controlled movement of the cart along the guide track during the

upending process, e.g. wherein the cart comprises a drive with a sprocket that cooperates with a rack extending along the guide track, and

preferably, the cart is provided with a pivotably mounted cradle or pylon holder for supporting the pile section, and a cradle drive for pivoting the cradle with the pile during the

5 up-ending process.

26. Vessel according to one or more of the claims 20-25, wherein the jack-up vessel comprises a pylon section storage location on at least one side of the guide track, for supporting a pylon section in a horizontal storage position in which a longitudinal axis of the pylon section extends parallel to the guide track and parallel to a pylon section in the

10 horizontal transport position on the transport track, and

wherein the vessel comprises a pylon section transfer device, e.g. one or more cranes or a transfer track with one or more track carts, for transferring a pylon section from the horizontal storage position into the horizontal transport position.

15 27. vessel according to claim 26, wherein the vessel further comprises at least a top transfer track and a bottom transfer track, the top transfer track and the bottom transfer track extending substantially perpendicular to the guide track, and the top transfer track and the bottom transfer track comprising at least one top transfer cart and at least one bottom transfer cart for supporting a pylon section at the top and at the bottom respectively, for

20 moving the pylon section into and out of the horizontal transport position on the guide track

28. Vessel according to one or more of the claims 20-27, wherein the guide track and the track cart, are configured to support the pylon section in the horizontal transport position such that the longitudinal axis of the pylon section extends parallel to a longitudinal axis of

25 the vessel and preferably is located at the centre of the vessel.

29. Vessel according to one or more of the claims 20-28, wherein the guide track and the track cart, are configured to support the pylon section, when in the horizontal transport position, with the top end located near the installation crane and an installation edge of the

30 deck, i.e. the edge of the deck over which the pylon section will be lifted off the vessel, and the bottom end located away from the installation crane and the installation edge of the vessel.

30. Vessel according to claim 20, wherein the pylon holder is configured to engage the

35 bottom end of the pylon section when in the vertical transport position, and wherein the cart can move the supported pylon section along the guide track while the pylon section is free standing, i.e. without additional supports, in vertical transport position.

31. Vessel according to one or more of the claims 20-30, wherein the track cart is configured for supporting a pylon section in the vertical transport position and in the horizontal transport position, e.g. wherein the cart comprises a bottom end pylon section coupling device

5 configured for engaging the bottom end of a pylon section, and which can be pivoted between a horizontal support position and a vertical support position.

32. Vessel according to one or more of the claims 20-31, wherein the track cart is provided with the pylon section holder for supporting pylon sections in the horizontal transport position

10 and with the pylon section holder for supporting pylon sections in the vertical transport position, which pylon section holders can be interchanged.

33. Vessel according to one or more of the claims 20-32, wherein the installation end of the guide track is located at an installation side of the main deck of the vessel, and wherein

15 preferably the guide track extends perpendicular to the installation side of the main deck of the vessel.

34. Vessel according to one or more of the claims 20-33, wherein the vertical slew axis of the respective installation cranes define a virtual plane, and wherein an installation side of

20 the main deck of the vessel is located at an installation side of the virtual plane and the main deck is located at a deck side of the virtual plane.

35. Vessel according to claim 34, the guide track passes between two installation cranes and between the two legs of the vessel located at the installation side of the main deck of

25 the vessel, and the guide track extends in a direction perpendicular to the virtual plane.

36. Vessel according to one or more of the claims 20-35, wherein the vessel comprises a second installation crane and wherein the two installation cranes are fixed to the hull on opposite sides of the guide track at the installation end thereof, for in unison lifting a pylon

30 section of which one end is supported by the track cart, and for lifting the pylon section from the vessel onto an installation site.

37. Vessel according to claim 36, wherein each crane has a storage configuration, in which the jib is located at the deck side of the virtual plane, and an installation configuration in

35 which the jib is located at the installation side of the virtual plane.

38. Vessel according to one or more of the claims 15-37, wherein the pylon section installation crane is an around the leg crane, i.e. is mounted around a leg of the jack-up vessel, preferably the two pylon section installation cranes are both around the leg cranes, i.e. are each mounted around a leg of the jack-up vessel.

5

39. Vessel according to one or more of the claims 20-38, the jack-up vessel has four legs, the four legs comprising two front legs and two rear legs, wherein the two rear legs are spaced farther away from each other than the two front legs, to thus create additional deck space between the two rear legs, preferably between the two around the leg cranes

10 mounted on said rear legs.

40. Vessel according to one or more of the claims 20-39, wherein the jack-up vessel furthermore comprises a cantilever, e.g. for performing well bore operations, and the guide track is adapted to cooperate with the cantilever to move the cantilever relative to the hull at least in longitudinal direction of the guide track between a retracted position and an extended position, in which extended position an operational end of the cantilever structure extends beyond an installation side of the main deck of the vessel.

15

41. Vessel according to claim 40 wherein the guide track and/or the installation crane is/are adapted to move the cantilever into a deck clearing position wherein a clear deck area of the main deck is present between said cantilever and the installation side of the main deck of the vessel, wherein the clear deck area extends at least 20 meters in a direction perpendicular to said installation side and at least 10 meters transverse to the guide track direction, e.g. to allow for placing a topsides on said clear deck area.

25

42. Vessel according to one or more of the claims 20-38, wherein the jack-up vessel comprises a cantilever motion assembly, which cantilever motion assembly preferably comprises the guide track, which guide track preferably comprises one or more rails mounted on said main deck, e.g. in an axial direction of the hull perpendicular to the second axial side, and wherein said one or more rails extend towards or up to a side of the hull so as to allow for the cantilever motion assembly to move the cantilever relative to the vessel between extended positions wherein an operational end of the cantilever extends beyond the side of the hull, a retracted position wherein said operational end is before the side of the hull and the entire cantilever is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs.

30

35

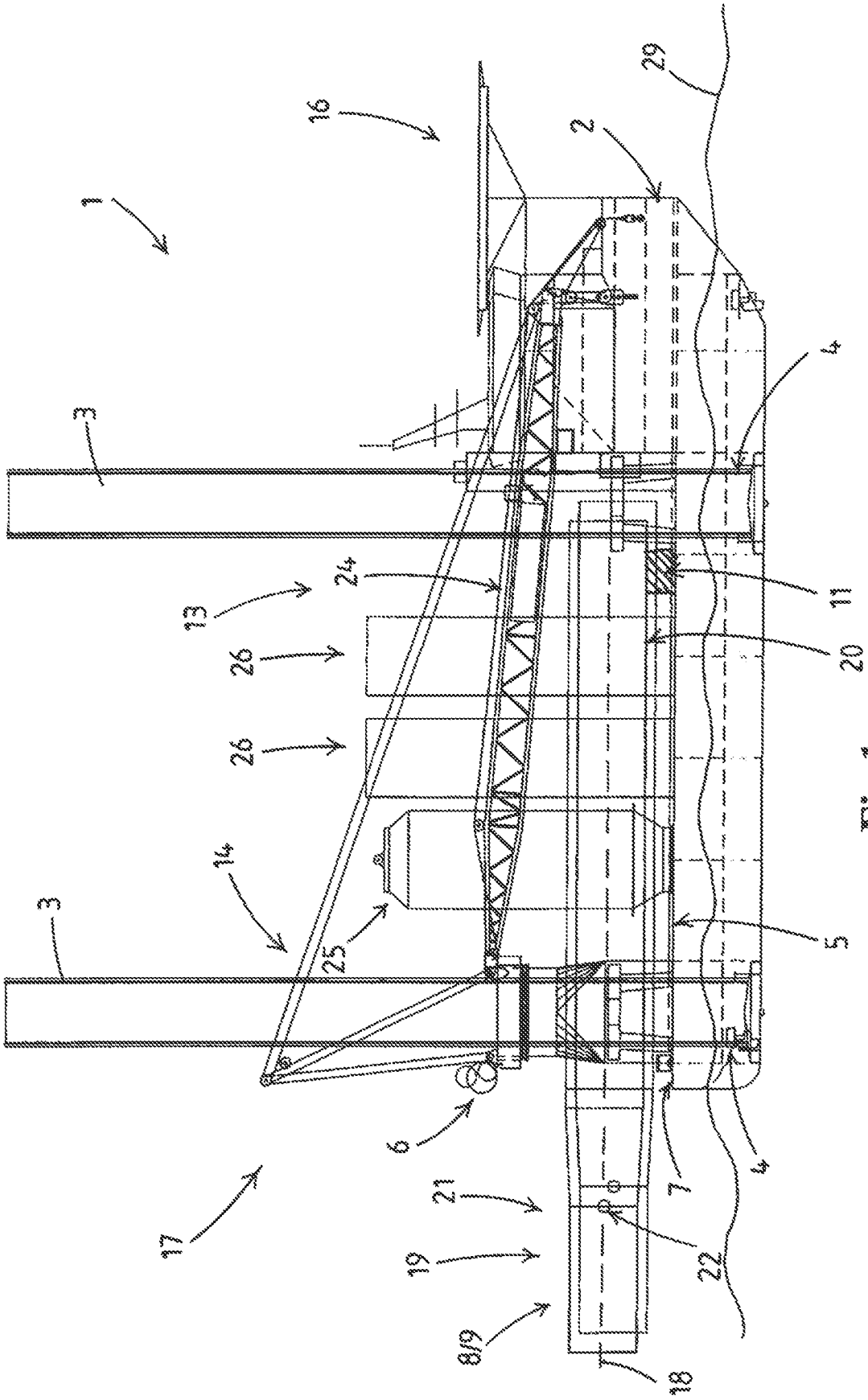


Fig.1

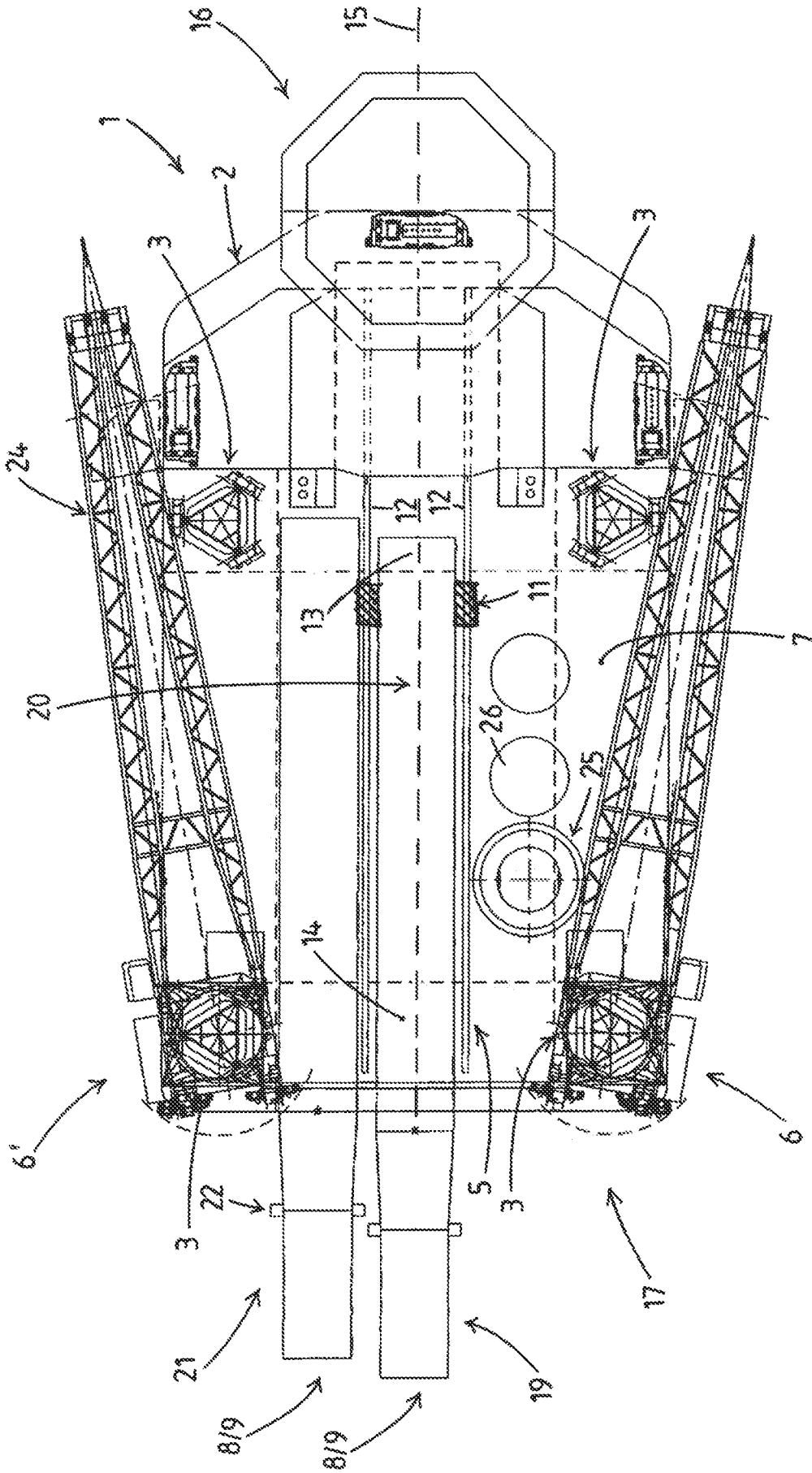


Fig.2

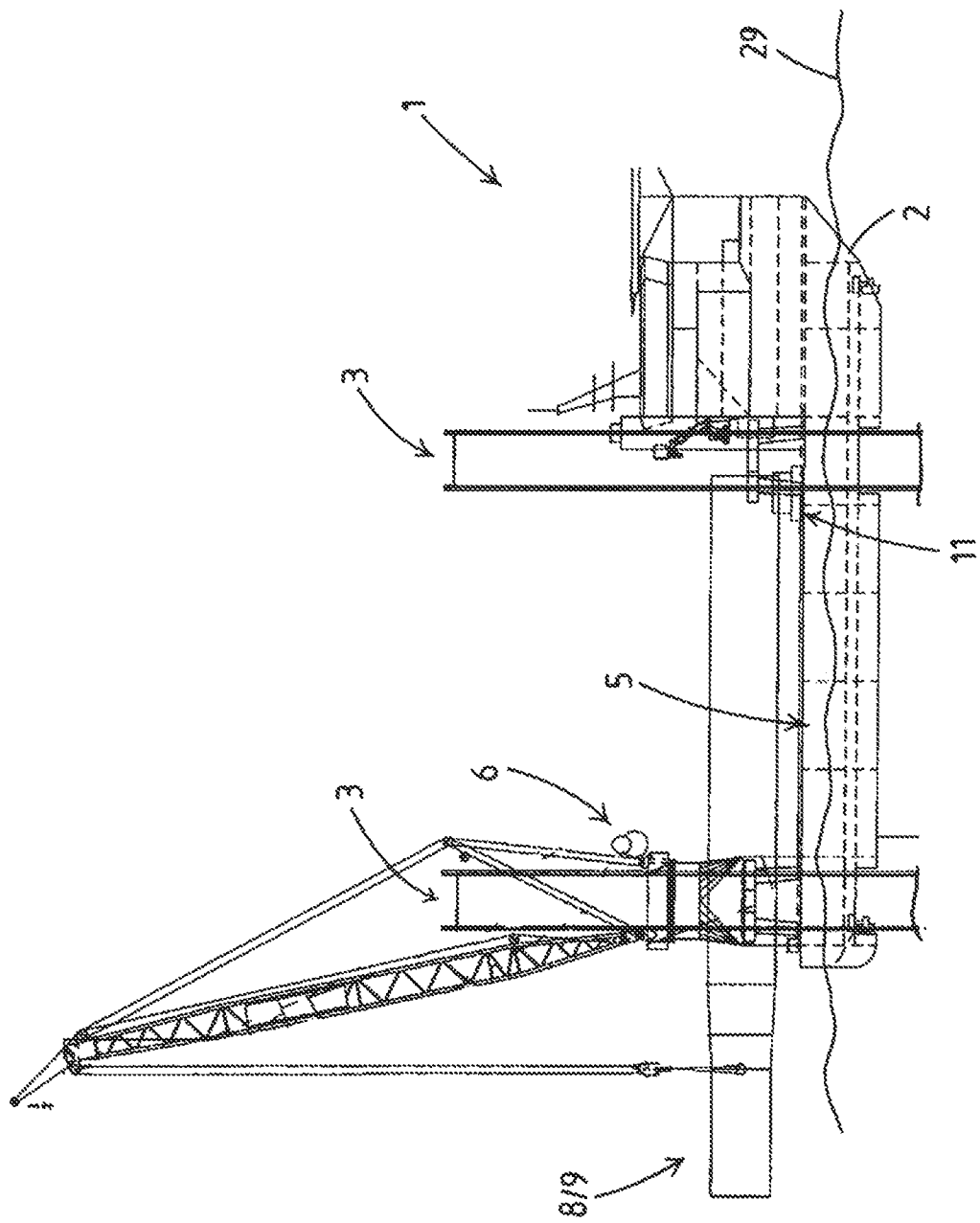


Fig.3

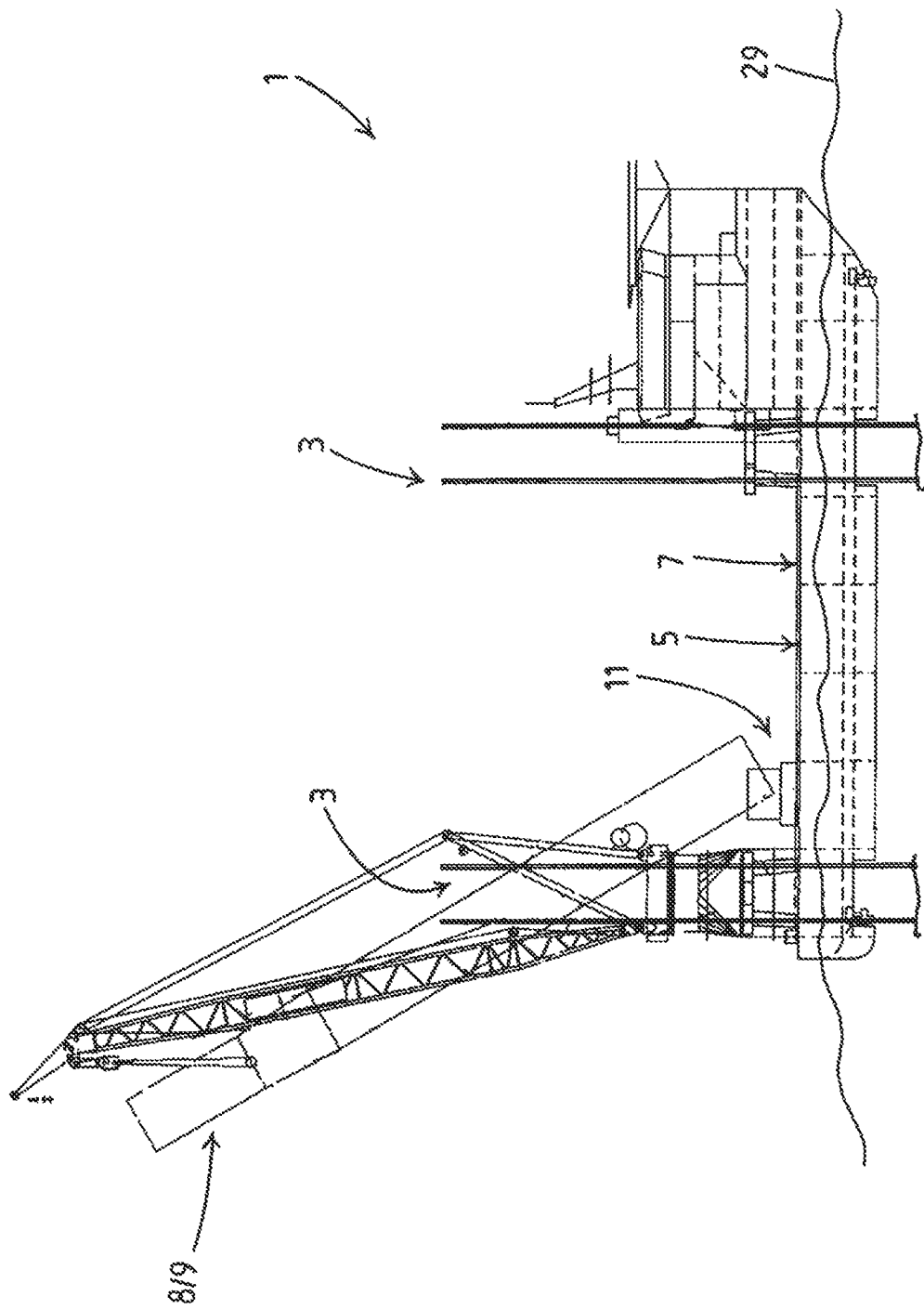


Fig.4

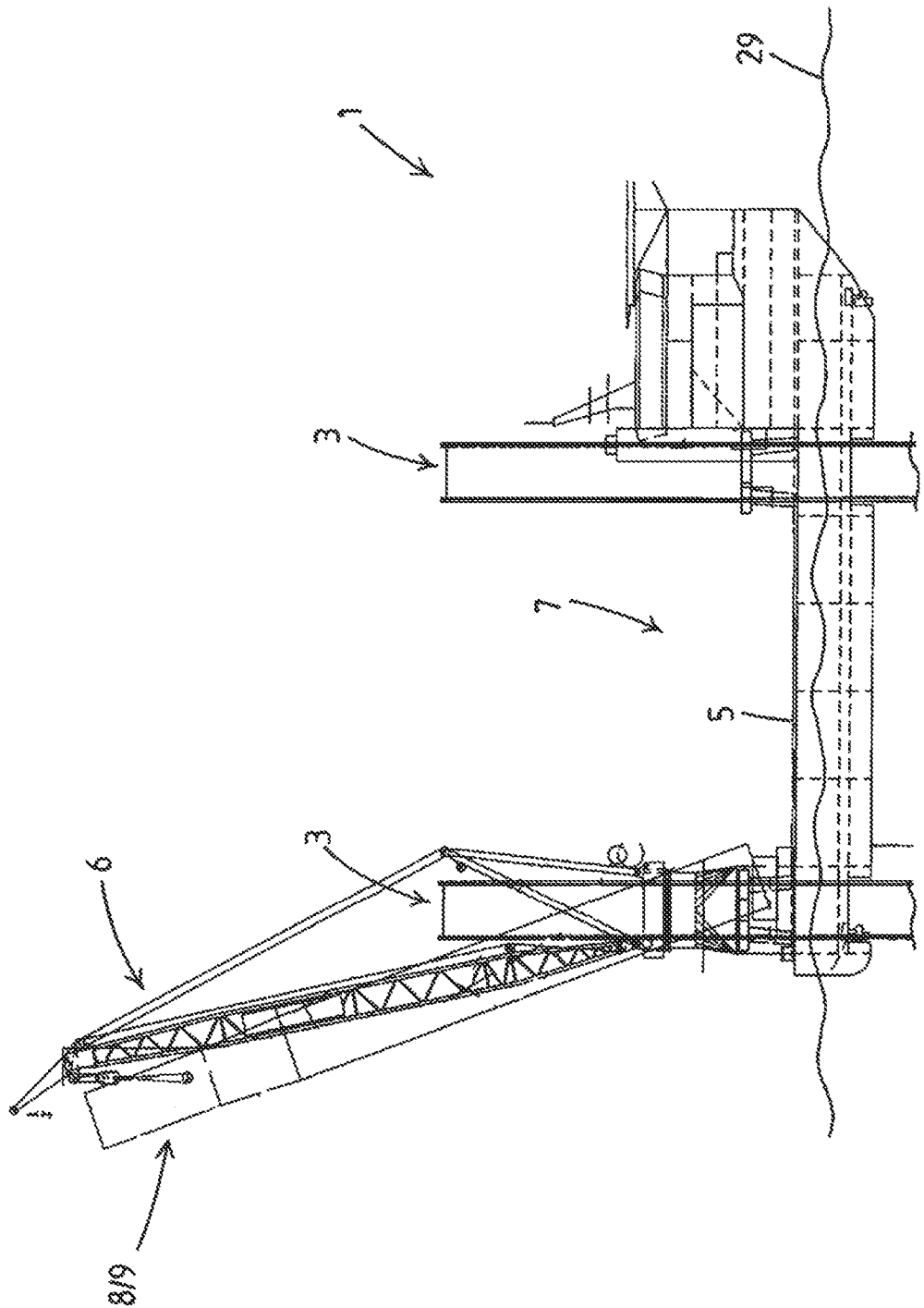


Fig.5

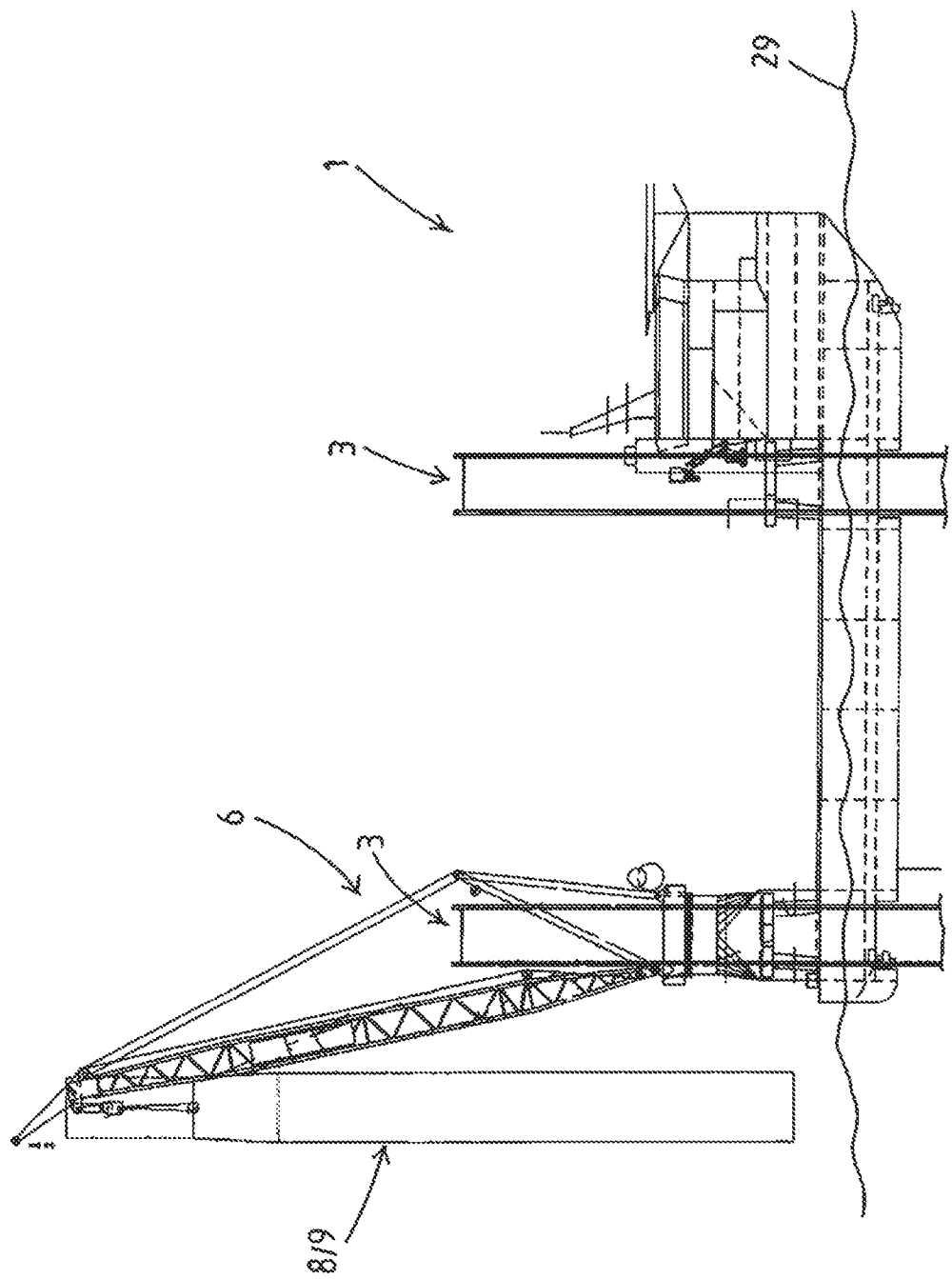


Fig.6

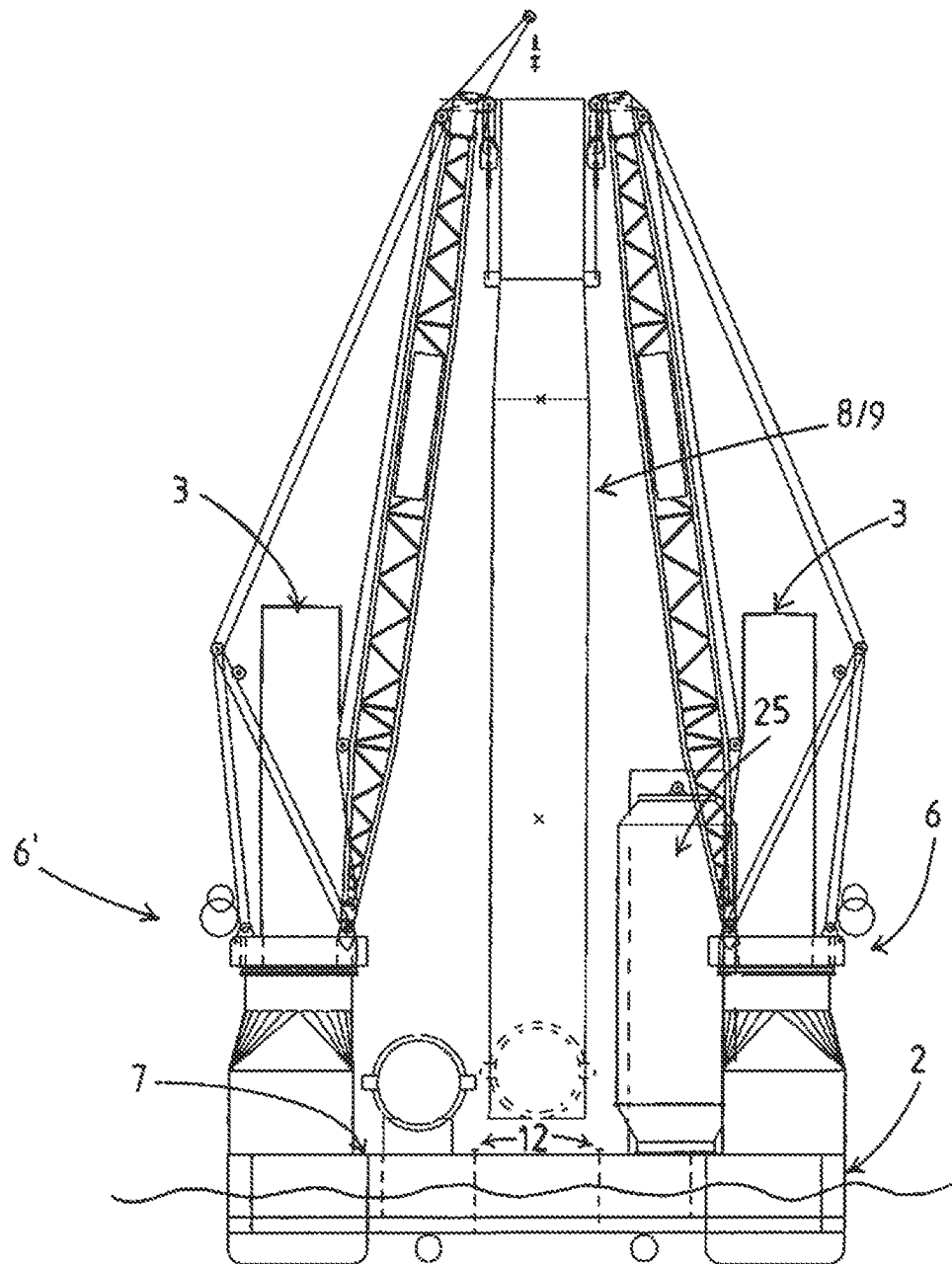


Fig.7

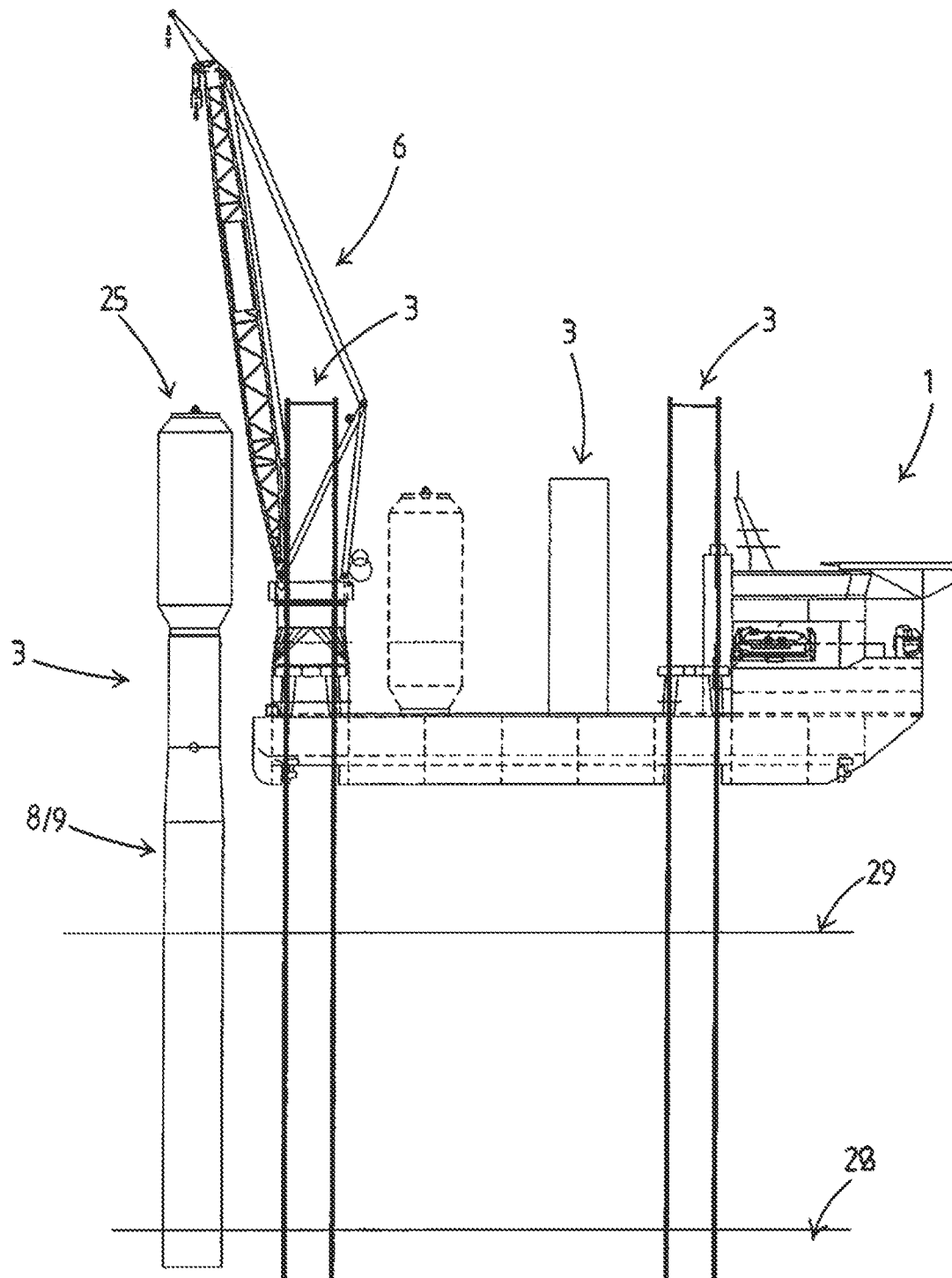
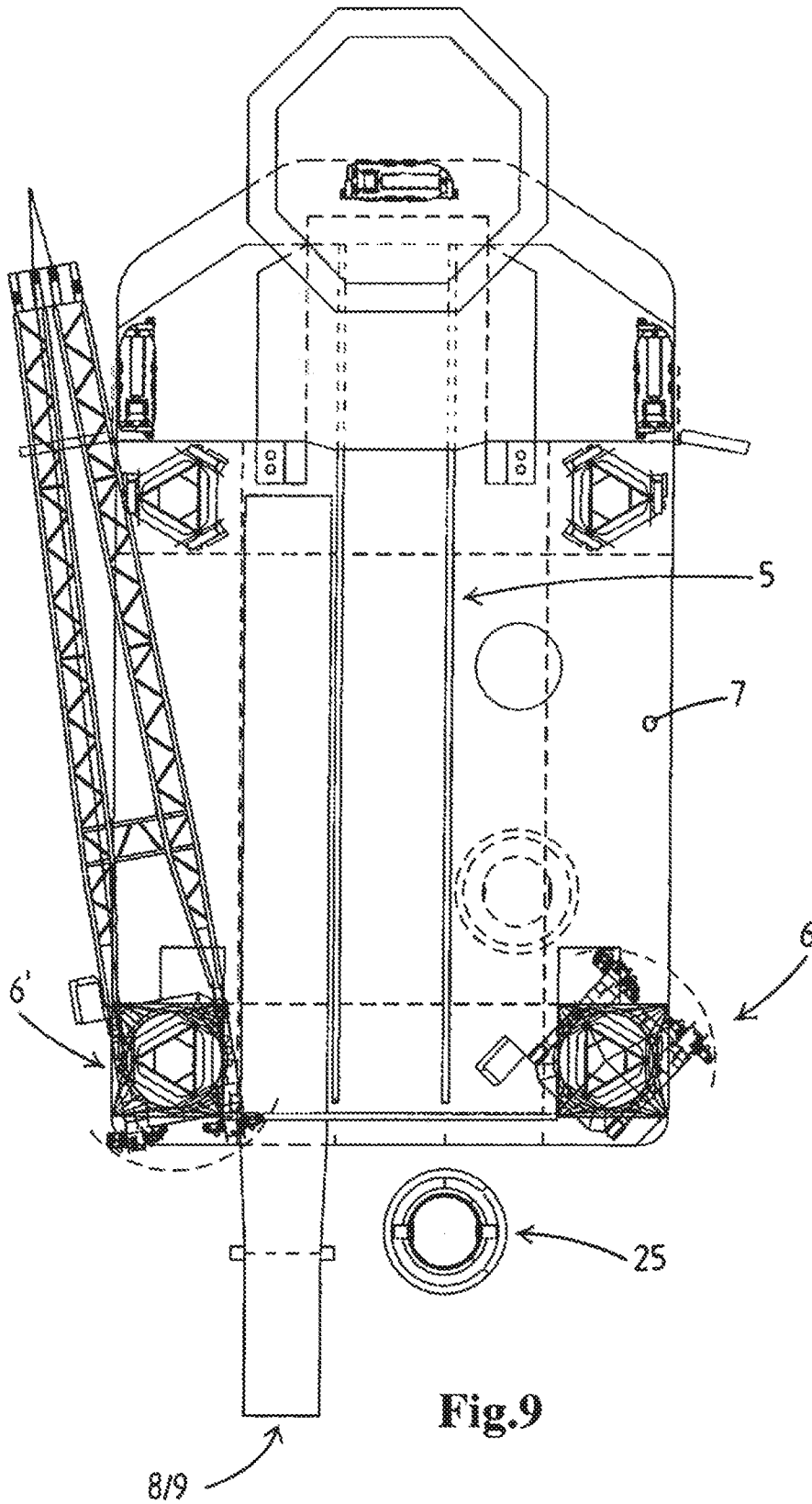


Fig.8



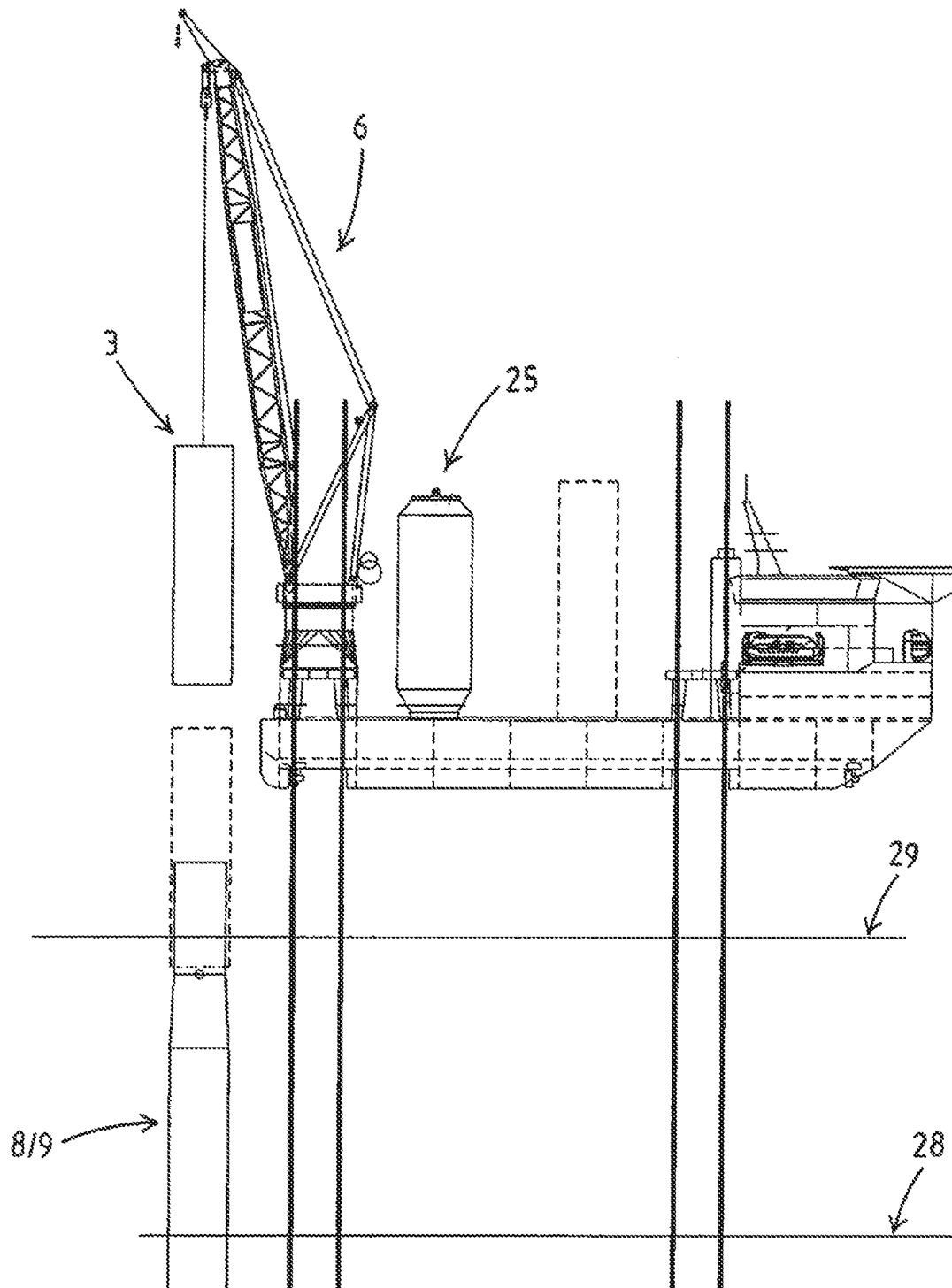


Fig.10

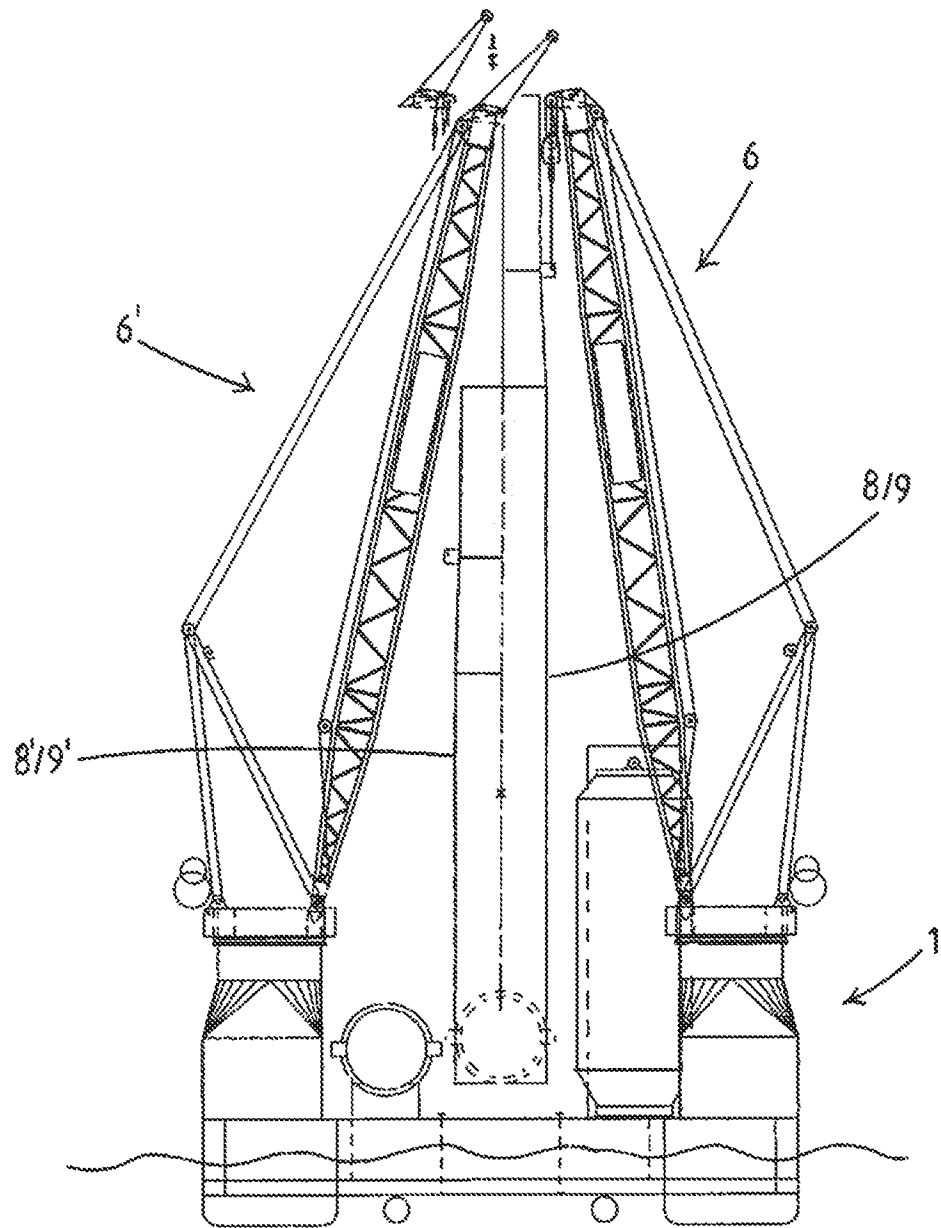


Fig.11

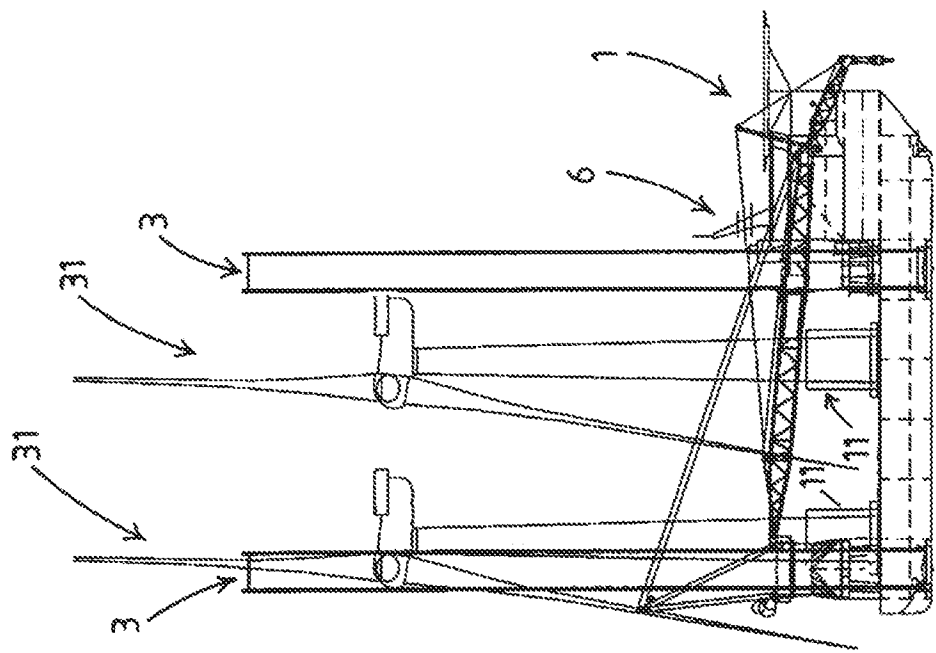


Fig. 12

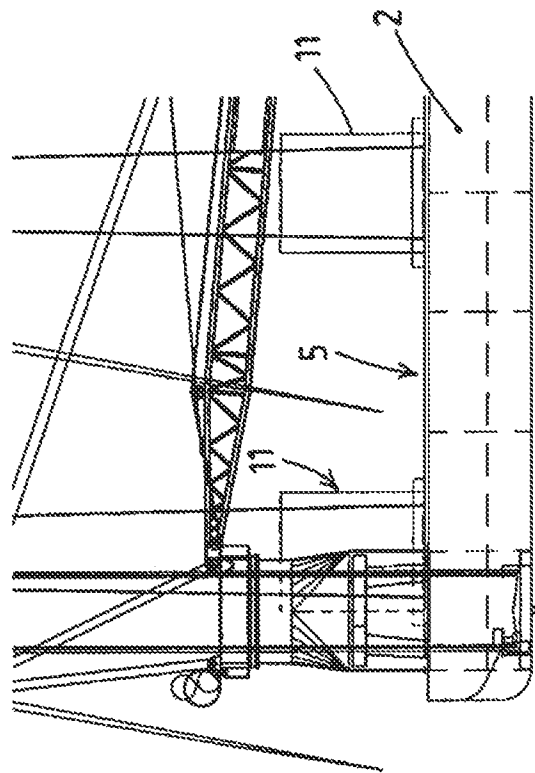


Fig. 13

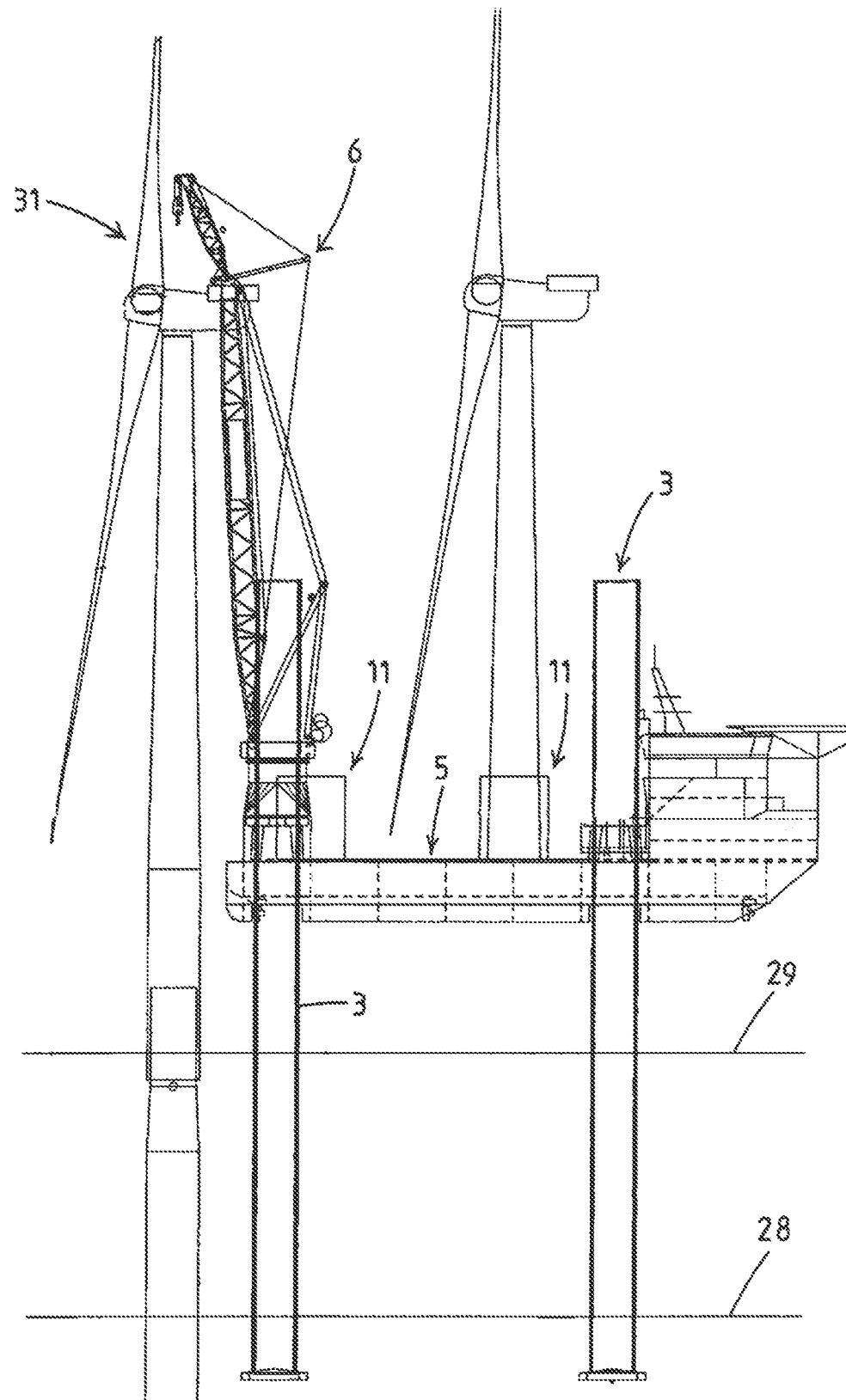


Fig.14

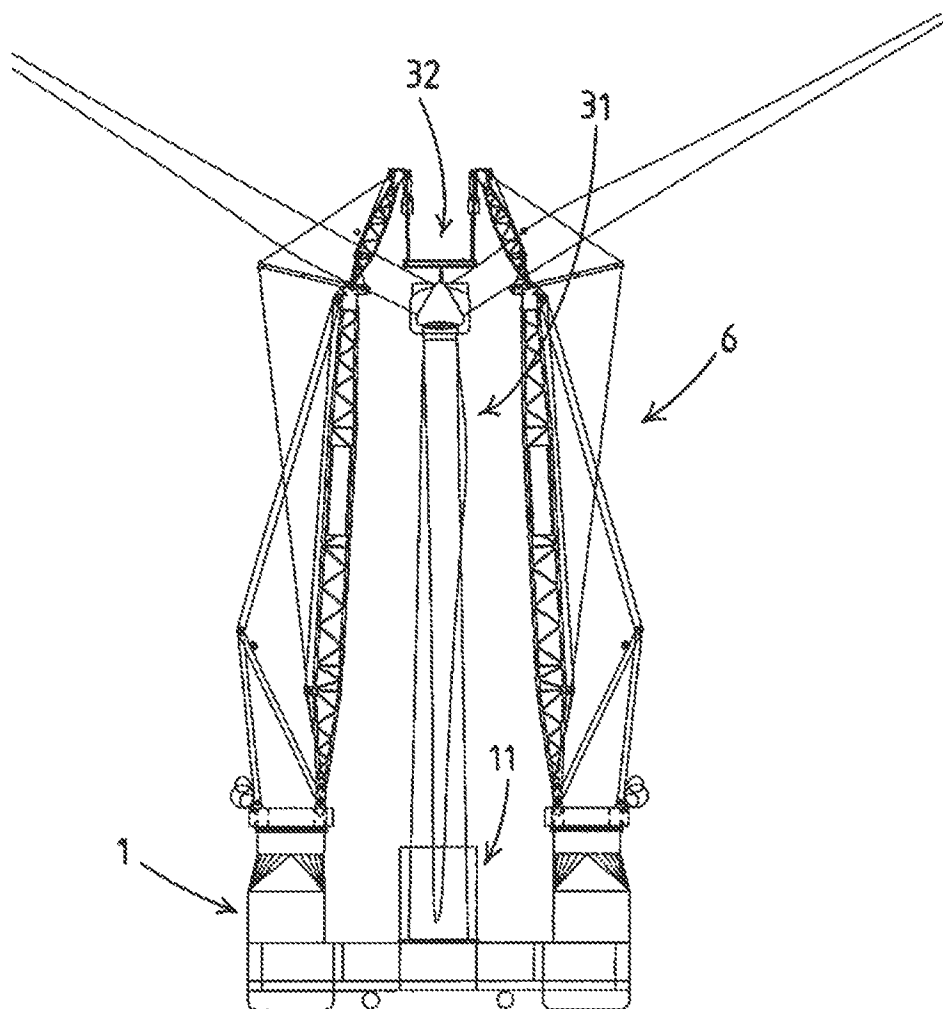


Fig. 15

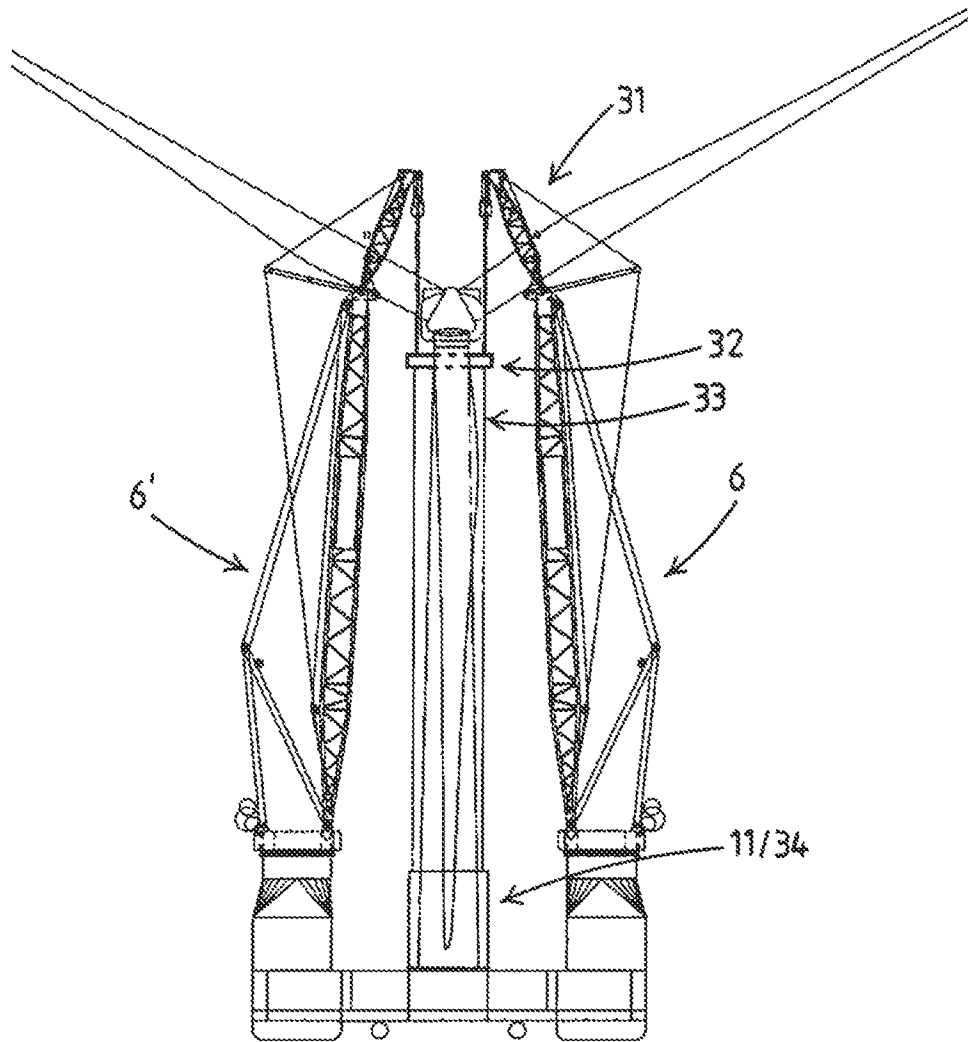


Fig.16

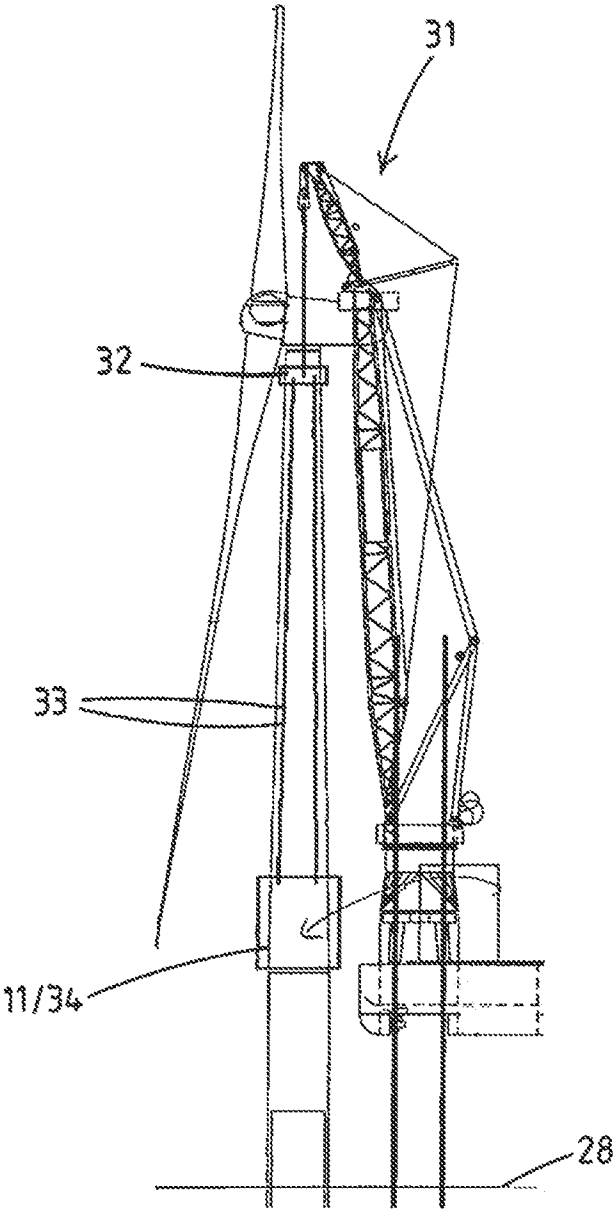
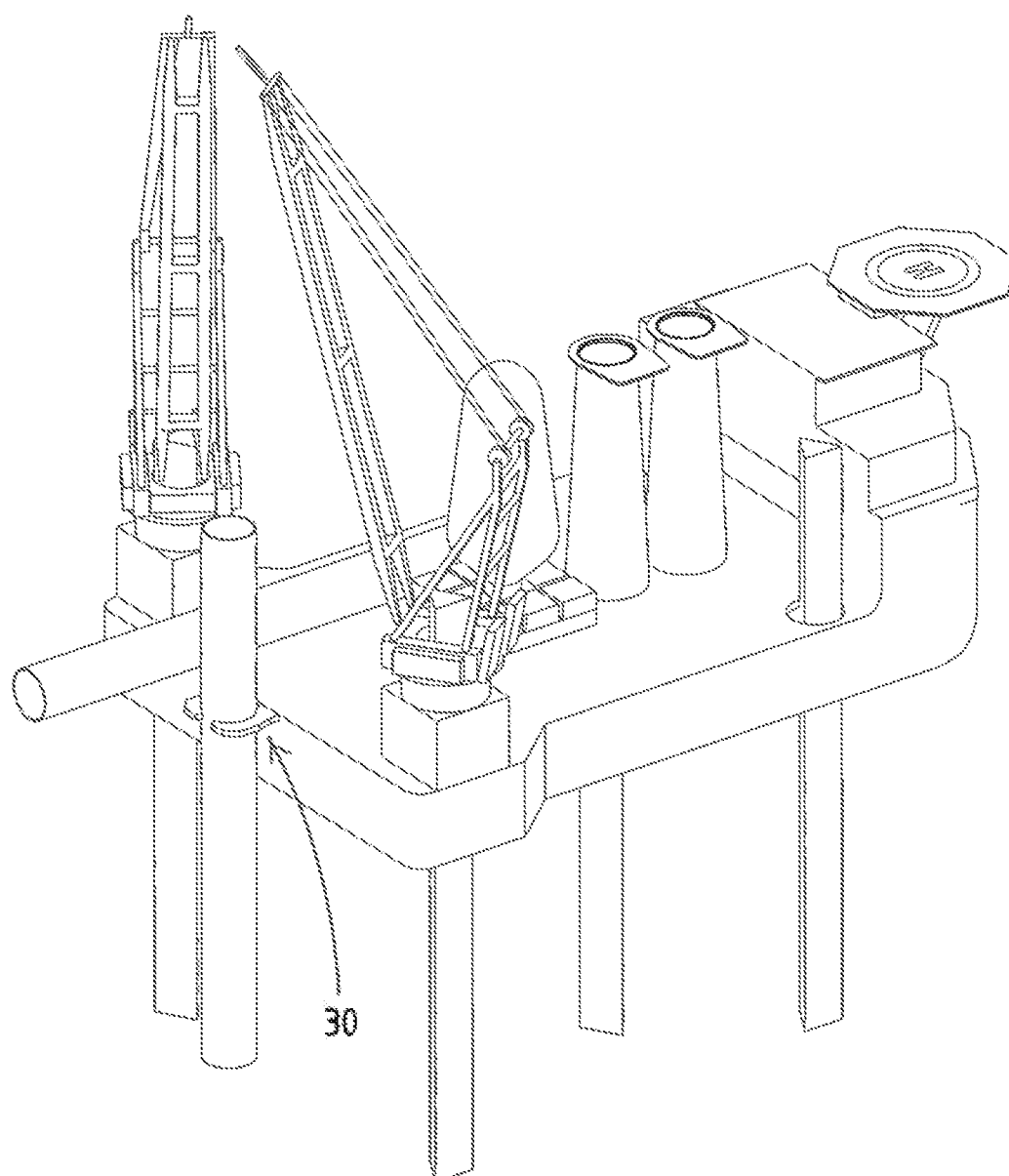


Fig.17

**Fig.18**

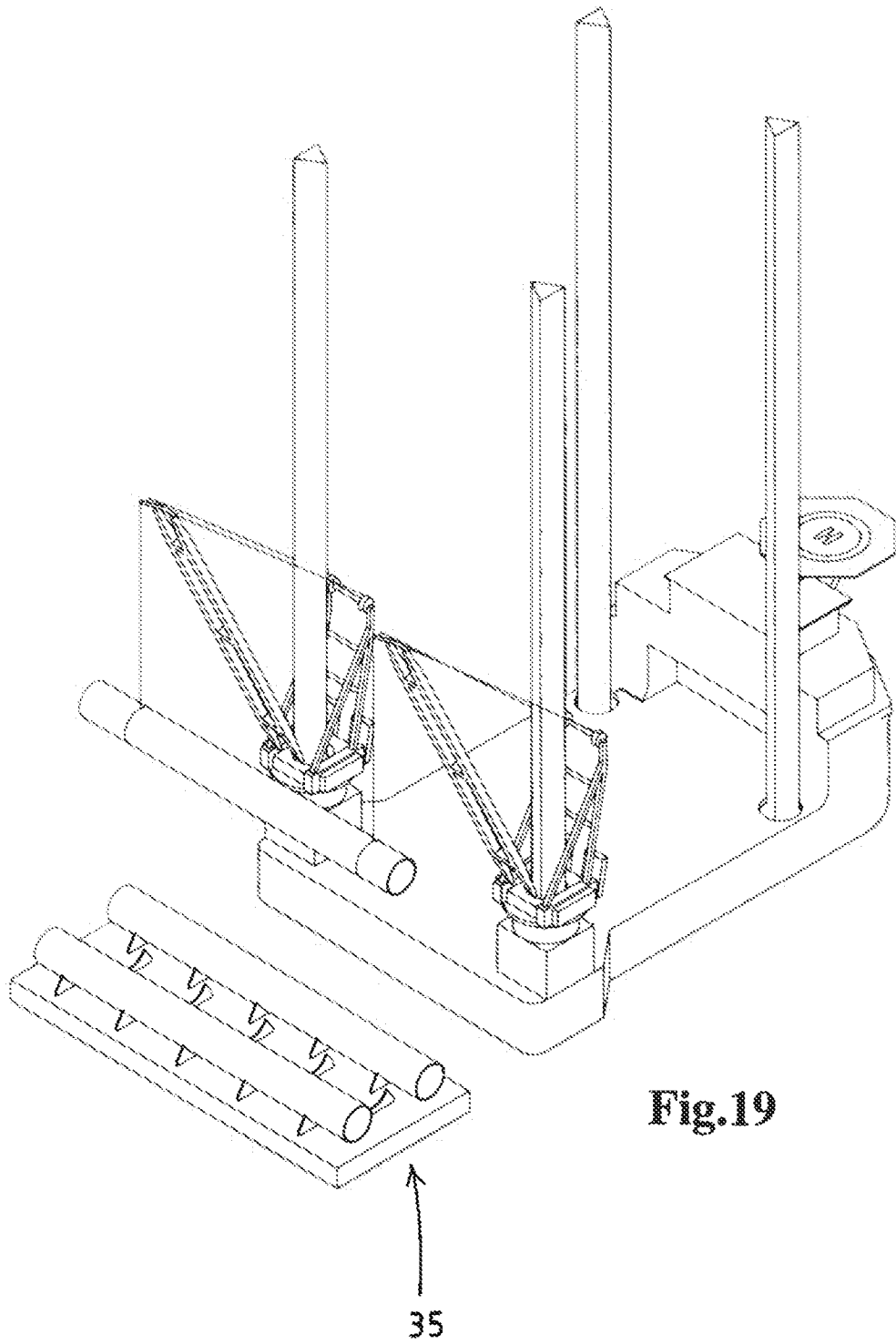


Fig.19

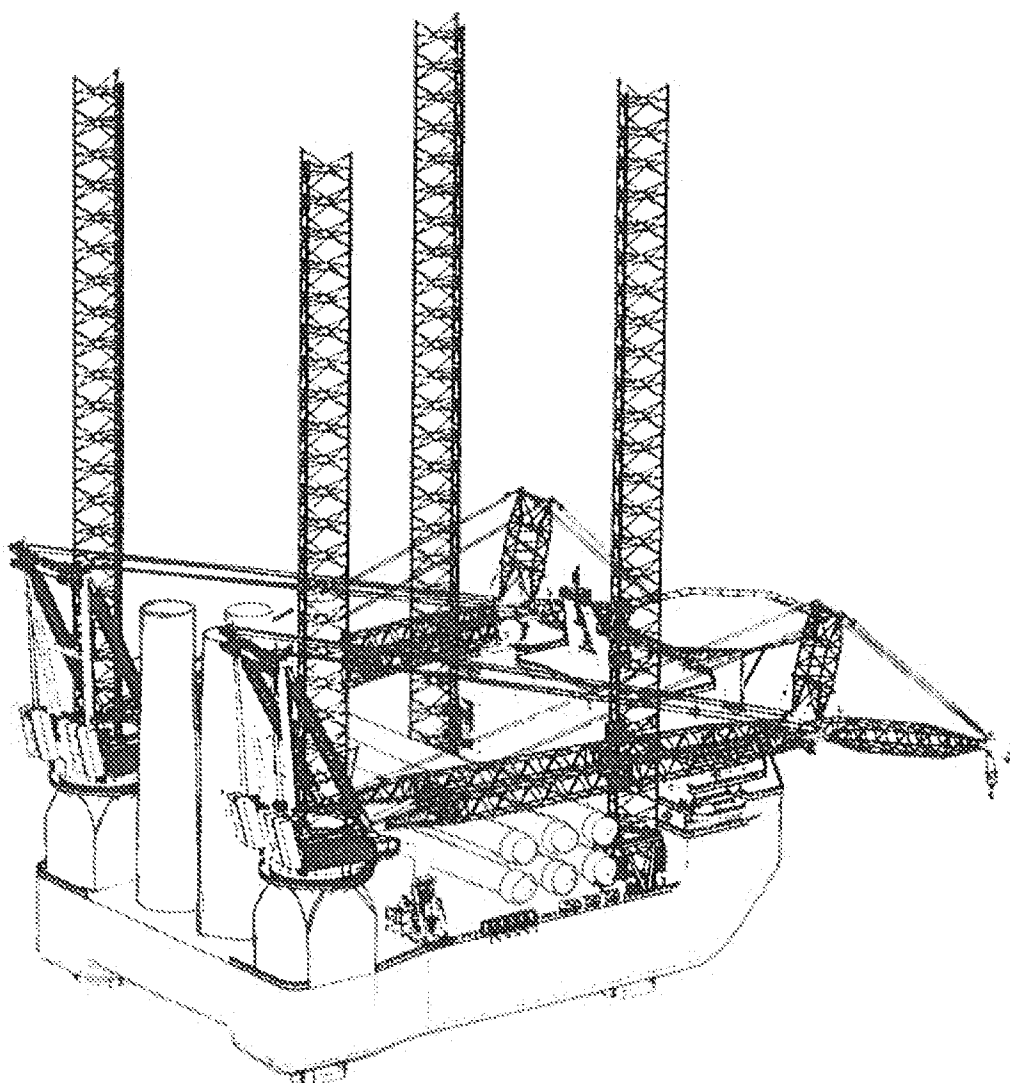


Fig.20

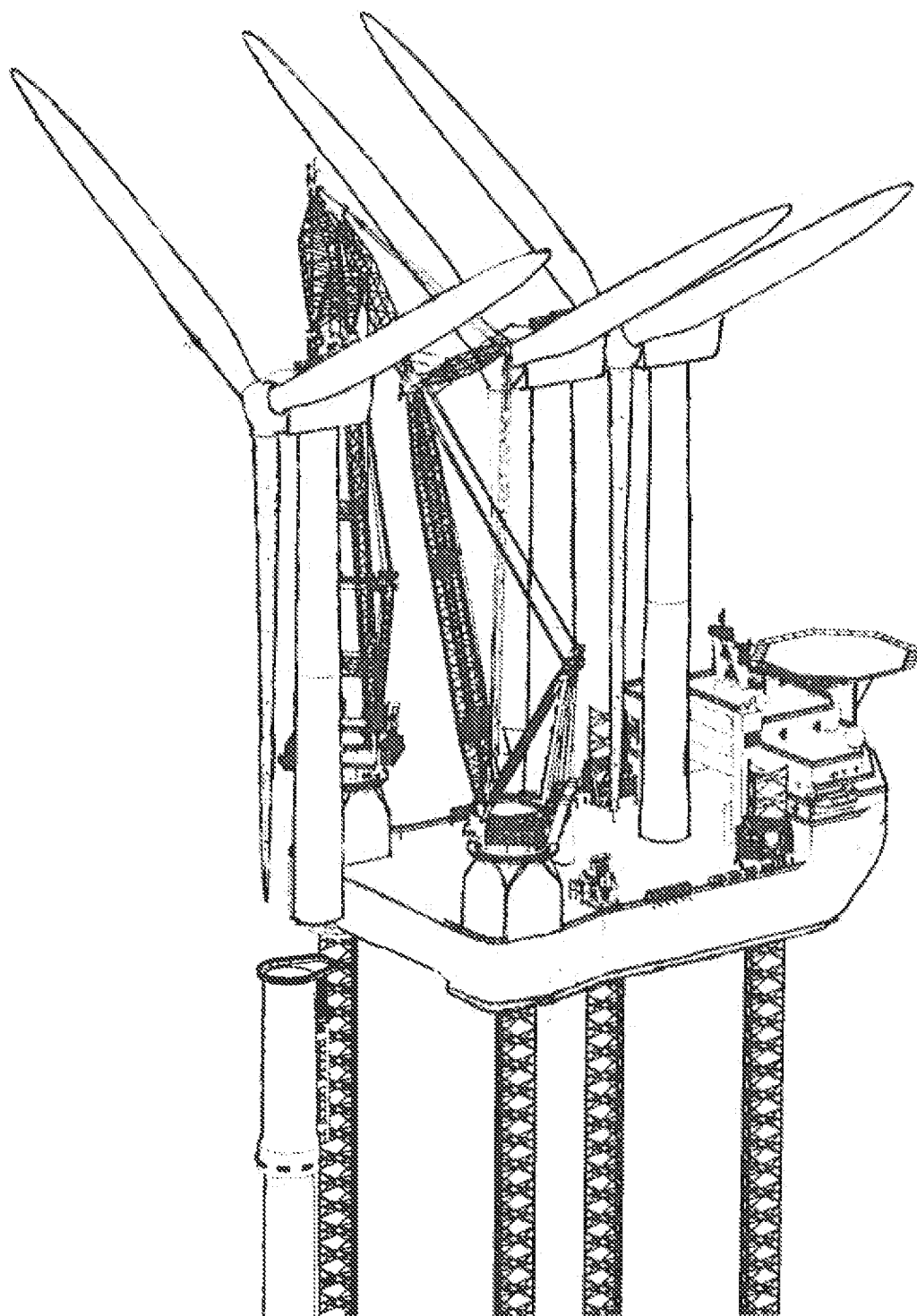


Fig.21

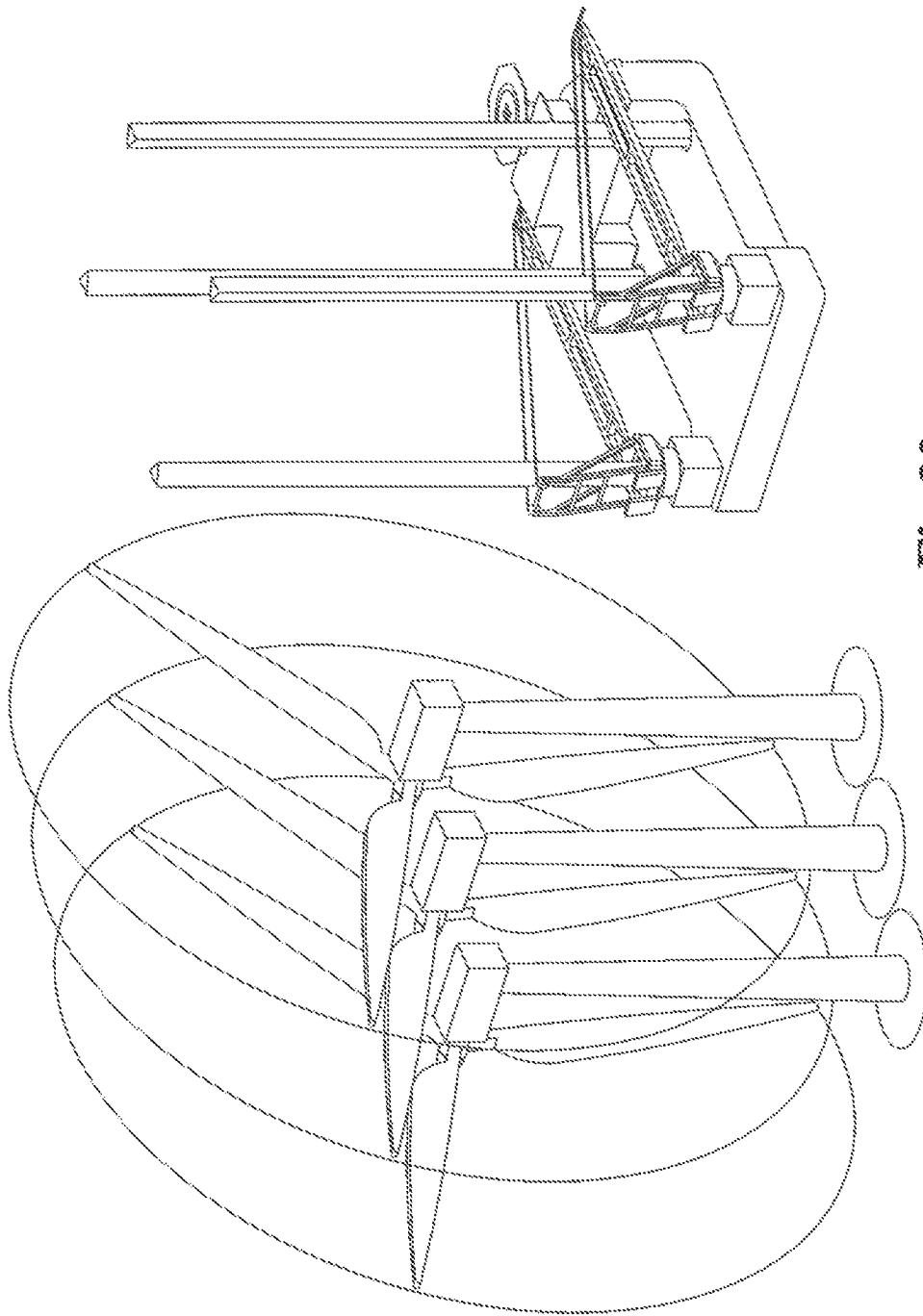


Fig.22

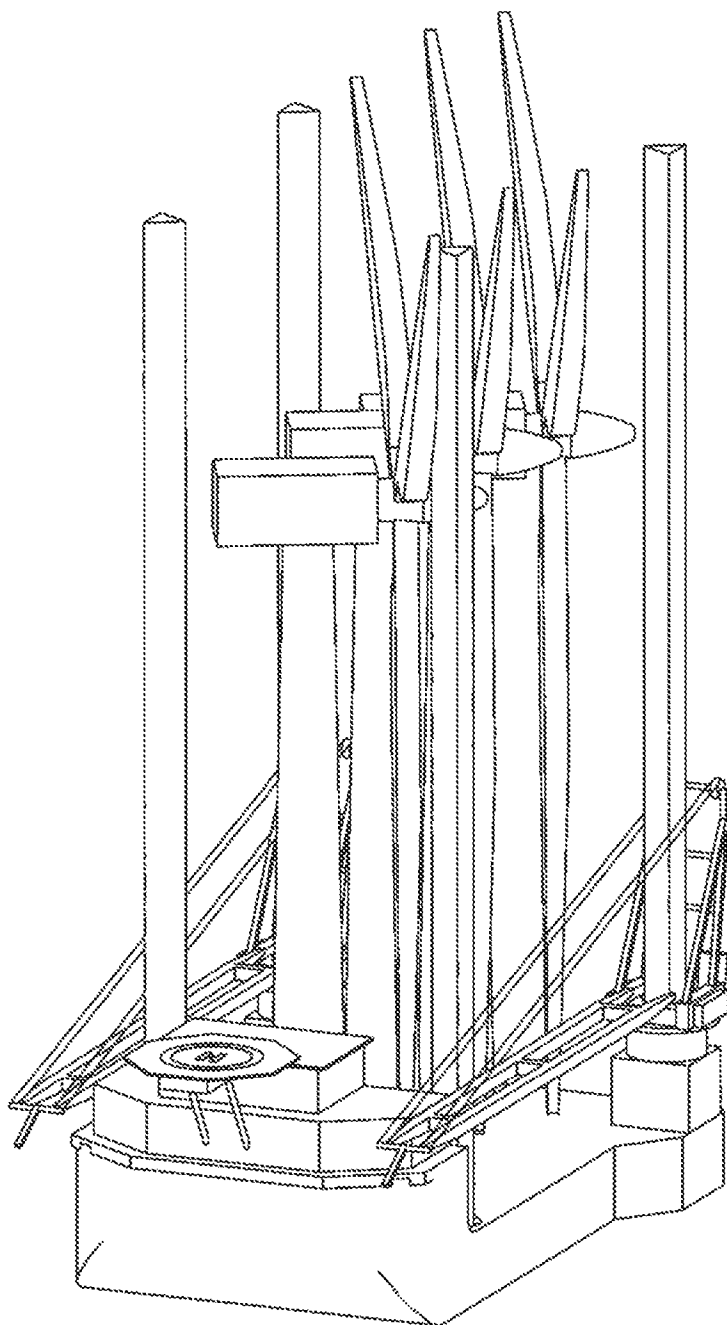


Fig.23

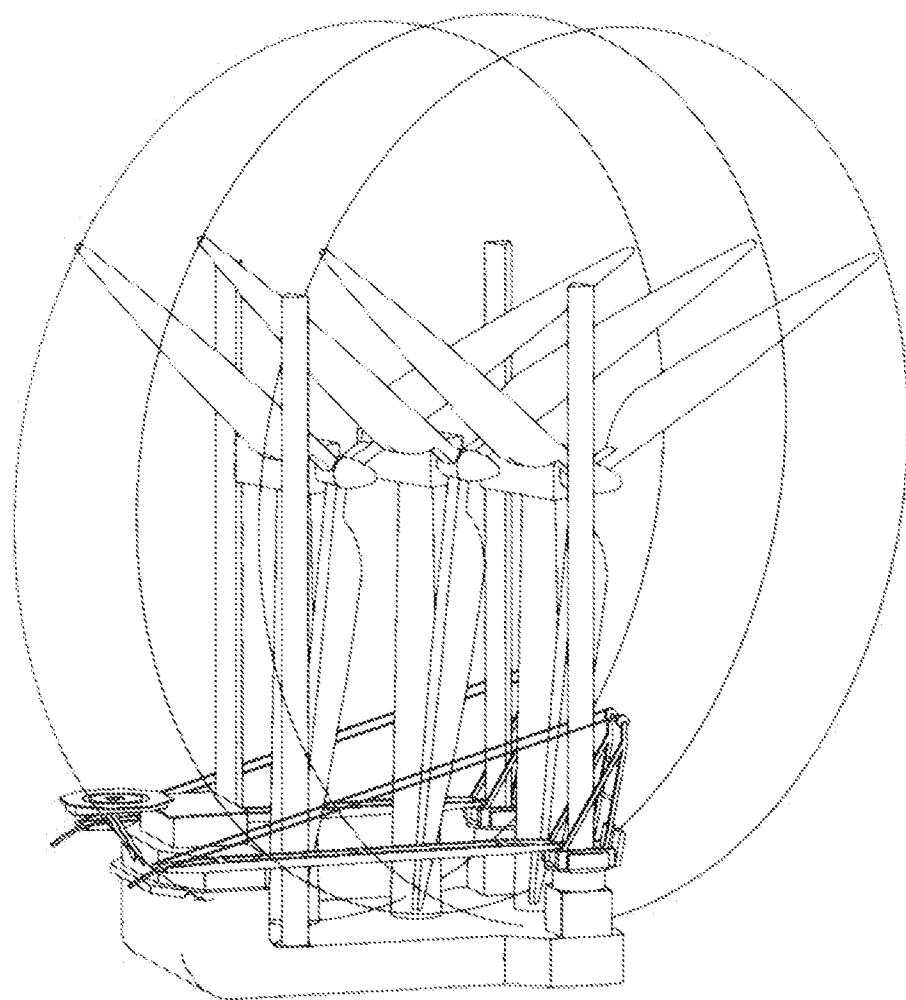
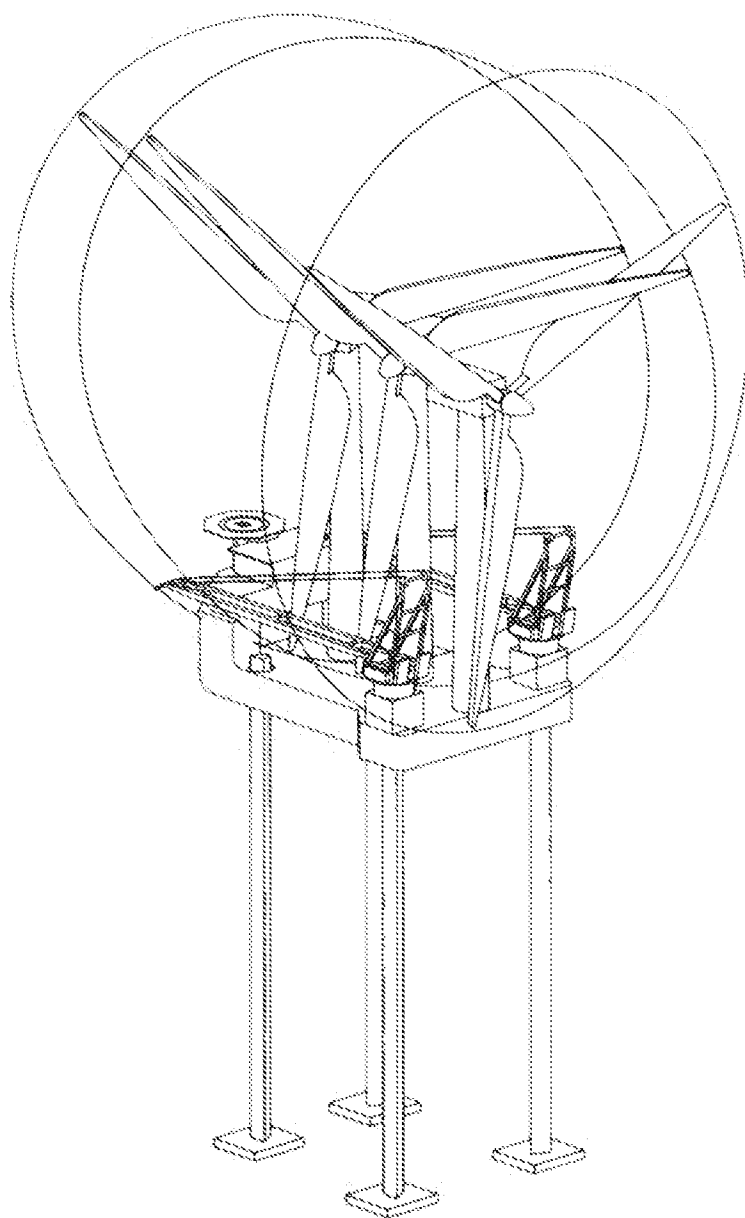


Fig.24

**Fig.25**

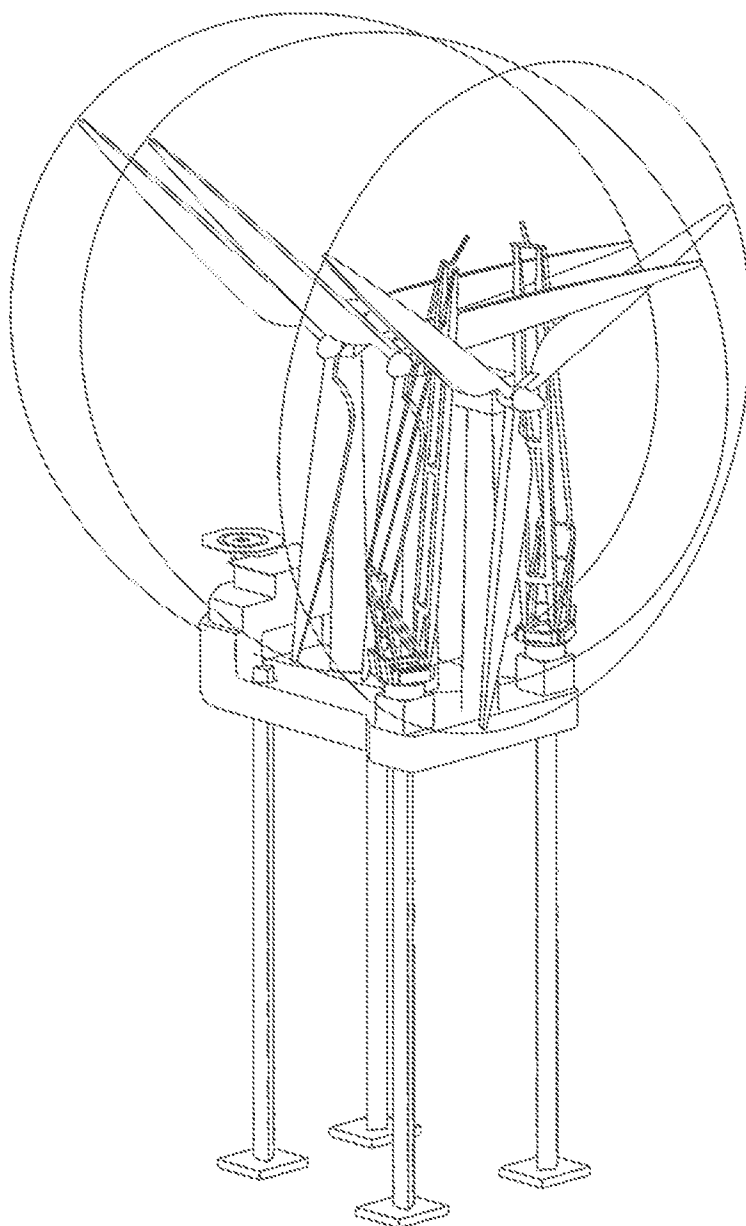


Fig.26

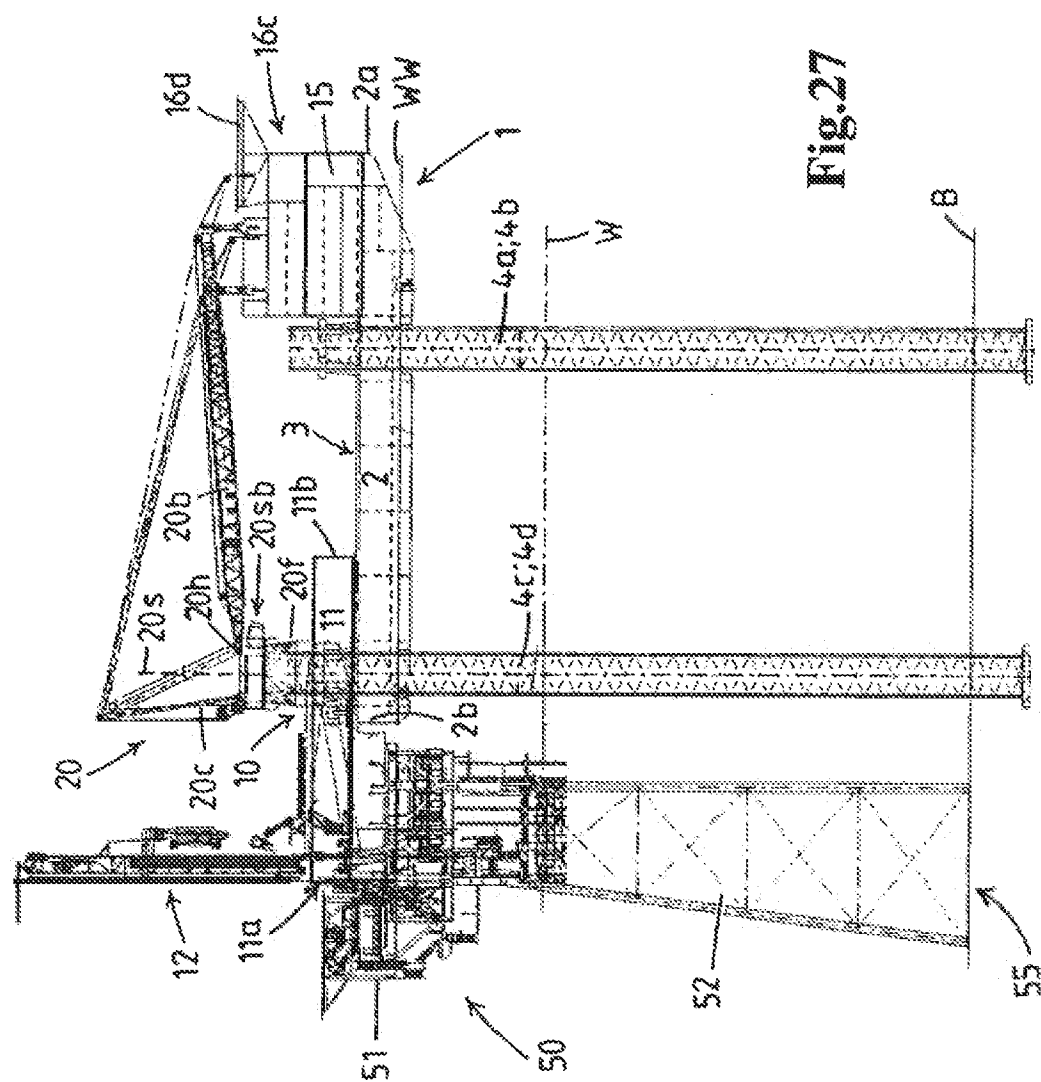
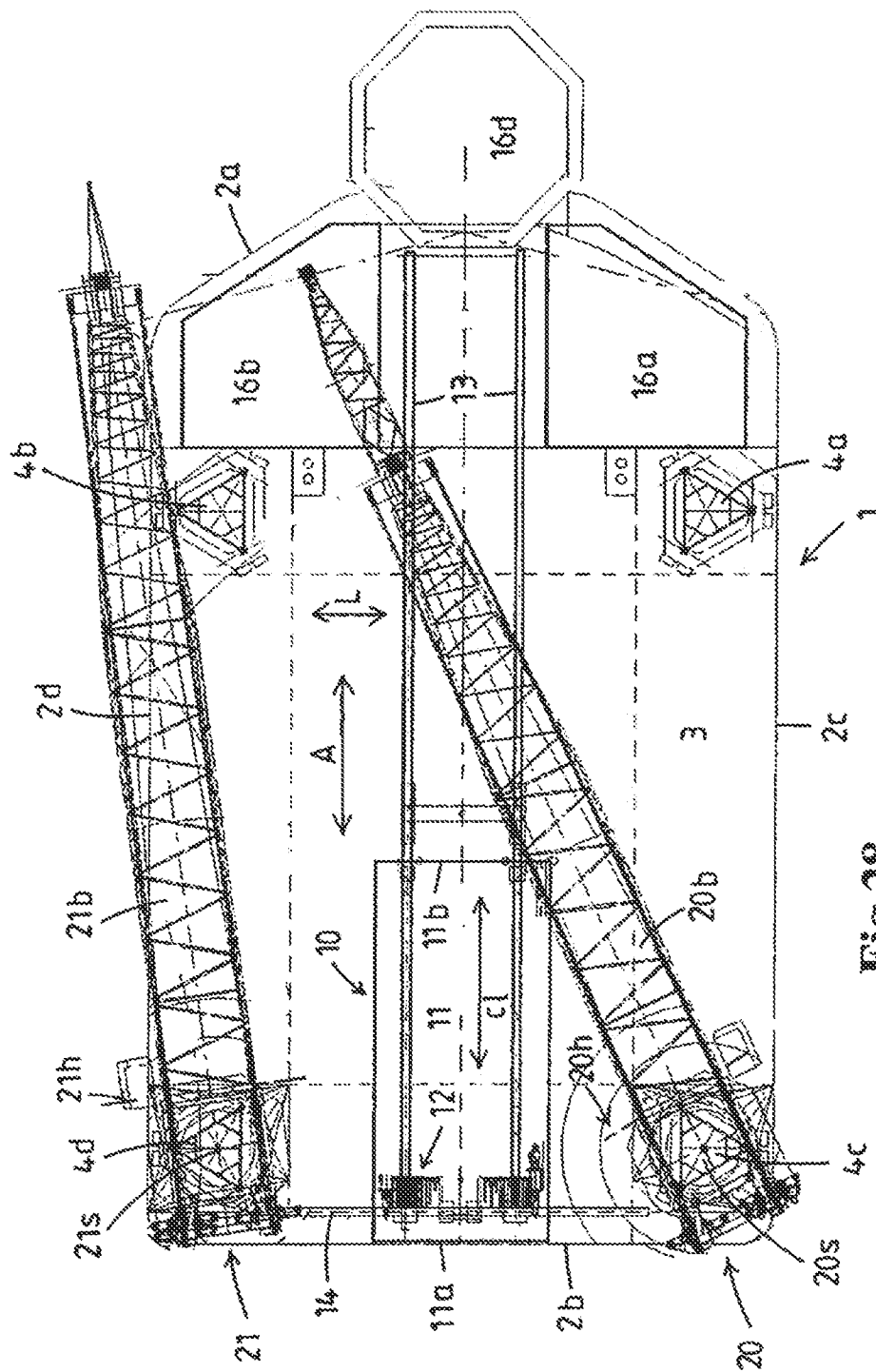


Fig. 27



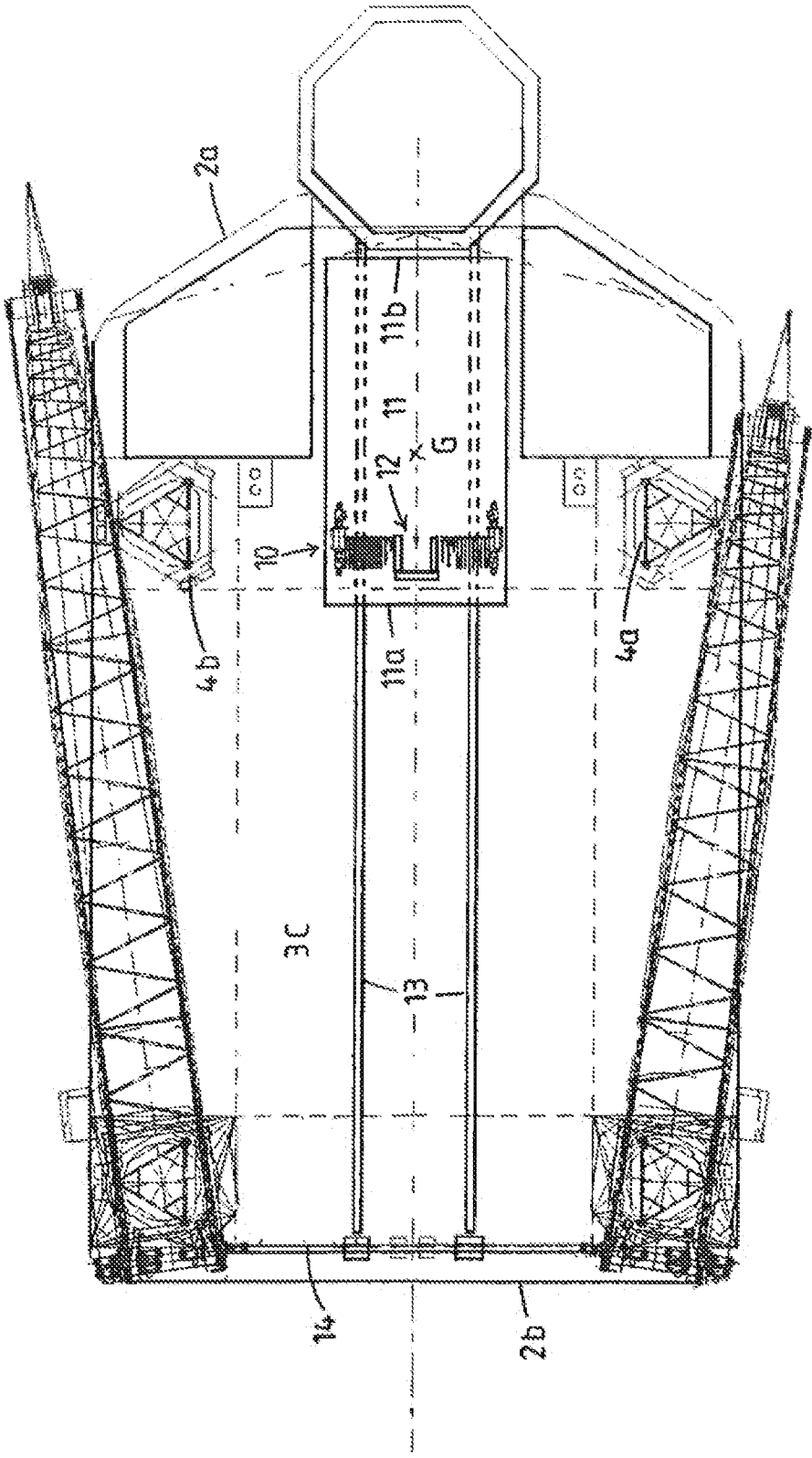


Fig.29

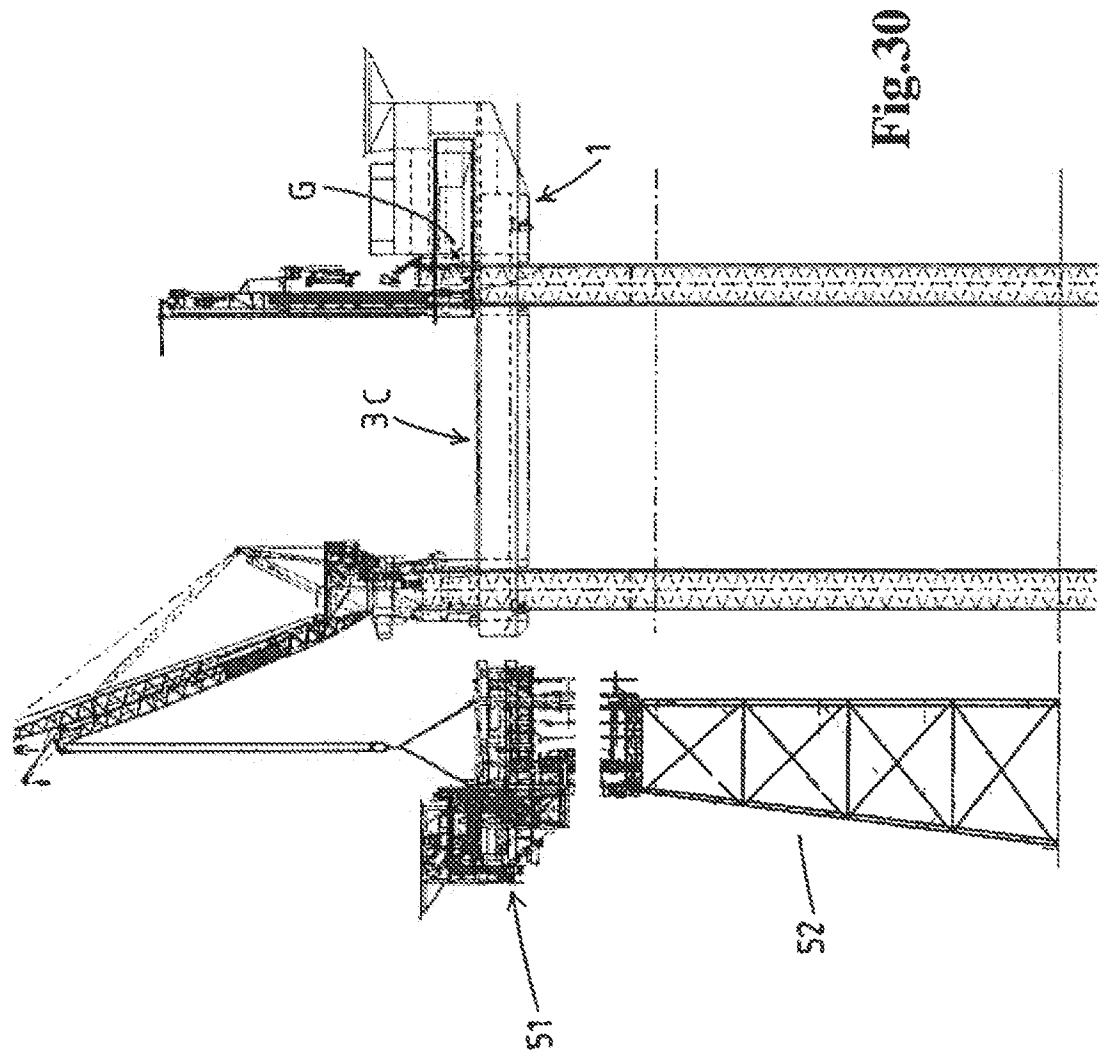


Fig.30

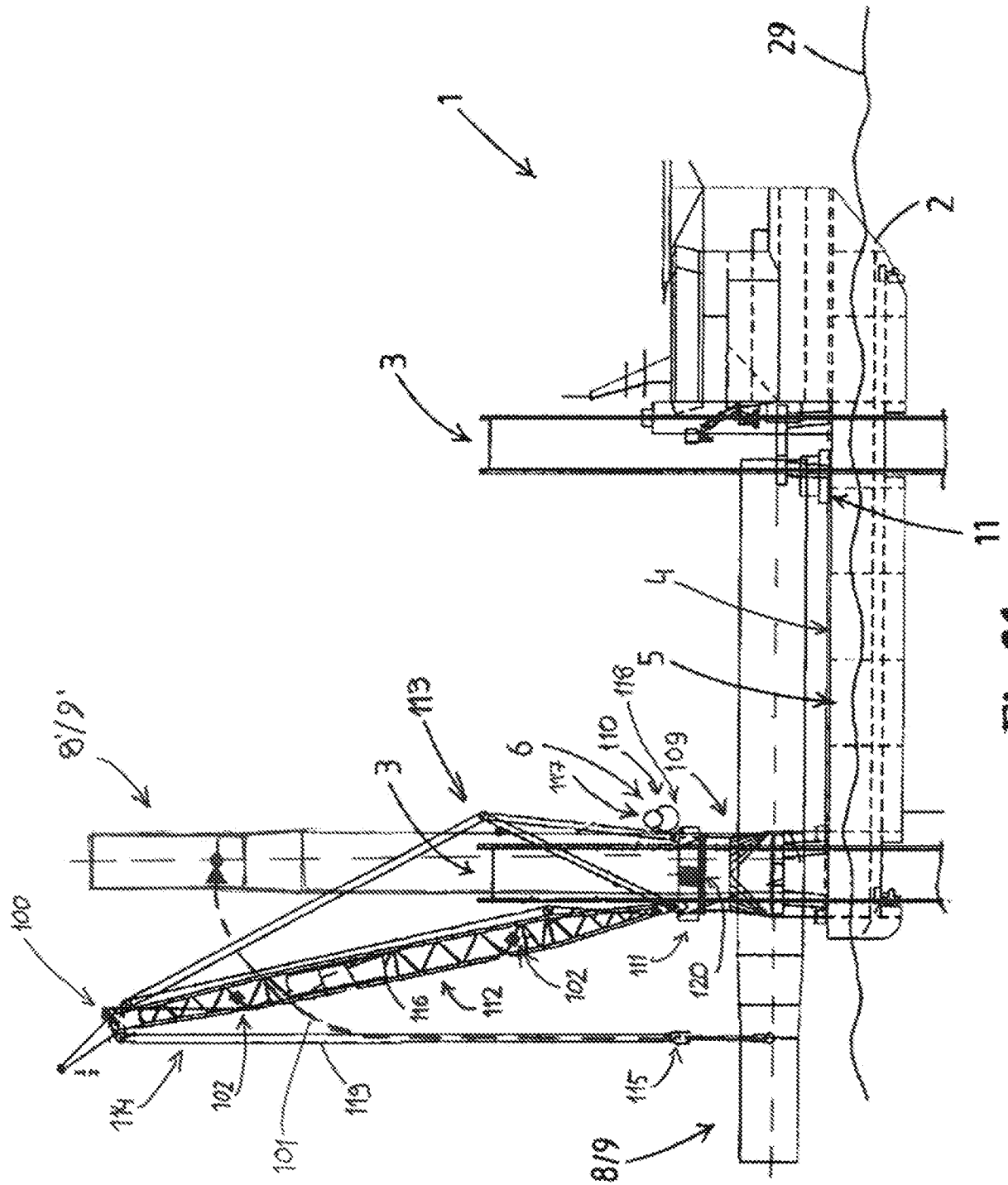


Fig.31