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(54) **Crane, vessel comprising such a crane, and a method for up-ending a longitudinal structure**

(57) The invention relates to a crane comprising:
- a base structure;
- a slew bearing;
- a crane housing mounted to the base structure via the slew bearing to be rotatable about a vertical slewing axis;
- a boom moveably mounted to the crane housing to be pivotable about a horizontal first pivot axis;
- three main hoisting systems; and
- a luffing system,

wherein the boom comprises an A-frame with two boom legs that are connected at one end to the crane housing and at the opposite end to each other via a hammerhead structure, wherein each main hoisting system comprises:
- a hoisting cable;
- a sheave block with one or more sheaves that are rotatable about a sheave rotation axis, which sheave block is arranged on the hammerhead structure of the boom;
- a hoisting block suspended from the sheave block by the hoisting cable; and
- a hoisting winch to lift and lower the hoisting block by hauling in or paying out the hoisting cable,

wherein the sheave block of each main hoisting system is pivotable about a horizontal second pivot axis that is perpendicular to the sheave rotation axis,

wherein the sheave blocks of the three main hoisting systems are arranged side-by-side, wherein the luffing system comprises:
- two luffing winches on the crane housing;
- two luffing cables extending between the respective two luffing winches on the crane housing and the boom,

and wherein the luffing cables are connected to respective outriggers of the hammerhead structure.

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Title: Crane, vessel comprising such a crane, and a method for up-ending a longitudinal structure

The invention relates to a crane, a vessel comprising such a crane, and a method for up-ending a longitudinal structure.

The invention in particular relates to the field of offshore wind turbine installation and/or maintenance. Current offshore wind turbines require a foundation, e.g. in the form of a monopile. The wind turbine is then installed on the monopile, either in one piece or in several pieces.

In order to make efficient use of wind energy, the trend is to increase the diameter of the rotor of the wind turbine. Wind turbine blades of 60 - 90m in length or even larger may be very common in the near future. However, this will also increase the size and weight of all other components including the foundation. It is envisaged that long and large diameter monopiles, e.g. weighing over 2000mt need to be installed. Practical monopiles have been proposed with lengths of about 100 metres.

Regardless of whether the wind turbine is installed on land or offshore, transporting the monopile to the installation site will mostly be done with the monopile in a substantially horizontal orientation. In order to drive the monopile into the earth, the monopile needs to be up-ended by a crane to be brought in the desired vertical orientation.

Many offshore wind turbine installation vessels are of the jack-up type, with extendible legs and with a crane for installation of the wind turbine. In a known design, the crane is an around-the-leg crane.

Prior art solutions for up-ending the monopile comprise methods in which a crane only lifts the upper end of the monopile and the lower end remains supported by the ground or on a deck of the vessel, e.g. by a tilting support frame. A drawback of this method is that control of the lower end is quite challenging, especially when the lower end needs to move relative to the ground or deck, e.g. for overboarding the monopile. Further, up-ending can usually only be done at a limited number of locations where there is enough space for up-ending the monopile with the crane.

Other prior art solutions for up-ending a monopile suggest to use two cranes, one for the upper end and the other one for the lower end of the monopile. However, this requires synchronized operation of the two cranes, where over time, the crane lifting the upper end needs to support more of the weight of the monopile than the crane lifting the lower end. Most wind turbine installation vessels lack two cranes capable of performing this operation and lack space to mount another crane on the vessel for this operation.

In a non-published patent application of the applicant, a solution is suggested in which a single crane using two separate main hoisting systems is used to respectively lift the upper end and lower end of the monopile for up-ending. However, a drawback thereof is that as up-ending progresses, the loads carried by the two main hoisting systems start to differ more and more (so-called asymmetric loading of the crane), which is likely to result in undesired torsion loads on the boom of the crane.

It is therefore an object of the invention to provide an improved method for up-ending longitudinal structures and to provide a crane and/or vessel suitable to carry out this improved method.

According to a first aspect of the invention, the object is achieved by a crane comprising:

- a base structure;
- a slew bearing;
- a crane housing moveably mounted to the base structure via the slew bearing to allow the crane housing to rotate relative to the base structure about a substantially vertical slewing axis;
- a boom moveably mounted to the crane housing to allow the boom to pivot relative to the crane housing about a substantially horizontal first pivot axis;
- three main hoisting systems; and
- a luffing system to set an angular orientation of the boom relative to the crane housing,

wherein the boom comprises an A-frame with two boom legs that are connected at one end to the crane housing and at the opposite end to each other via a hammerhead structure, wherein each main hoisting system comprises:

- a hoisting cable;
- a sheave block with one or more sheaves that are rotatable about a sheave rotation axis, which sheave block is arranged on the hammerhead structure of the boom;
- a hoisting block suspended from the sheave block by the hoisting cable; and

- a hoisting winch to lift and lower the hoisting block by hauling in or paying out the hoisting cable,

wherein the sheave block of each main hoisting system is pivotable about a substantially horizontal second pivot axis that is perpendicular to the sheave rotation axis of the one or more sheaves of the sheave block,

wherein the sheave blocks of the three main hoisting systems are arranged side-by-side,

wherein the luffing system comprises:

- two luffing winches on the crane housing;
- two luffing cables extending between the respective two luffing winches on the crane housing and the boom,

and wherein the luffing cables are connected to respective outriggers of the hammerhead structure that extend beyond the boom legs of the A-frame seen in plan view.

The main advantage of the crane according to the invention is that the crane is very suitable for asymmetric loads, such as for instance encountered during up-ending of a longitudinal structure. As will be explained later in more detail, two of the three main hoisting systems may be combined to increase the hoisting capacity required for the upper end of a longitudinal structure, e.g. a monopile, while the remaining hoisting system may be used to hold and lift the lower end. Further, the additional degree of freedom as provided to the sheave blocks allow the respective hoisting blocks to be moved sideways in order to be connected to a respective end of the longitudinal structure while keeping the one or more sheaves of the sheave block aligned with the respective hoisting cable and the one or more sheaves of the hoisting blocks. Last but not least, the A-frame construction of the boom provides torsional stiffness against an asymmetric load while at the same time the luffing cables are connected to the boom at a larger distance from the centre of the boom which aids in counteracting the asymmetric load on the boom. As a result thereof, this specific construction of the crane makes the crane very suitable for up-ending heavy longitudinal structures such as monopiles.

In an embodiment, the second pivot axis is parallel to the first pivot axis.

In an embodiment, the boom legs are truss structures. Preferably, the boom legs are further connected to each other in between the two ends of the boom legs, more preferably using truss structures.

In an embodiment, the hammerhead structure comprises a box structure, e.g. a box welded of steel plates forming the outside of the box with possible internal reinforcement members to strengthen the box structure.

In an embodiment, the boom comprises a jib extending from the hammerhead structure. Possibly, the jib is fixed, so non-moveable, to the hammerhead structure, e.g. as a rigid extension of the crane boom.

Preferably, the crane comprises one or more auxiliary hoisting systems having a hoisting cable, sheave block, hoisting block and hoisting winch similar to the main hoisting system, wherein the sheave block is mounted on the jib, e.g. a single such sheave block is arranged on the jib on the longitudinal axis of the boom.

In an embodiment, a centre plane of the A-frame of the boom is defined as the plane spanned by the first pivot axis and the longitudinal axis of the A-frame, wherein the middle sheave block of the three main hoisting systems is mounted at a larger distance from the centre plane than the two outer sheave blocks of the three main hoisting systems.

The invention according to the first aspect also relates to a vessel comprising a crane according to the invention. Such a vessel can be used for offshore wind turbine installation and maintenance, where the crane can be used to up-end a monopile on site.

In an embodiment, the vessel is a jack-up vessel comprising:

- a hull with at least three openings in the hull, said openings extending vertically through the hull to receive a respective leg;
- a leg per opening in the hull; and
- a leg driving device per leg allowing to move the corresponding leg relative to the hull in a vertical direction to allow the hull to be lifted out of a water body.

As a result, the vessel can be stabilized relative to the sea bottom during crane operations, enabling to handle heavy loads, also overboard.

In an embodiment, the base structure and the crane housing of the crane are arranged around an opening in the hull, so that the respective leg can extend through the base structure and crane housing. Such around-the-leg cranes make efficient use of the available deck space on the vessel, while at the same time the weight of the crane including load is efficiently transferred to the respective leg via the hull of the vessel.

The invention according to the first aspect further relates to a method for up-ending a longitudinal structure, e.g. a monopile for a wind turbine, wherein use is made of a crane according to the invention, said method comprising the following steps:

a) providing a longitudinal structure with an upper end and a lower end in a substantially horizontal orientation, e.g. on a deck of a vessel equipped with the crane;
b) connecting the middle hoisting block of the three main hoisting systems and one of the outer hoisting blocks of the three main hoisting systems to the upper end or end portion of the longitudinal structure;
c) connecting the other outer hoisting block of the three main hoisting systems to the lower end or end portion of the longitudinal structure; and
d) operating the respective winches of the three main hoisting systems until the longitudinal structure is in a substantially vertical orientation with the upper end above the lower end.

In an embodiment, connecting the other outer hoisting block of the three main hoisting systems to the lower end of the longitudinal structure comprises the following steps:

c1) providing a gripping element;

c2) providing the gripping element around the lower end or end portion of the longitudinal structure; and

c3) connecting the other outer hoisting block of the three main hoisting systems to the gripping element.

In an embodiment, after connecting the three main hoisting systems, the longitudinal structure is lifted first while remaining in the substantially horizontal orientation, and preferably moved to the installation site, e.g. involving slewing of the crane, before moving the longitudinal structure to the vertical orientation. For example, the longitudinal structure, e.g. monopile, is first moved beyond the hull of the vessel, so overboard, e.g. involving slewing of the crane, and only then moved into its vertical orientation.

In an embodiment, the longitudinal structure is provided such that in plan view a straight line between a centre of gravity of the longitudinal structure and the slewing axis of the crane is perpendicular to a longitudinal axis of the longitudinal structure.

According to a second aspect of the invention, there is provided a method for up-ending a longitudinal structure, e.g. a monopile, e.g. as a foundation of an offshore wind turbine, wherein use is made of a crane comprising:

- a base structure;

- a slew bearing;
- a crane housing moveably mounted to the base structure via the slew bearing to allow the crane housing to rotate relative to the base structure about a substantially vertical slewing axis;
- a boom moveably mounted to the crane housing to allow the boom to pivot relative to the crane housing about a substantially horizontal first pivot axis; and
- three main hoisting systems,

wherein the boom preferably comprises an A-frame with two boom legs that are connected at one end to the crane housing and at the opposite end to each other via a connection element,

wherein each main hoisting system comprises:

- a hoisting cable;
- a sheave block with one or more sheaves that are rotatable about a sheave rotation axis, which sheave block is arranged on the connection element of the boom;
- a hoisting block suspended from the sheave block by the hoisting cable; and
- a hoisting winch to lift and lower the hoisting block by hauling in or paying out the hoisting cable,

wherein the sheave block of each main hoisting system is pivotable about a substantially horizontal second pivot axis that is perpendicular to the sheave rotation axis of the one or more sheaves of the sheave block,

wherein the sheave blocks of the three main hoisting systems are arranged side-by-side, and wherein the method comprises the following steps:

a) providing a longitudinal structure with an upper end and a lower end in a substantially horizontal orientation;
b) connecting the middle hoisting block of the three main hoisting systems and one of the outer hoisting blocks of the three main hoisting systems to the upper end of the longitudinal structure;
c) connecting the other outer hoisting block of the three main hoisting systems to the lower end of the longitudinal structure; and
d) operating the respective winches of the three main hoisting systems until the longitudinal structure is in a substantially vertical orientation with the upper end above the lower end.

The invention according to the second aspect of the invention further relates to a crane comprising:

- a base structure;

- a slew bearing;
- a crane housing moveably mounted to the base structure via the slew bearing to allow the crane housing to rotate relative to the base structure about a substantially vertical slewing axis;
- a boom moveably mounted to the crane housing to allow the boom to pivot relative to the crane housing about a substantially horizontal first pivot axis; and
- three main hoisting systems,

wherein the boom preferably comprises an A-frame with two boom legs that are connected at one end to the crane housing and at the opposite end to each other via a connection element,

wherein each main hoisting system comprises:

- a hoisting cable;
- a sheave block with one or more sheaves that are rotatable about a sheave rotation axis, which sheave block is arranged on the connection element of the boom;
- a hoisting block suspended from the sheave block by the hoisting cable; and
- a hoisting winch to lift and lower the hoisting block by hauling in or paying out the hoisting cable,

wherein the sheave block of each main hoisting system is pivotable about a substantially horizontal second pivot axis that is perpendicular to the sheave rotation axis of the one or more sheaves of the sheave block,

and wherein the sheave blocks of the three main hoisting systems are arranged side-by-side.

The crane and method according to the second aspect of the invention may be combined with features from the first aspect of the invention where appropriate. For example, the boom is provided with outriggers laterally from both sides of the boom (seen in plan view), each outrigger connected to a luffing cable, e.g. supporting a luffing cable sheave assembly in case of a multiple fall luffing cable arrangement. The boom may be embodied as an A-frame, but other embodiments are envisaged in this second aspect of the invention as well.

It will be appreciated that the crane according to the second aspect may be mounted on a vessel, e.g. as discussed with reference to the first aspect of the invention. The second aspect also relates to such a vessel and also to the use thereof for installation of a wind turbine an/or a wind turbine foundation, e.g. a monopile.

The invention will now be described in more detail 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 of a vessel according to an embodiment of the invention;
Fig. 2 depicts a rear view of the vessel of Fig. 1;
Fig. 3 depicts a top view of the vessel of Fig. 1;
Fig. 4 depicts in more detail an end of the boom of the crane on the vessel of Fig. 1;
Fig. 5 depicts in more detail the hammerhead structure on the boom of the crane of the vessel of Fig.1;
Fig. 6A+6B depict respectively a side view and a front view of a first configuration of the three main hoisting systems of the crane of the vessel of Fig. 1;
Fig. 7A+7B depict respectively a side view and a front view of a second configuration of the three main hoisting systems of the crane of the vessel of Fig. 1;
Fig. 8A+8B depict respectively a side view and a front view of a third configuration of the three main hoisting systems of the crane of the vessel of Fig. 1;
Fig. 9 depicts the rear side of the vessel of Fig. 1 in plan view;
Fig. 10 depicts a rear view of the vessel of Fig. 1;
Fig. 11 depicts a step in the method for up-ending a monopile;
Fig. 12 depicts a further step in the method for up-ending a monopile;
Fig. 13 depicts yet a further step in the method for up-ending a monopile;
Fig. 14 depicts a preparatory step for driving a monopile into a sea bottom with the vessel of Fig. 1;
Fig. 15 depicts the vessel of Fig. 1 during installation of a tower on a monopile foundation;
Fig. 16 depicts the vessel of Fig. 1 during installation of a nacelle on the tower of Fig. 15 after installation of said tower;
Fig. 17A depicts the vessel of Fig. 1 during installation of a platform on another type of foundation; and
Fig. 17B depicts an example of connecting the three main hoisting systems.

Figs. 1 to 3 depict a vessel 1 according to an embodiment of the invention. Fig. 1 is a side view of the vessel 1, Fig. 2 is a rear view of the vessel 1, and Fig. 3 is a top view of the vessel 1.

The vessel 1 comprises a hull 2 with four openings 2A, 2B, 2C, 2D in the hull 2, wherein the openings extend vertically through the hull 2 to receive a respective leg 3A, 3B, 3C, 3D.

Each leg 3A, 3B, 3C, 3D is provided with a leg driving device 4A, 4B, 4C, 4D allowing to move the corresponding leg 3A, 3B, 3C, 3D up and down relative to the hull 2 in a vertical direction to allow the hull 2 to be lifted out of a water body 5 as shown in Figs. 1 and 2. Hence, the vessel 1 is a jack-up vessel. The height of the legs 3A, 3B, 3C, 3D relative to the hull 2 when the legs are retracted for sailing with the vessel is indicated by dashed lines above the respective legs.

Provided on the vessel 1 is a crane 10. The crane 10 comprises a base structure 11 mounted to the hull 2, a slew bearing 12 and a crane housing 13 moveably mounted to the base structure 11 via the slew bearing 12 to allow the crane housing 13 to slew relative to the base structure 11 about a substantially vertical slewing axis 14.

The crane 10 further comprises a boom 15. The boom 15 is moveably mounted to the crane housing 13 to allow the boom 15 to pivot relative to the crane housing 13 about a substantially horizontal first pivot axis 16. In Fig. 1, the boom is depicted at two distinct angular orientations, a lower orientation in which the boom 15 is supported by the vessel at a distance from the horizontal first pivot axis 16, and an upright orientation in which the boom 15 is almost vertical.

The boom 15 comprises an A-frame with two boom legs 15A, 15B that are connected at one end to the crane housing, thereby defining the first pivot axis 16, and are connected at the opposite end to each other via a hammerhead structure 17. In between the two ends, the boom legs are connected by intermediate connection members 15D to increase the stiffness of the A-frame.

The boom legs in this embodiment are truss structures as are the intermediate members 15D. The hammerhead structure 17 may have a box structure. The box structure of the hammerhead structure may make it easier to mount components thereto while at the same time a torsion stiff structure is formed. The truss structures of the boom legs have the advantage that they provided a good stiffness to weight ratio.

The crane further comprises a luffing system to set an angular orientation of the boom 15 relative to the crane housing 13. The luffing system comprises two luffing winches 20, 21 on the crane housing 13, and two respective luffing cables 22, 23 extending between the two luffing winches 20,21 on the crane housing 13 and the boom 15. One combination of luffing winch 20 and luffing cable 22 is arranged on one side of the crane 10, while the other

combination of luffing winch 21 and luffing cable 23 is arranged on the opposite side of the crane 10 thereby passing the leg 3C on both sides.

In this embodiment, the distance between the boom legs 15A, 15B of the A-frame at the legs 3B and 3C is not large enough to position the A-frame over the legs for storage or transport reasons. Hence, therefore the boom is supported from the hull 2 in between the two legs 3B, 3C as shown in Figs. 1 and 3. However, it is also possible to position the boom on the opposite side of leg 3C as shown partially in Fig. 3, which has the advantage that more deck space is available for storage of other components.

The hammerhead structure 17 at the end of the A-frame and nearby components of the boom 15 are depicted in more detail in Figs. 4 and 5.

In Fig. 4, the boom legs 15A, 15B of the A-frame are depicted and it can be clearly seen that the boom legs are connected to each other via the hammerhead structure 17. The hammerhead structure 17 comprises outriggers 17A, 17B extending beyond the boom legs 15A, 15B of the A-frame seen in plan view. Each outrigger 17A, 17B comprises a respective sheave block 24, 25 to which the respective luffing cables 22 and 23 are connected, thereby allowing to set the angular orientation of the boom relative to the crane housing by paying out or hauling in the luffing cables 22, 23 with the luffing winches 20,21. The sheave blocks 24, 25 are also schematically depicted in Fig. 5.

The crane 10 further comprises three main hoisting systems. Components of the three main hoisting systems will be indicated using a similar reference numeral followed by a .X, where X will be 1, 2 or 3 to indicate one of the three main hoisting systems.

Each main hoisting system comprises a hoisting cable 30.1, 30.2, 30.3, a sheave block 31.1, 31.2, 31.3, and a hoisting block 32.1, 32.2, 32.3. Each sheave block 31.1, 31.2, 31.3 comprises in this embodiment a plurality of sheaves that are rotatable about a respective sheave rotation axis 33.1, 33.2, 33.3. The sheave blocks 31.1, 31.2, 31.3 are arranged on the hammerhead structure, in this embodiment within the contour of the A-frame, i.e. not arranged on the outriggers 17A, 17B, in a side-by-side configuration, in this case in a row seen in plan view.

The rotation axes 33.1, 33.2, 33.3 of the sheaves of the sheave blocks provide one degree of freedom for the hoisting cable, which degree of freedom is normally used in combination with gravity to keep the hoisting block below the corresponding sheave block independent of

the angular orientation of the boom relative to the crane housing. In this embodiment, this degree of freedom is used to allow a sideways movement of the hoisting blocks as is for instance shown in Fig. 5 for the outer hoisting blocks. In Fig. 5, the outer hoisting blocks are moved sideways by an angle α, which can be easily be 40 degrees.

In order to keep the hoisting blocks 32.1, 32.2, 32.3 below the sheave blocks 31.1, 31.2, 31.3 independent of the angular orientation of the boom 15, each sheave block 31.1, 31.2, 31.3 is pivotable about a substantially horizontal second pivot axis 34.1, 34.2, 34.3 perpendicular to the sheave rotation axis 33.1, 33.2, 33.3 of the corresponding sheaves of the sheave block 31.1, 31.2, 31.3.

The three main hoisting systems each further comprise a hoisting winch 35.1, 35.2, 35.3 (see Fig. 1) to lift and lower the hoisting block 32.1, 32.2, 32.3 by hauling in or paying out the hoisting cable 30.1, 30.2, 30.3.

The boom 15 of the crane 10 further comprises a jib 15C extending from the A-frame, i.e. extending from the hammerhead structure 17 carrying, in this embodiment, two auxiliary hoisting systems, which are similar to a main hoisting system except that the loading capacity is usually smaller and that the additional degree of freedom for the sheave blocks is not provided. In Fig. 4, a sheave block 36 associated with a first auxiliary hoisting system and a sheave block 37 associated with a second auxiliary hoisting system are depicted.

An advantage of the crane 10 according to the invention is that the three main hoisting systems can be used in various ways depending on the hoisting demand. A first example is depicted in Figs. 6A and 6B, in which Fig. 6A is a side view of Fig. 6B. In this example, only the outer hoisting blocks 32.1, 32.3 are used. The outer hoisting blocks are pivoted sideways about respective axes 33.1, 33.3 allowing to be connected to a longitudinal structure with a relatively large distance between the hoisting block. This hoisting configuration is especially suitable in case the hoisting blocks are lifted and lowered simultaneously and thus carry a load in the same order of magnitude. The two outer hoisting systems allow to control movement of the hoisted objects in two degrees of freedom.

A second example is depicted in Figs. 7A and 7B, in which Fig. 7A is a side view of Fig. 7B. In this example, all hoisting blocks are used. The outer hoisting blocks 32.1, 32.3 are spread similar to the example of Figs. 6A and 6B, but the hoisting blocks are also pivoted about respective second pivot axes 34.1 and 34.2. The middle hoisting block 32.3 is kept straight seen in the view of Fig. 7B, but is also pivoted about second pivot axis 34.2, albeit in an

opposite direction as the outer hoisting blocks 32.1 and 32.3. As a result thereof, the three main hoisting systems can be connected to three distinct locations of an object, which three locations form a triangle seen in plan view. This hoisting configuration is especially suitable in case the hoisting blocks are lifted and lowered simultaneously and thus carry a load in the same order of magnitude. The configuration further allows to control movement of the hoisted object in three degrees of freedom.

A third example is depicted in Figs. 8A and 8B, in which Fig. 8A is a side view of Fig. 8B. In this example, all hoisting blocks are used, but one of the outer hoisting blocks, in this case outer hoisting block 32.1 is combined with the middle hoisting block 32.2 to hoist one end of an object and the other outer hoisting block, in this case outer hoisting block 32.3, is used to hoist another end of an object. This configuration is especially suitable for situations in which during hoisting the load is or becomes asymmetrical, e.g. during up-ending of longitudinal structures.

It is noted with respect to the example of Figs. 8A and 8B that the sheave block 31.2 associated with the middle hoisting block 32.2 is arranged somewhat lower than the other sheave blocks 31.1 and 31.3. In other words, a centre plane 15F of the A-frame can be defined as the plane spanned by the first pivot axis 16 and the longitudinal axis 15G of the A-frame, wherein the middle sheave block 31.2 is mounted at a larger distance from the centre plane 15F than the other two outer sheave blocks 31.1 and 31.3. The advantage of this arrangement is that for large angles α, in this embodiment an angle of 40 degrees, the hoisting cables 30.1 and 30.2 are not too close to each other (do not touch or interfere with each other) and in this case are parallel to each other.

With reference to Figs. 9-13, a method according to the invention will be described in which a monopile is up-ended by the crane 10 on the vessel 1 of Fig. 1. Figs. 9 and 10 depict the rear side of the vessel 1 with the hull 2 and legs 3A and 3D and crane 10 arranged around leg 3D.

On a deck 2E of the hull 2 of the vessel, a stack of monopiles 50 are provided in a substantially horizontal orientation. As shown in Fig. 9, the monopiles 50 may even extend beyond the rear side of the hull 2. Alternatively, the monopiles may be provided using a separate vessel, e.g. a barge.

In Fig. 9, the boom 15 of the crane 10 is positioned for hoisting the nearest monopile 50, i.e. the monopile 50 nearest to leg 3D, and in Fig. 10, the boom 15 of the crane 10 is positioned

for hoisting the monopile 50 nearest to leg 3A. Both monopiles 50 have been positioned relative to the crane 10, such that in plan view (see Fig. 9) a straight line between a centre of gravity 50C of the longitudinal structure and the slewing axis 14 of the crane 10 is perpendicular to a longitudinal axis 50D of the longitudinal structure 50.

Fig. 11 depicts a monopile 50 that is suspended by the three main hoisting systems of the crane 10 (which is further omitted for clarity reasons) using the configuration of Figs. 8A and 8B. Hence, the middle hoisting block 32.2 of the three main hoisting systems and one of the outer hoisting blocks 32.1 are connected to an upper end 50A of the monopile 50 via connection element 51.

The other outer hoisting block 32.3 is connected to a lower end 50B of the monopile 50 using a gripping element 52 that is provided around the lower end 50B of the monopile 50.

By synchronized hauling in of the hoisting cables 30.1, 30.2, possibly in combination with the paying out of hoisting cable 30.3, the monopile 50 is up-ended. Fig. 12 depicts the monopile 50 in an oblique orientation halfway the up-ending process, and Fig. 13 depicts the monopile 50 after up-ending. In Fig. 13 it can be clearly seen that when the hoisting blocks 32.1, 32.2 are connected to a centre of the monopile and the hoisting block 32.3 is connected to the gripping element on the side of the monopile, the hoisting cables 30.1, 30.2, 30.3 are nearly parallel to each other.

After up-ending, the gripping element 52 and thereby the outer hoisting block 32.3 are disengaged for driving the monopile into a sea bottom 55. While lowering the monopile 50 towards the sea bottom 55, the monopile 50 may be guided by a guide 60 extending from the hull 2 as shown in Fig. 14. The weight of the monopile itself will cause the monopile to be partially driven into the sea bottom. The monopile can then be disconnected from the hoisting systems and a separate device for driving the monopile further into the sea bottom may be provided.

Fig. 15 depicts the use of the crane 10 to install a tower 70 on top of the previously installed monopile 50. The tower may have a lower weight than the monopile, so that in case of up-ending the tower, if applicable, the crane may use the hoist configuration of Figs. 6A and 6B. In case the tower is too heavy, the hoist configuration of Figs. 8A and 8B can be used.

Fig. 16 depicts the use of the crane 10 to install a nacelle 80 on top of the previously installed tower 70. In this embodiment, the nacelle is such a light weight component that the nacelle can be hoisted by the first auxiliary hoisting system.

Fig. 17A depicts the use of the crane 10 to install a platform 100 on top of a previously installed other foundation 90 in the form of a truss construction. In this embodiment, platform 100 has a weight requiring all three hoisting systems to use the combined hoisting capacity.

However, when connecting all three hoisting blocks 32.1, 32.2, 32.3 directly to the platform or indirectly via single connection element whereto the three hoisting blocks are directly connected to, it is not possible to use the full potentially available hoisting capacity.

Hence, for these cases, two of the hoisting blocks, in this embodiment hoisting blocks 32.1 and 32.3 are connected to a first intermediate member 110, see Fig. 17B. The first intermediate member 110 and the other remaining hoisting block 32.3 are connected to a second intermediate member 120. Connected to the second intermediate member 120 is a load connector 130 to be connected to the platform 100. The connections between the hoisting blocks and intermediate members and the connection between the first and second intermediate members are such that the load of the platform 100 is substantially evenly distributed over the three hoisting systems, e.g. by providing sheave and cable connections between the various components.

It is noted here that although the examples and embodiments described disclose the use of a specific number of winches, cables and sheaves, it is apparent to the skilled person that additional components may be provided. Hence, it is very common to use two winches for one hoisting or luffing cable or to provide additional combinations of winch and cable. In other words, any specific number provided in the description should be construed as meaning at least that specific number. The same holds for the number of main hoisting systems. Although three main hoisting systems have been described, a fourth and even a fifth main hoisting system may be provided and falls within the scope of the invention.

C O N C L U S I E S

1. Een kraan omvattende:
   - een basisconstructie;
   - een zwenklager;
   - een kraanhuis dat beweegbaar gemonteerd is op de basisconstructie via het zwenklager om het kraanhuis te laten roteren ten opzichte van de basisconstructie om een in hoofdzaak verticale zwenkas;
   - een kraanarm beweegbaar bevestigd aan het kraanhuis om de kraanarm te laten draaien ten opzichte van het kraanhuis om een in hoofdzaak horizontale eerste draaias;
   - drie hoofdhijssystemen; en
   - een luffing systeem om een hoekoriëntatie van de kraanarm in te stellen ten opzichte van het kraanhuis,

   waarbij de kraanarm een A-frame omvat met twee poten die aan een uiteinde verbonden zijn met het kraanhuis en aan het andere uiteinde met elkaar verbonden zijn via een hamerkopstructuur,
   waarbij elk hoofdhijssysteem omvat:
   - een hijskabel;
   - een schijvenblok met een of meer schijven die geroteerd worden om een schijfrotatieas, waarbij het schijvenblok is aangebracht op de hamerkopstructuur van de kraanarm;
   - een hijsblok gehangen aan het schijvenblok middels de hijskabel; en
   - een hijslier om het hijsblok op te tillen en te laten zakken door het binnen halen of vieren van de hijskabel,

   waarbij het schijvenblok van elk hoofdhijssysteem draaibaar is om een in hoofdzaak horizontale tweede draaias die loodrecht staat op de schijfrotatieas van de een of meerdere schijven van het schijvenblok,
   waarbij de schijvenblokken van de drie hoofdhijssystemen zij aan zij zijn geplaatst,
   waarbij het luffing systeem omvat:
   - twee luffing lieren op het kraanhuis;
   - twee luffing kabels die zich uitstrekken tussen de twee respectieve luffing lieren op het kraanhuis en de kraanarm,

   en waarbij de luffing kabels zijn verbonden met respectieve uitsteeksels van de hamerkopstructuur die zich voorbij de poten van het A-frame uitstrekken gezien in bovenaanzicht.

2. Een kraan volgens conclusie 1, waarbij de tweede draaias parallel is aan de eerste draaias.
3. Een kraan volgens conclusie 1 of 2, waarbij de poten vakwerken of vakwerkconstructies zijn, waarbij bij voorkeur de poten eveneens verbonden zijn met elkaar tussen de twee uiteinden van de poten in.
4. Een kraan volgens een van de voorgaande conclusies, waarbij de kraanarm een giek omvat die zich uitstrekt vanaf de hamerkopstructuur, waarbij bij voorkeur de kraan een of meerdere aanvullende hijssystemen omvat met een hijskabel, schijvenblok, hijsblok en hijslier, waarbij bij voorkeur het schijvenblok van de een of meerdere aanvullende hijssystemen is aangebracht op de giek.
5. Een kraan volgens een van de voorgaande conclusies, waarbij een middenvlak van het A-frame is gedefinieerd als het vlak opgespannen door de eerste draaias en een lengteas van het A-frame, waarbij een middelste schijvenblok van de drie hoofdhijssystemen is gemonteerd op een grotere afstand van het middenvlak dan de twee buitenste schijvenblokken van de drie hoofdhijssystemen.
6. Een vaartuig omvattende een kraan volgens een van de voorgaande conclusies.
7. Een vaartuig volgens conclusie 6, waarbij het vaartuig een jack-up vaartuig is, omvattende:
   - een romp met ten minste drie openingen in de romp, waarbij genoemde openingen zich verticaal uitstrekken door de romp om een betreffende poot te ontvangen;
   - een poot per opening in de romp; en
   - een poot aandrijfinrichting per poot om de overeenkomstige poot te kunnen bewegen ten opzichte van de romp in een verticale richting om te romp uit het water te kunnen tillen.
8. Een vaartuig volgens conclusie 7, waarbij de basisconstructie en het kraanhuis van de kraan zijn aangebracht rond een opening in de romp zodat de respectieve poot zich kan uitstrekken door de basisconstructie en het kraanhuis heen.
9. Een werkwijze voor het rechtop zetten van een lange structuur, waarbij gebruik wordt gemaakt van een kraan volgens een van de conclusies 1 t/m 5, waarbij de werkwijze de volgende stappen omvat:
   a. het verschaffen van een lange structuur met een bovenste uiteinde en een onderste uiteinde in een in hoofdzaak horizontale oriëntatie;
   b. het verbinden van het middelste hijsblok van de drie hoofdhijssystemen en een van de buitenste hijsblokken van de drie hoofdhijssystemen met het bovenste uiteinde of einddeel van de lange structuur;
   c. het verbinden van het andere buitenste hijsblok van de drie hoofdhijssystemen met het onderste uiteinde of einddeel van de lange structuur; en

d. het bedienen van de respectieve lieren van de drie hoofdhijssystemen totdat de lange structuur een in hoofdzaak verticale oriëntatie heeft met het bovenste uiteinde boven het onderste uiteinde.

10. Een werkwijze volgens conclusie 9, waarbij stap c de volgende stappen omvat:

c1) het verschaffen van een grijpelement;

c2) het verschaffen van een grijpelement rond het onderste uiteinde of einddeel van de lange structuur; en

c3) het verbinden van het andere buitenste hijsblok van de drie hoofdhijssystemen met het grijpelement.

11. Een werkwijze volgens conclusie 9 of 10, waarbij de lange structuur is verschaft zodanig dat in bovenaanzicht een rechte lijn tussen een zwaartepunt van de lange structuur en de zwenkas van de kraan loodrecht staat op een lengteas van de lange structuur.

Fig. 1

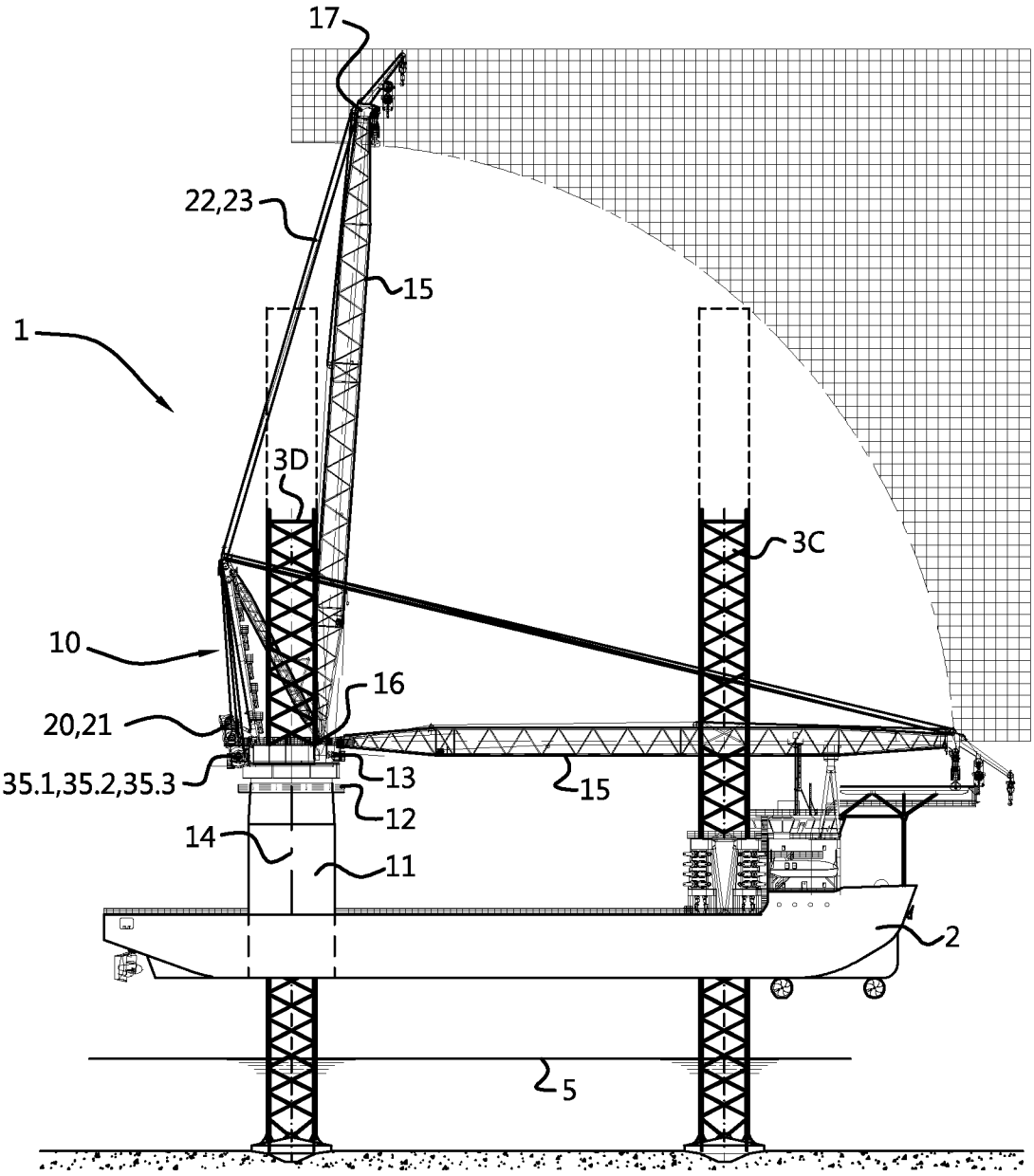


Fig. 2

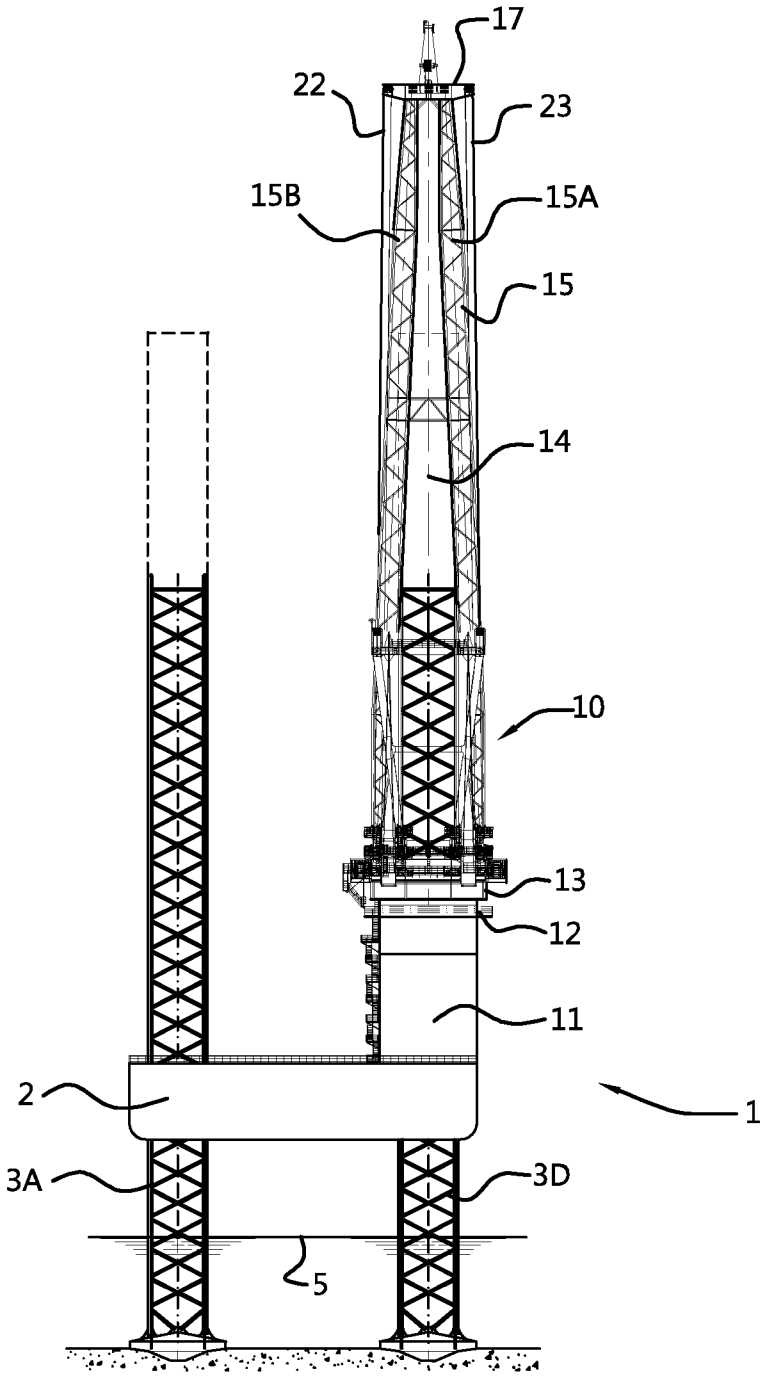


Fig. 3

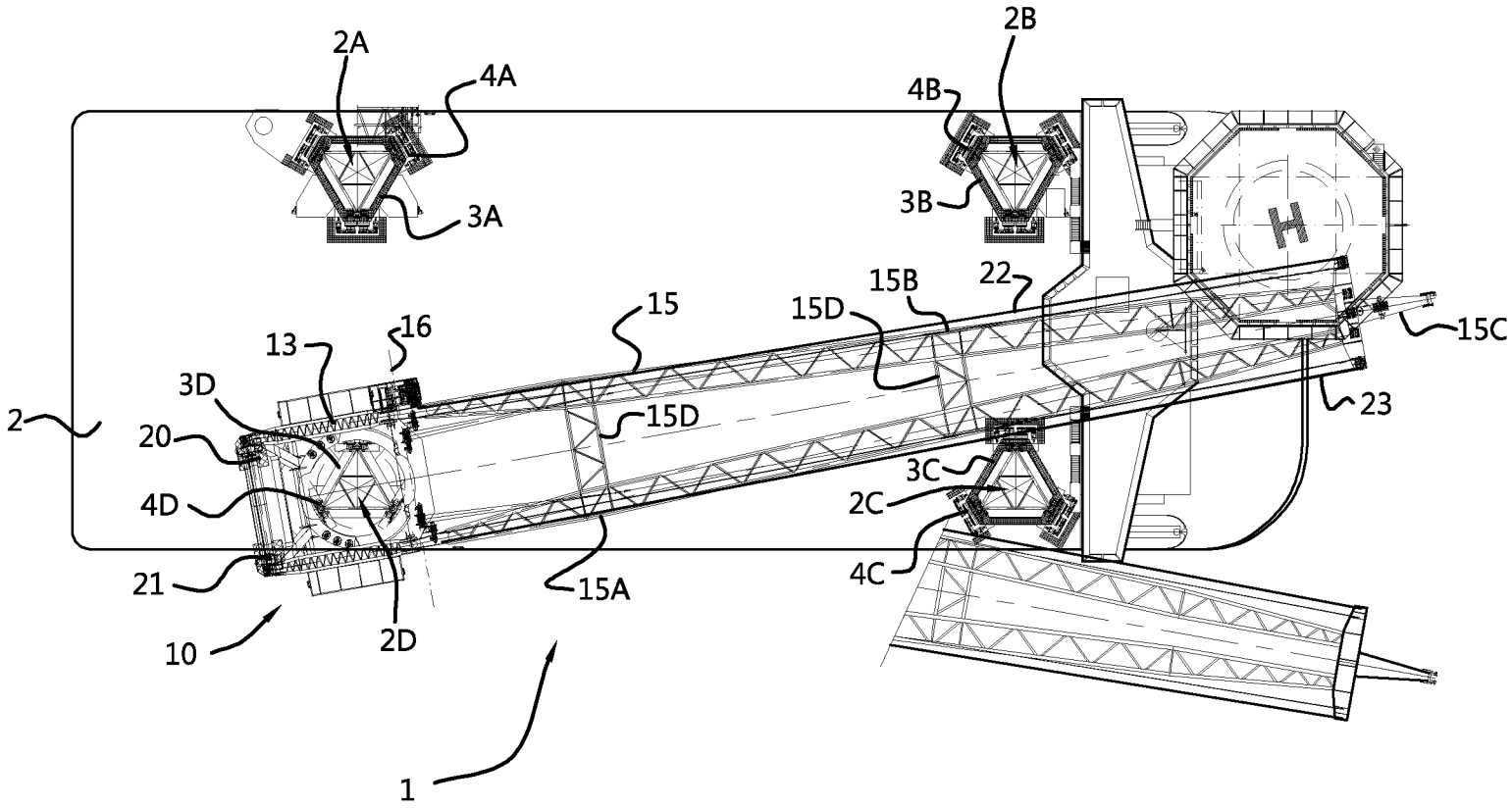

2A
4A
3A
2B
4B
3B
H
22
15B
15D
15C
15
16
13
3D
20
4D
21
10
2D
15D
23
3C
2C
4C
15A
2
1

Fig. 4

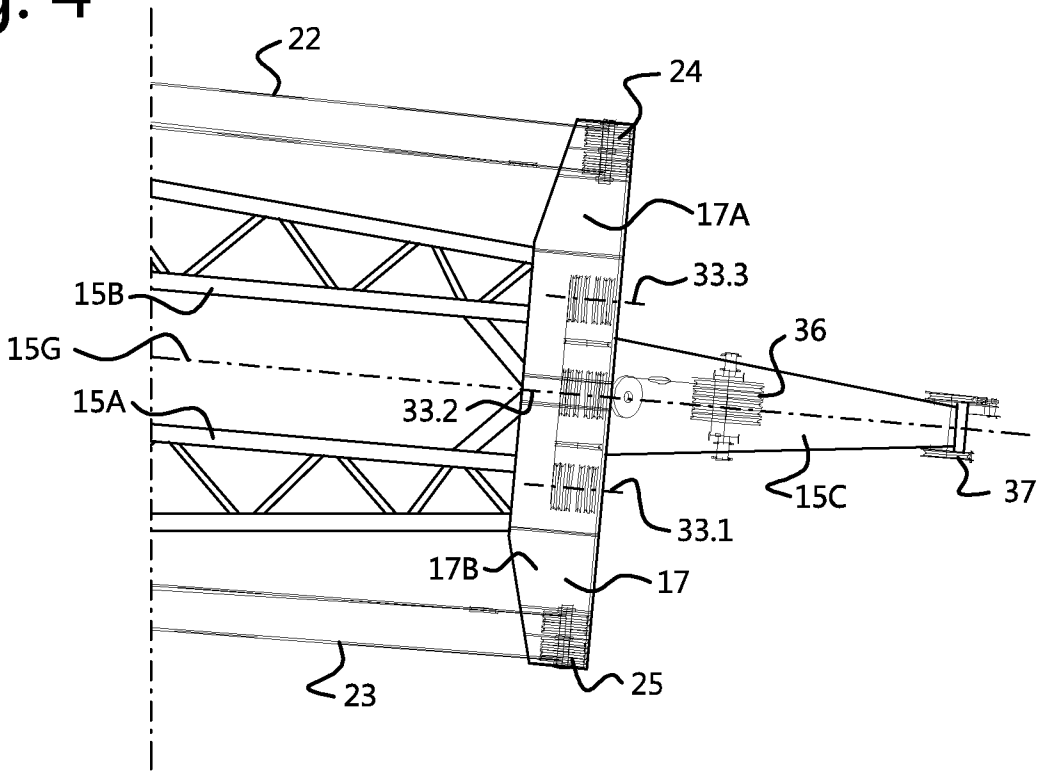

22
24
17A
33.3
15B
36
15G
15A
33.2
15C
37
33.1
17B
17
23
25

Fig. 5

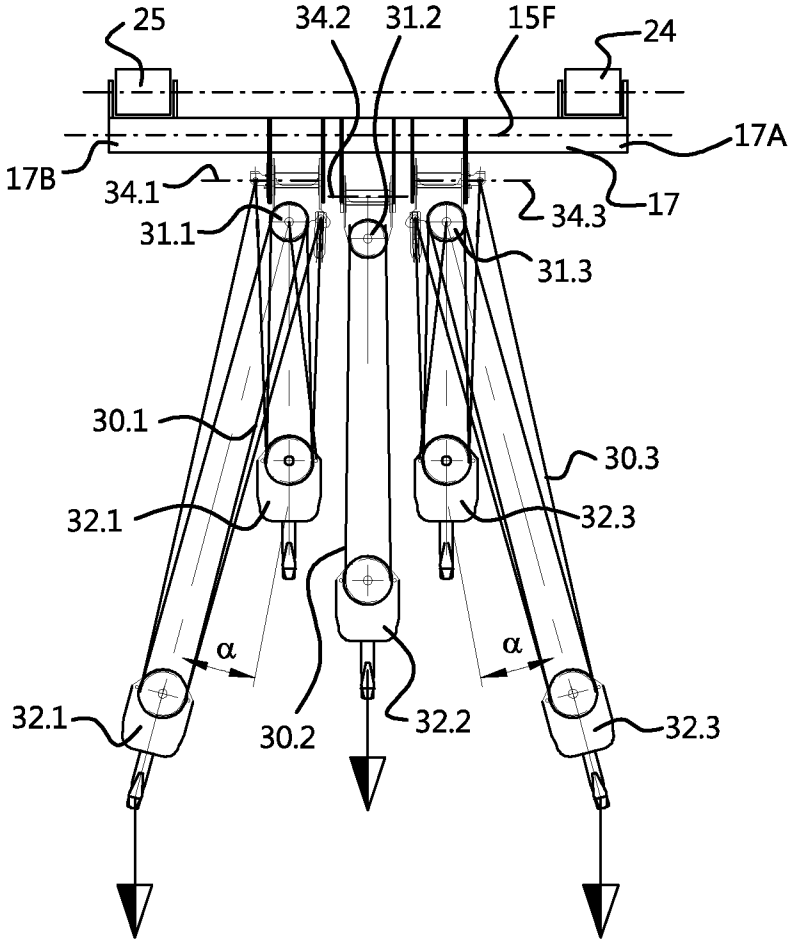

25
34.2
31.2
15F
24
17A
17B
34.1
34.3
17
31.1
31.3
30.1
30.3
32.1
32.3
α
α
32.1
30.2
32.2
32.3

Fig. 6A

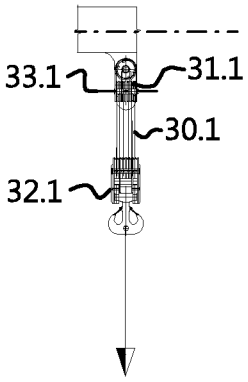


Fig. 6B

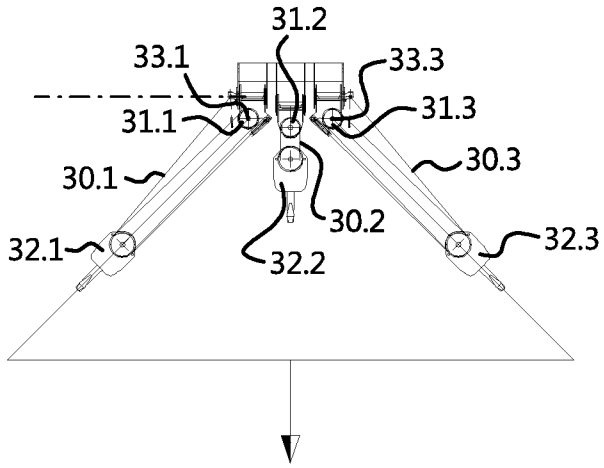


Fig. 7A

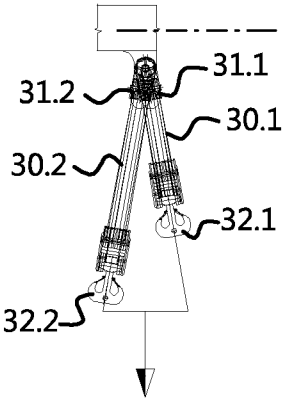


Fig. 7B

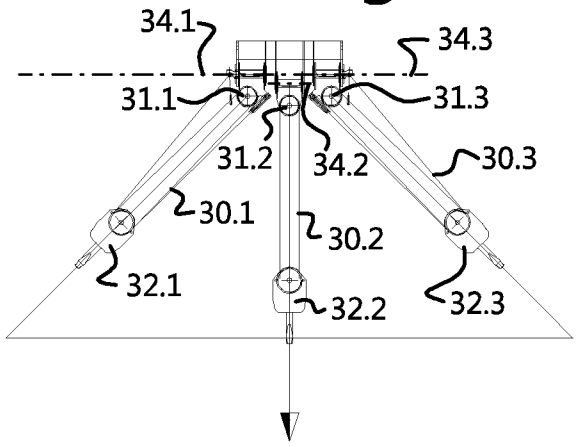


Fig. 8A

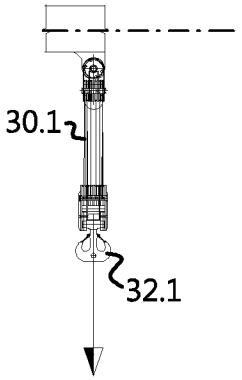


Fig. 8B

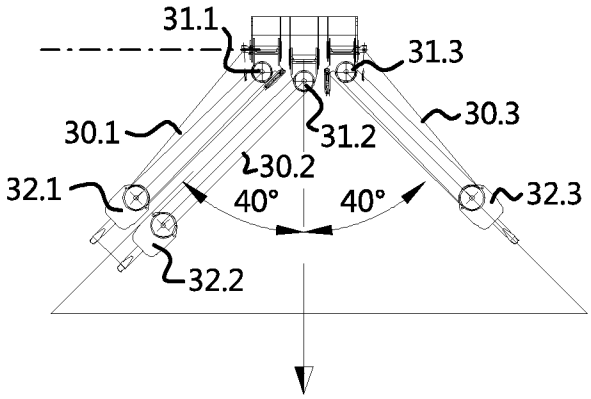


Fig. 9

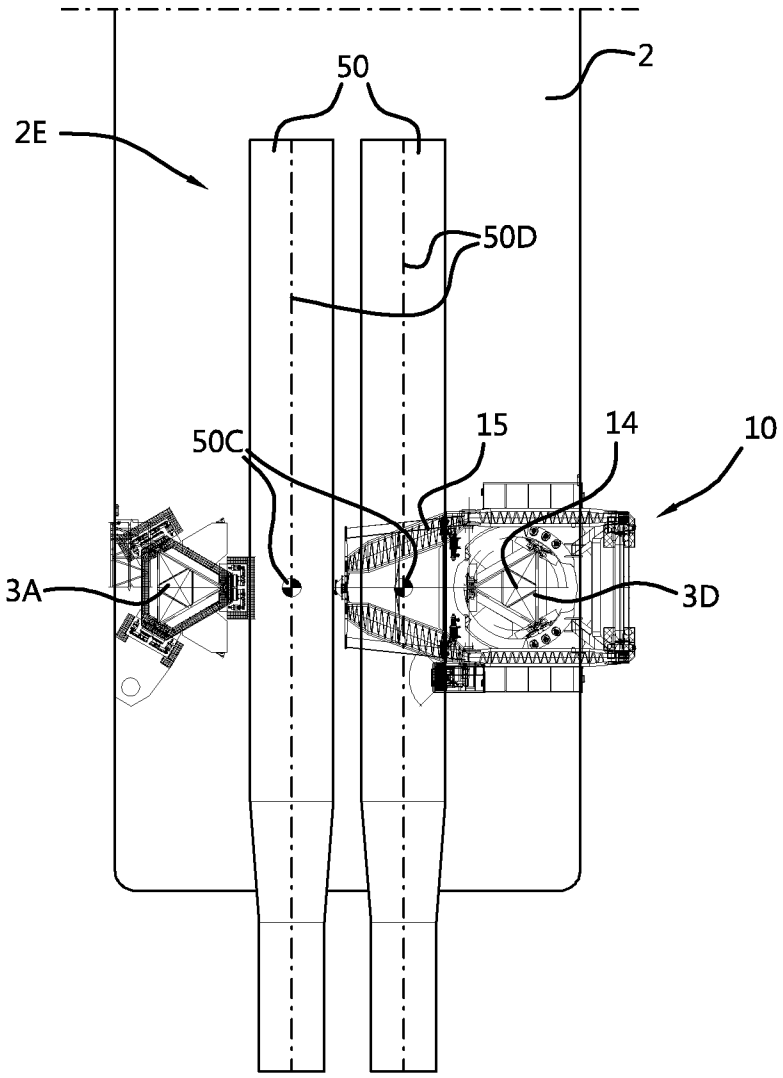


Fig. 10

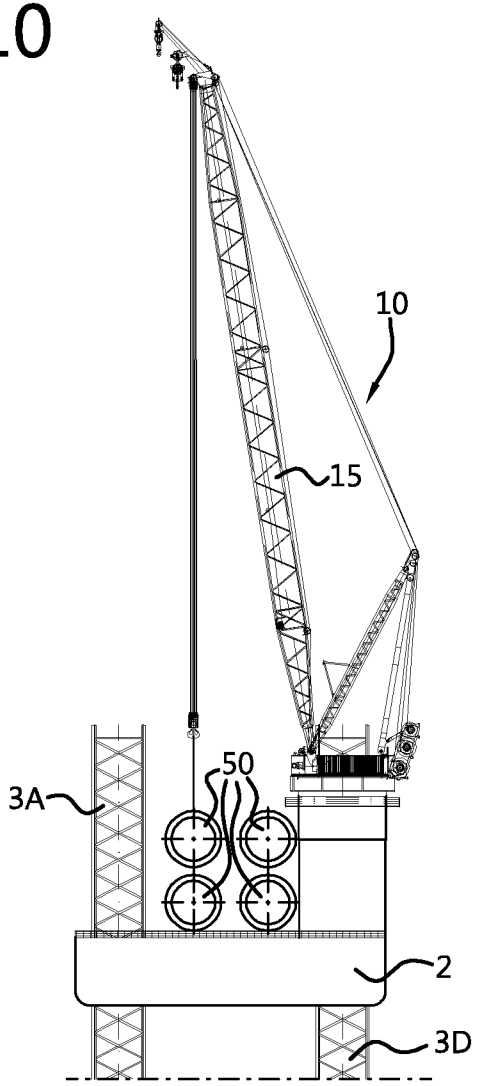


Fig. 11

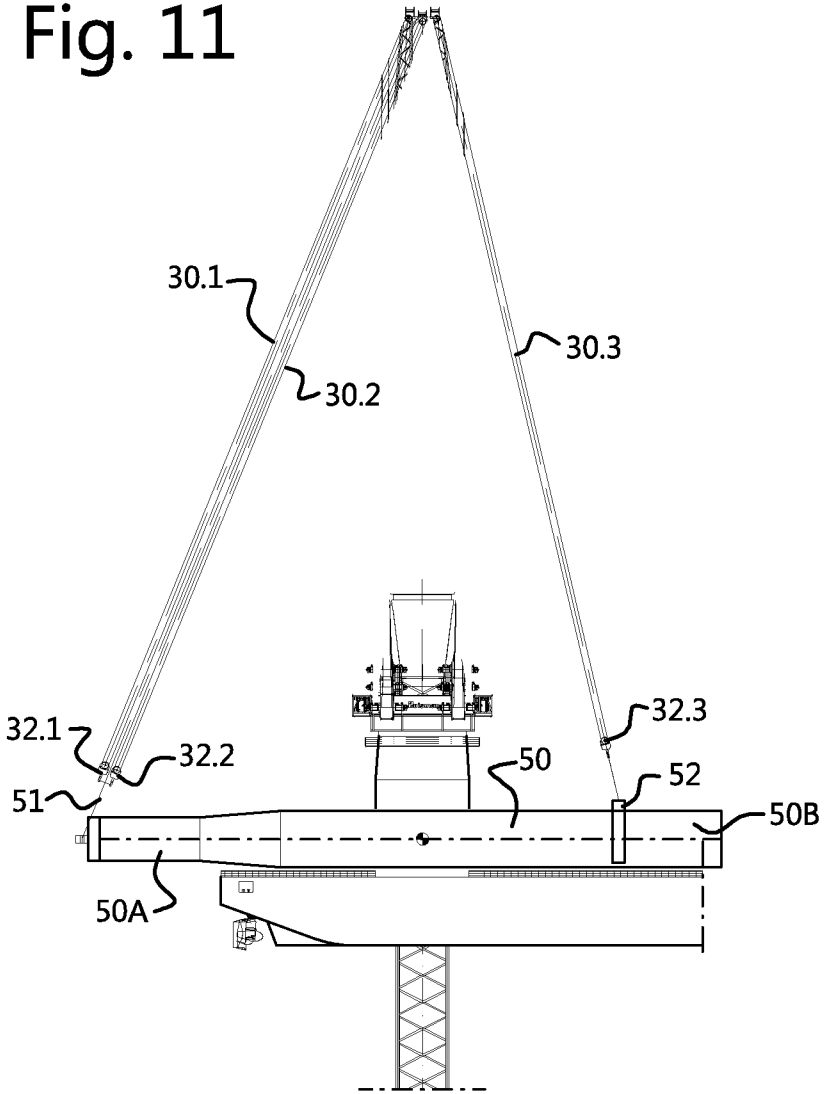


Fig. 12

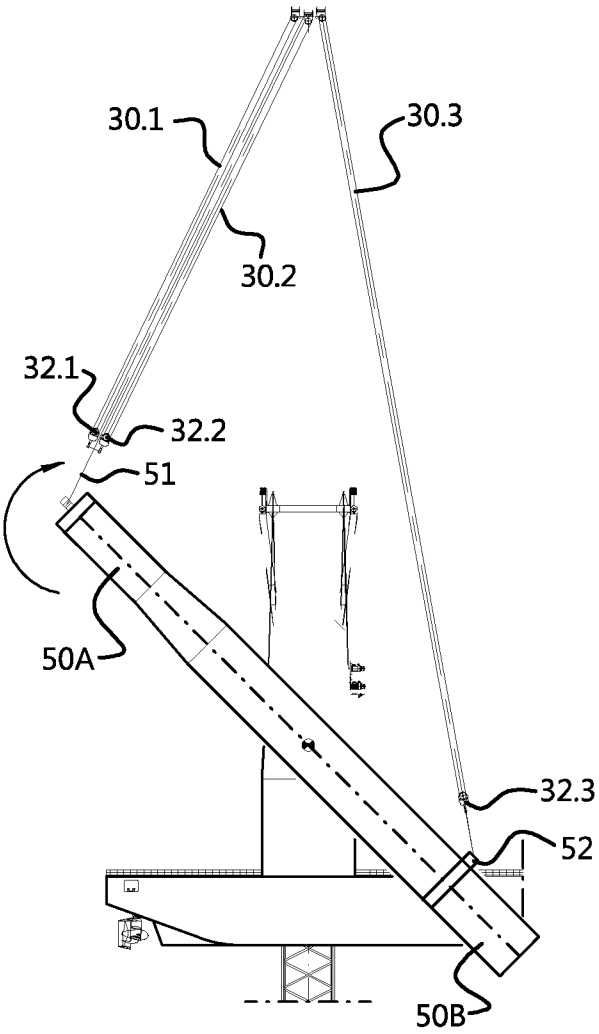

30.1
30.3
30.2
32.1
32.2
51
50A
32.3
52
50B

Fig. 13

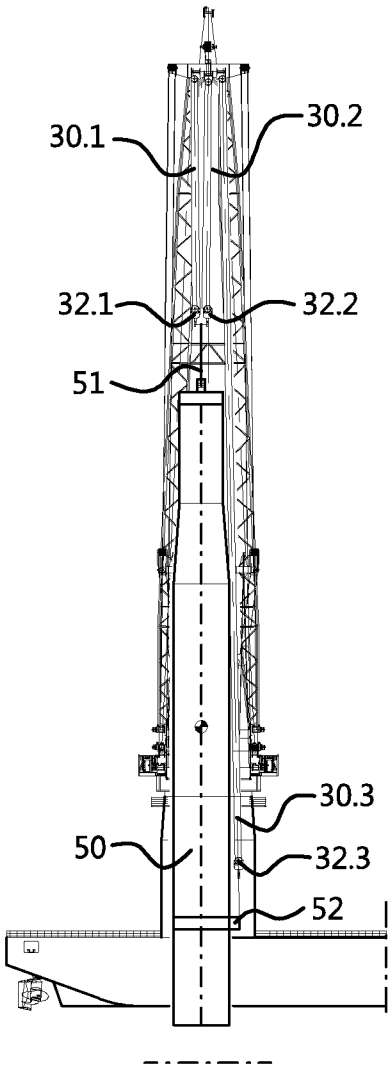

30.1
30.2
32.1
32.2
51
30.3
50
32.3
52

Fig. 14

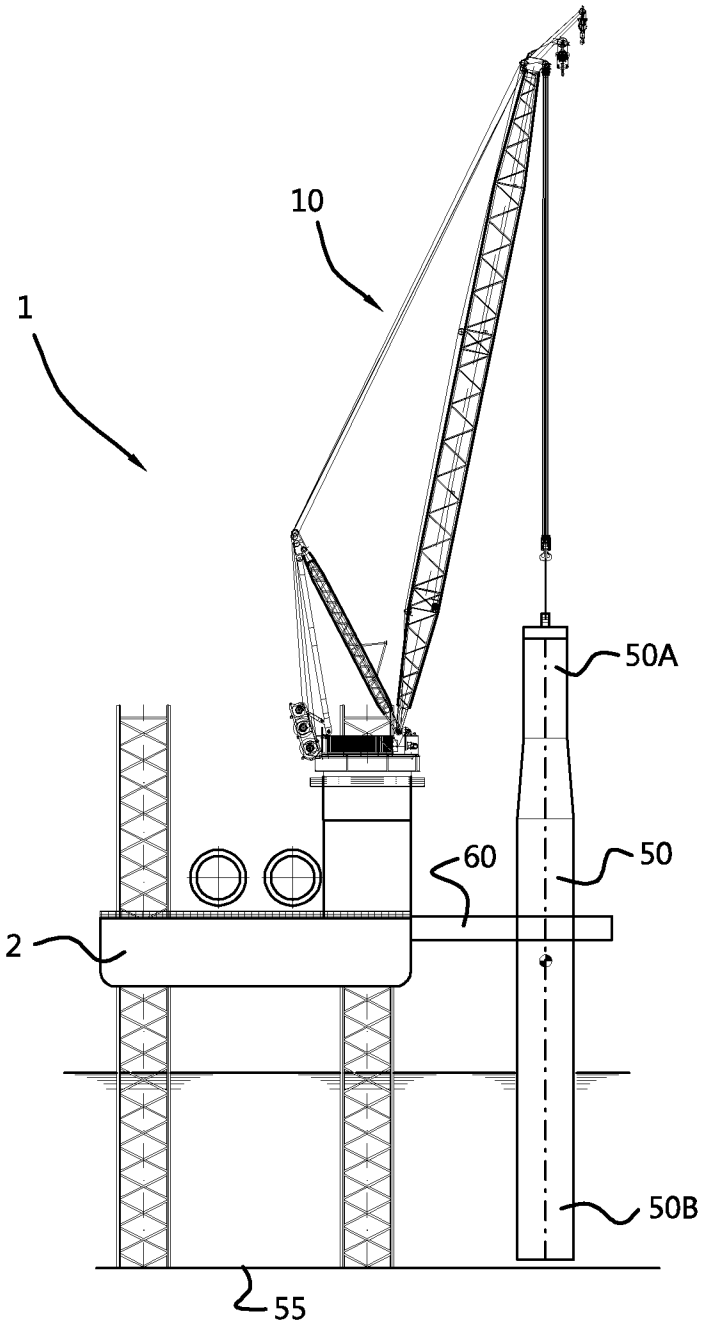


Fig. 15

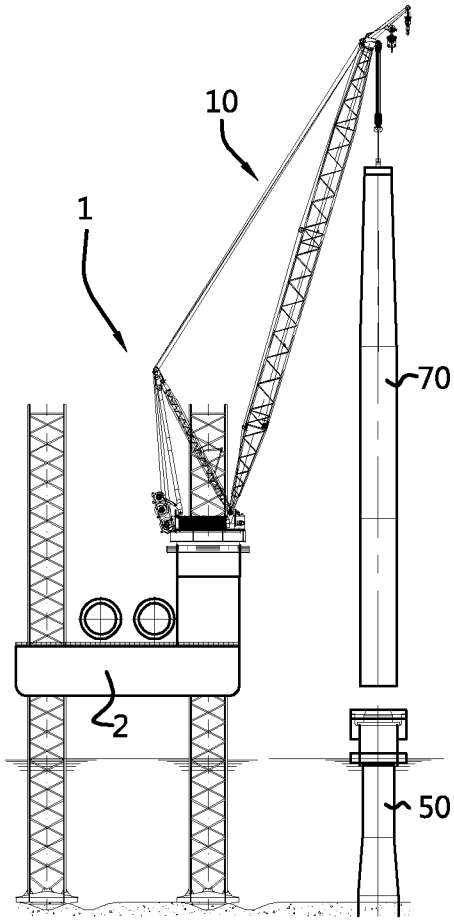


Fig. 16

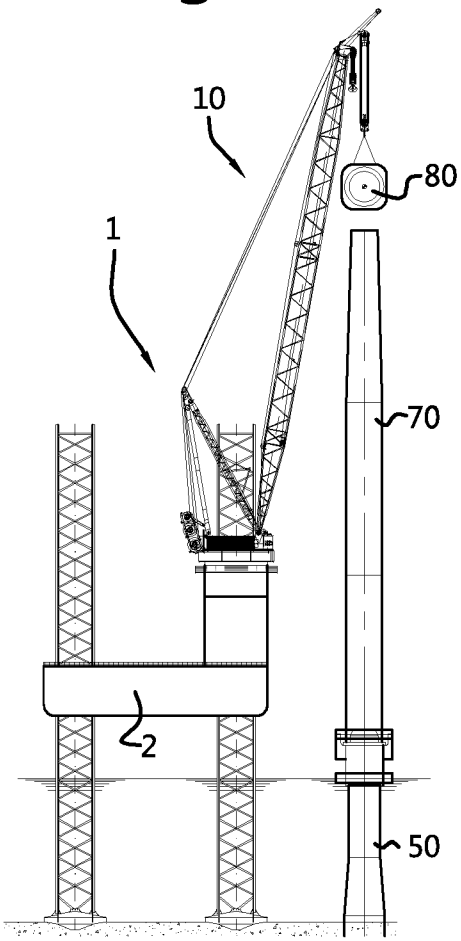


Fig. 17A

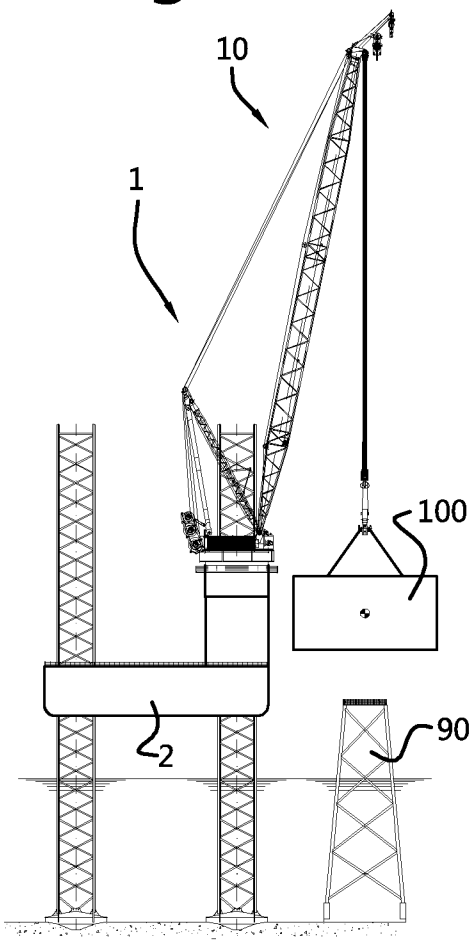
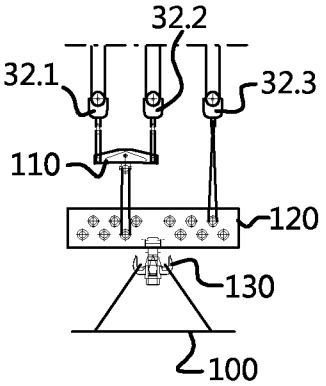


Fig. 17B



ABSTRACT

The invention relates to a crane comprising:

- a base structure;
- a slew bearing;
- a crane housing mounted to the base structure via the slew bearing to be rotatable about a vertical slewing axis;
- a boom moveably mounted to the crane housing to be pivotable about a horizontal first pivot axis;
- three main hoisting systems; and
- a luffing system,

wherein the boom comprises an A-frame with two boom legs that are connected at one end to the crane housing and at the opposite end to each other via a hammerhead structure,
wherein each main hoisting system comprises:

- a hoisting cable;
- a sheave block with one or more sheaves that are rotatable about a sheave rotation axis, which sheave block is arranged on the hammerhead structure of the boom;
- a hoisting block suspended from the sheave block by the hoisting cable; and
- a hoisting winch to lift and lower the hoisting block by hauling in or paying out the hoisting cable,

wherein the sheave block of each main hoisting system is pivotable about a horizontal second pivot axis that is perpendicular to the sheave rotation axis,
wherein the sheave blocks of the three main hoisting systems are arranged side-by-side,
wherein the luffing system comprises:

- two luffing winches on the crane housing;
- two luffing cables extending between the respective two luffing winches on the crane housing and the boom,

and wherein the luffing cables are connected to respective outriggers of the hammerhead structure.

Fig. 4

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	P32888NL00/HJB
Nederlands aanvraag nr. **2017468**	Indieningsdatum **15-09-2016**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Itrec B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **10-12-2016**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN67939**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

B66C23/82;B66C23/52;B66C23/84

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**B66C;B63B;E02B;E21B;F03D**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2017468

A. CLASSIFICATIE VAN HET ONDERWERP
INV. B66C23/82 B66C23/52 B66C23/84
ADD.

Volgens de internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)
B66C B63B E02B E21B F03D

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 2014/166604 A1 (HEY JOHN E [US]) 19 juni 2014 (2014-06-19) * samenvatting * * alinea [0024] - alinea [0027] * * alinea [0022] * * conclusies 1, 14 * * figuren 1-6 * -----	1
A	WO 2009/131442 A1 (ITREC BV [NL]; ROODENBURG JOOP [NL]; WETERINGS HENDRIKUS JACOBUS [NL];) 29 oktober 2009 (2009-10-29) * bladzijde 10, regel 1 - regel 37 * * conclusies 1, 10 * * figuren 3, 7, 8 * -----	1,6

-/--

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

* Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
4 mei 2017	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Guthmuller, Jacques

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ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2017468

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 2013/168345 A1 (HEY JOHN [US]) 4 juli 2013 (2013-07-04) * "Material Handling System"; alinea [0033] - alinea [0040]; conclusie 1 * * "Guide System"; alinea [0041] - alinea [0051] * * figuren 1-3, 5, 6, 17-24 * -----	1
A	CN 104 649 155 A (SOUTH CHINA MARINE MACHINERY CO LTD) 27 mei 2015 (2015-05-27) * figuren * * three winchs 3, three lines * -----	1
A	US 4 280 628 A (GOSS JOHN B ET AL) 28 juli 1981 (1981-07-28) * figuren 2-5 * * conclusies 1, 5 * -----	1
A	US 4 951 924 A (CALKINS DENNIS E [US]) 28 augustus 1990 (1990-08-28) * figuren 1, 2, 4, 5, 10-13 * * conclusies 1, 2, 3 * -----	1,6,9
A	US 5 580 189 A (SANDERS RONALD E [US] ET AL) 3 december 1996 (1996-12-03) * samenvatting * * figuren 1, 4 * * conclusies 1, 11 * -----	1,6,7

1

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek: NL 2017468

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2014166604 A1	19-06-2014	CN 104981424 A	14-10-2015
		DK 2931648 T3	06-02-2017
		EP 2931648 A1	21-10-2015
		SG 11201504502U A	30-07-2015
		US 2014166604 A1	19-06-2014
		WO 2014093804 A1	19-06-2014
WO 2009131442 A1	29-10-2009	CN 102015513 A	13-04-2011
		EP 2274225 A1	19-01-2011
		US 2011114587 A1	19-05-2011
		WO 2009131442 A1	29-10-2009
US 2013168345 A1	04-07-2013	DK 2797830 T3	17-05-2016
		EP 2797830 A1	05-11-2014
		EP 3034451 A1	22-06-2016
		KR 20140116386 A	02-10-2014
		SG 11201403593Y A	30-10-2014
		US 2013168345 A1	04-07-2013
		US 2016376132 A1	29-12-2016
		WO 2013101899 A1	04-07-2013
CN 104649155 A	27-05-2015	GEEN	
US 4280628 A	28-07-1981	GEEN	
US 4951924 A	28-08-1990	GEEN	
US 5580189 A	03-12-1996	AU 1127597 A	17-07-1997
		EP 0868575 A2	07-10-1998
		NO 982857 A	18-08-1998
		US 5580189 A	03-12-1996
		WO 9723402 A2	03-07-1997

WRITTEN OPINION

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Applicant
Itrec B.V.

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

Examiner
Guthmuller, Jacques

Application number

WRITTEN OPINION

NL2017468

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-11
	No:	Claims	
Inventive step	Yes:	Claims	1-11
	No:	Claims	
Industrial applicability	Yes:	Claims	1-11
	No:	Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1 US 2014/166604 A1 (HEY JOHN E [US]); (2014-06-19)

D2 WO 2009/131442 A1 (ITREC BV [NL]; ROODENBURG JOOP [NL]; WETERINGS HENDRIKUS JACOBUS [NL];); (2009-10-29)

D3 US 2013/168345 A1 (HEY JOHN [US]); (2013-07-04)

D4 CN 104 649 155 A (SOUTH CHINA MARINE MACHINERY CO LTD); (2015-05-27)

D5 US 4 280 628 A (GOSS JOHN B ET AL); (1981-07-28)

2 **Concerning independent apparatus claim 1:**

2.1 The document is regarded as being one of the prior art closest to the subject-matter of claim 1, and discloses:

Een kraan omvattende:
- een basisconstructie;
- een zwenklager;
- een kraanhuis dat beweegbaar gemonteerd is op de basisconstructie via het zwenklager om het kraanhuis te laten roteren ten opzichte van de basisconstructie om een in hoofdzaak verticale zwenkas;
- een kraanarm [100] beweegbaar bevestigd aan het kraanhuis om de kraanarm te laten draaien ten opzichte van het kraanhuis om een in hoofdzaak horizontale eerste draaias;
- ~~drie~~ een dubbel hoofdhijssystemen (***see the figure 4-6 and the paragraphs [0024]-[0027]***); en
- een luffing systeem om een hoekoriëntatie van de kraanarm in te stellen ten opzichte van het kraanhuis (***obvious; see the figures 1-4,*** *the two legs of the A-frame are movable around an horizontal axis*),

waarbij de kraanarm een A-frame omvat (***see the figures 1-3***) met twee poten die aan een uiteinde verbonden zijn met het kraanhuis en aan het andere uiteinde met elkaar verbonden zijn ~~via een hamerkopstructuur~~,

waarbij elk hoofdhijssysteem omvat:
o een hijskabel (***see for example the lines 66A, 66B***);
o een schijvenblok met een of meer schijven die geroteerd worden om een schijfrotatieas (***see for example the sheaves 74A, 74B***),

waarbij het schijvenblok is aangebracht ~~op de hamerkopstructuur~~ aan het uiteinde van de kraanarm (***see the figures 1-3***);
o een hijsblok (***see the load block 73 on the figures 1-3***) gehangen aan het schijvenblok middels de hijskabel; en
o een hijslier (***spools 64A & 64B; see paragraph [0022]***) om het hijsblok op te tillen en te laten zakken door het binnen halen of vieren van de hijskabel (***66A, 66B***),

waarbij de schijvenblokken van de ~~drie~~ het dubbele hoofdhijssystem~~en~~ zij aan zij zijn geplaatst,

waarbij het luffing systeem omvat (***obvious; see the figures 1-4***):
o twee luffing lieren op het kraanhuis;
o twee luffing kabels die zich uitstrekken tussen de twee respectieve luffing lieren op het kraanhuis en de kraanarm,

2.2 It is believed that document D2 (see the corresponding passages mentioned in the search report) does roughly disclose the same technical features as document D1.

2.3 The subject-matter of claim 1 therefore differs from this known crane in that:

a) de kraan omvat **drie** hoofdhijssystemen;

b) waarbij de twee poten (van de kraanarm van de kraan) aan het andere uiteinde met elkaar verbonden zijn via een hamerkopstructuur,

c) waarbij elk schijvenblok is aangebracht op de hamerkopstructuur van de kraanarm;

d) waarbij het schijvenblok van elk hoofdhijssysteem draaibaar is om een in hoofdzaak horizontale tweede draaias die loodrecht staat op de schijfrotatieas van de een of meerdere schijven van het schijvenblok,

e) waarbij de schijvenblokken van de **drie** hoofdhijssystemen zij aan zij zijn geplaatst,

f) en waarbij de luffing kabels zijn verbonden met respectieve uitsteeksels van de hamerkopstructuur die zich voorbij de poten van het A-frame uitstrekken gezien in bovenaanzicht.

The subject-matter of claim 1 therefore new.

2.4 The goal to be achieved by the proposed invention may be defined as:

Providing an alternative and improved crane, a vessel supporting said crane and the corresponding method for manipulating, lifting, up-ending long and cumbersome longitudinal structures, like wind turbine (monopiles).

2.5 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons:

2.5.1 This goal is especially achieved by a crane with the additional technical features as defined in point 2.3, especially the sub-points a), c), d) & e).

2.5.2 Advantages of the proposed solution: *The crane is very suitable for asymmetric loads, such as for instance encountered during up-ending of a (very) long longitudinal structure. Two of the three main hoisting systems may be combined to increase the hoisting capacity required for the upper end of such a longitudinal structure, e.g. a monopile, while the remaining hoisting system may be used to hold and lift the lower end. The additional degree of freedom as provided to the sheave blocks allow the respective hoisting blocks to be moved sideways in order to be connected to a respective end of said longitudinal structure while keeping the one or more sheaves of the sheave block aligned with the respective hoisting cable and the one or more sheaves of the hoisting blocks. The A-frame construction of the boom provides torsional stiffness against an asymmetric load while at the same time the luffing cables are connected to the boom at a larger distance from the centre of the boom (which aids in counteracting the asymmetric load on the boom).*

2.5.3 The documents D3 and D4 disclose a system having three (or more) sheaves arrangements. But, said documents concern fail to disclose at least some aspects mentioned under point 2.1 (D3 and D4 are about a different type of crane) as well as at least sub-point d) of point 2.3.

D5 (see the figures 2-5) discloses an alternative sheave arrangement.

The skilled person trying to combine anyone or several of the documents taken from D3 to D5 would not arrive the solution defined in independent apparatus claim 1

2.6 Conclusions:

The subject-matter of claim 1 does involve an inventive step.

Claims 2 to 5 all dependent on claim 1 and as such also meet the requirements of novelty and inventive step.

Claims 6 to 8 which are about the vessel supporting the claimed crane are thus also new and inventive.

Claim 9 which describes the method for erecting long structure by using the crane defined in anyone of the claims 1 to 6, and its depending claims 10 & 11 are also new and inventive.

Re Item VII

Certain defects in the application

3 Documents reflecting the prior art described on the pages 1 & 2, but are not identified in the description.

4 The relevant background art disclosed in the documents D1-D5 is not mentioned in the description, nor are these documents identified therein.

5 The features of the claims are not provided with reference signs placed in parentheses.

6 Independent claim 1 is not drafted in the two-part form, with those features known in combination from the prior art (D1 or D2) being placed in the preamble and the remaining features being included in the characterising part.