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(54) **Device and method for placing a pile**

Vorrichtung und Verfahren zur Platzierung eines Erdpfahls

Dispositif et procédé pour l'installation d'un pieu

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Description

[0001] The invention relates to a device and method for placing a sizeable, slender object with a longitudinal direction on a ground surface. The invention relates particularly to a device and method for placing a monopile of a wind turbine on an underwater bottom such as generally known from WO99/11872A.

[0002] The invention will be elucidated with reference to an offshore wind turbine. The reference to such a wind turbine does not however imply that the invention is limited thereto, and the device and method can be applied equally well for placing on any ground surface any other sizeable slender object, such as for instance other offshore foundation structures, jetties, radar and other towers or onshore applications.

[0003] The foundation of a wind turbine at sea generally has a slender design because the height difference with an underwater bottom has to be bridged. A great deal of material is further required in order to absorb the considerable loads, whereby a foundation generally also has a great weight. A frequently applied foundation of a wind turbine comprises a monopile provided on an upper side with a transition piece which forms the connection to a turbine mast arranged on the monopile. The monopile is carried under water and driven with an underside into an underwater bottom. A large part of the monopile foundation is thus located under water in use.

[0004] Monopiles typically comprise hollow cylindrical structures of steel or concrete which can have a length of more than 50 m, a diameter of 6 m and more, and a weight which can rise to 800 tons and more. Foundations for wind turbines are moreover becoming increasingly heavier because wind turbines are constantly being scaled up. Because the monopile foundations are becoming increasingly more sizeable, they are increasingly more difficult to handle.

[0005] A known method for placing a monopile on an underwater bottom comprises of taking up the monopile from a vessel using a lifting means such as a crane and lowering the monopile onto or into the underwater bottom, the monopile being kept under control here in a roughly vertically oriented position by auxiliary cables operated with winches. Only when the monopile has been fixed in the underwater bottom, for instance by being driven into the underwater bottom, is the monopile uncoupled from the lifting means.

[0006] A drawback of the known method and device is that it can only be performed in a relatively calm sea. Such a sizeable object is indeed subject to a great deal of energy from the sea (currents, waves) and from the wind as it is lowered into the water. The heavier the swell, the more difficult it becomes for this reason to keep a sizeable object such as a monopile under control. Because it is only possible to work in a relatively calm sea, much time may be lost.

[0007] An object of the present invention is therefore to provide a device and method for placing a sizeable, slender object with a longitudinal direction on a ground surface, which at least partially obviates the above stated drawback of the prior art. The invention particularly seeks to provide an improved device and method for placing a monopile of a wind turbine on an underwater bottom.

[0008] Provided for this purpose according to the invention is a device which comprises a lifting means with which the object can be taken up and a gripping construction separate from the lifting means, which gripping construction is connected to a support structure, comprises gripping members movable relative to this support structure and configured to engage a peripheral part of the object suspended from the lifting means, and comprises movement-damping means configured to damp movements of the gripping members relative to the support structure.

[0009] The device, and more specifically the gripping construction thereof, acts as a damping system which absorbs at least some of the energy of an object suspended from the lifting means without swinging movements of the objects otherwise being wholly prevented. The movement-damping connection ensures that, while a transverse movement of the object can take place, this is increasingly countered as the movement becomes greater. Swinging movements of the object transversely of the longitudinal direction thereof are thus damped. Support structure is understood to mean a stable support structure which is able to absorb the forces produced by a moving object received in the gripping construction.

[0010] Another aspect of the invention relates to a method for placing a sizeable, slender object with a longitudinal direction on a ground surface, wherein the method comprises the steps of

a) providing an object and a device according to the invention;
b) taking up the object with the lifting means;
c) gripping with the gripping members a peripheral part of the object suspended from the lifting means, wherein the gripping members are connected by means of the movement-damping connection to the support structure, whereby movements of the gripping members relative to the support structure are damped;
d) lowering the object onto or into the ground surface;
e) fixing the object relative to the ground surface; and
f) uncoupling the object from the device.

[0011] While the object is being lowered a peripheral part of the object is gripped with a suitable clamping force by the gripping construction, wherein the object can move in transverse direction in the manner of a pendulum. The movement-damping means avoid these movements reaching such high amplitudes that the device and/or the object are damaged. A better controlled process is moreover obtained by removing peak amplitudes. It thus becomes possible to work in a heavier swell of up to 2-2.5 m of significant wave height and more, where a prior art

method can only be applied up to a significant wave height of 1.5 m. In an embodiment of the invention the object is taken up at a lifting point by the lifting means, wherein the gripping construction is configured to clamp round a cross-section, lying at a distance from the lifting point, of the object suspended from the lifting means. The distance from the clamping to the lifting point can be selected within wide limits.

[0012] Provided in another aspect of the invention is a method wherein, prior to fixing of the object relative to the ground surface, the angular position of the object is adjusted by actively moving the gripping members by means of the movement-damping means. An object arranged on the ground surface can hereby be brought into the correct, generally vertical position before this object is fixed in the ground surface. The angular position is determined by the angle which the longitudinal direction of the object makes with the vertical direction. In the present aspect of the invention the movement-damping means are not only used to damp swinging movements of an object received in the gripping construction but also actively employed to precisely set the angular position of a placed object.

[0013] An embodiment of the device according to the invention is characterized in that the movement-damping means are configured to convert the kinetic energy of the gripping members (and an object received therein) moving relative to the support structure to thermal energy.

[0014] The temperature increase resulting from the generated heat can for instance be kept under control by cooling of conduits and the like in the ambient air. In a possible embodiment the device comprises cooling means for the movement-damping means or components thereof.

[0015] The movement-damping connection between the gripping members and the support structure can be configured in many ways. In an embodiment of the device according to the invention the movement-damping means comprise a mechanical spring means arranged between the gripping members and the stable support structure. A suitable mechanical spring means comprises for instance a prestressed wire, preferably steel wire, which is connected to a winch, if desired by means of a hydraulic cylinder.

[0016] Another embodiment of the invention provides a device wherein the movement-damping means comprise a hydraulic piston cylinder and throttle means for hydraulic liquid present in the piston cylinder. Flowing hydraulic liquid is subjected by the throttle means to a hydraulic resistance, whereby the friction increases and the temperature rises. Generated kinetic energy is hereby dissipated in effective manner. This embodiment can if desired be applied in combination with a hydraulic accumulator which can optionally generate desired prestressing forces and/or can compensate possible volume differences in hydraulic cylinder chambers. The prestressing of the movement-damping connection can be controlled in simple manner by applying an accumulator. Suitable accumulators comprise membrane accumulators and/or piston accumulators. In the case of a transverse movement of the monopile and the gripping members the counteracting stress in such a movement-damping connection will increase to a value which depends on the gas volume in the accumulator, whereby the movement is countered.

[0017] A further embodiment of the invention relates to a device wherein the piston cylinder comprises a hydraulic synchronous cylinder arranged between the gripping members and the support structure. A synchronous cylinder (also referred to as synchronization cylinder) is provided with a piston rod on both sides of the piston disc. Running between the cylinder volumes present on either side of the piston rod is an external hydraulic conduit which connects the cylinder volumes. The volume of the hydraulic oil flowing in and out therefore always remains the same. A synchronous cylinder acts in two directions without an accumulator being necessary. The throttle means can be embodied as openings in the piston of the piston cylinder and/or as constrictions in the hydraulic conduits. Suitable throttle means for instance comprise optionally controllable throttle valves.

[0018] According to the invention the movement-damping means of the device act transversely of the longitudinal direction of the object. This means that swinging movements transversely of the longitudinal direction of an object received in the gripping members are counteracted with a force component acting transversely of the longitudinal direction of the object.

[0019] In order to be able to absorb and transfer the considerable forces in efficient manner to the support structure when an object is taken up, the device is characterized according to an embodiment of the invention in that the gripping construction comprises a lattice frame connected to the support structure. Also connected to the lattice frame in this embodiment are the gripping members, wherein the connection between the lattice frame and the gripping members takes place via the movement-damping means.

[0020] It is further advantageous for the gripping construction, and particularly the lattice, to be rotatably connected to the support structure. The gripping construction can thus be brought into a folded-down, non-operational position, which saves space. In the case that for instance a wind turbine is placed at sea, a fold-down gripping construction creates more space for installing auxiliary constructions, such as for instance a transition piece between the wind turbine and a placed monopile, and navigating away from the device is moreover simplified. In order to engage an object the gripping construction can be brought into an operational position, for instance by being folded out.

[0021] The gripping construction of the invented device can be embodied in many ways. A suitable embodiment comprises a device wherein the gripping members comprise a set of arms, wherein the arms extend in an operational position transversely of the longitudinal direction

of the object and are movable relative to each other between a free position at a distance from the peripheral part in which the peripheral part is released, and a clamping position in which the peripheral part is clampingly received.

[0022] In such an embodiment of the gripping members the movement-damping means are configured to damp the movement of the arms jointly relative to the support structure. During damping of the movement the arms therefore remain an equal distance from each other, whereby the object remains clamped between the arms. In this embodiment the movement of the arms is preferably damped in a direction perpendicularly of a longitudinal direction of the arms. Movement-damping means suitable for this purpose therefore preferably perform their damping action in this direction.

[0023] In another embodiment of the invention a device is provided wherein it, and preferably the arms, is provided with second gripping members which are movable in the longitudinal direction of the arms. Second movement-damping means are configured in this embodiment to damp the movement of the second gripping members jointly relative to the support structure, wherein the second gripping members are therefore held an equal distance from each other and the object remains clamped between the second gripping members. In this embodiment the movement of the second gripping members is preferably damped in a direction running parallel to the longitudinal direction of the arms. Second movement-damping means suitable for this purpose therefore preferably perform their damping action in this direction.

[0024] It is advantageous to configure the movement-damping means such that they can damp the movement of the gripping members in two mutually differing (transverse) directions. This can be realized in efficient manner by providing first and second gripping members which can perform their damping action in two directions, and corresponding first and second movement-damping means which perform their damping action on respectively the first and second gripping member in said directions.

[0025] A further embodiment according to the invention relates to a device wherein the support structure has a peripheral edge, the gripping members extend beyond the peripheral edge, whereby an object suspended from the lifting means can hang downward along the support structure, and first movement-damping means act parallel to the peripheral edge.

[0026] Another embodiment of the invention provides a device wherein second movement-damping means act perpendicularly of the peripheral edge. The swinging movements of the object in a transverse direction running substantially perpendicularly of said peripheral edge are countered in this embodiment by second movement-damping means acting in this direction.

[0027] Although the device and method according to the invention can be applied for the purpose of placing any sizeable, slender object on or in a ground surface, the object is preferably the monopile of a wind turbine, and the ground surface an underwater bottom. When the device and method are applied at sea, the support structure preferably comprises a vessel, in particular a jack-up platform.

[0028] It is noted that the device can not only be applied for placing a sizeable, slender object with a longitudinal direction on a ground surface under more difficult conditions, but it can also be applied according to a preferred method for orienting the object correctly relative to a vertical direction. Provided for this purpose is a method wherein, prior to the step of fixing the object relative to the ground surface, the orientation or angular position of the object is adjusted by actively moving the gripping members by means of the movement-damping means. The position of the object is generally determined with the lifting means.

[0029] Fixing relative to the ground surface of a sizeable, slender object placed on or in a ground surface with the device and method according to the invention can take place in any manner. It is thus possible to drive the monopile into the ground surface by making use of a per se known hydraulic hammer, by drilling or by another suitable technique. In a preferred method the object is supported by the gripping construction while the object is being driven into the ground.

[0030] The invention will now be elucidated with reference to the following figures, without otherwise being limited thereto. In the figures:

Fig. 1 is a schematic perspective view of an embodiment of the device according to the invention with the gripping construction in operational position;
Fig. 2 is a schematic rear view of the embodiment shown in figure 1;
Fig. 3 is a schematic side view of the embodiment of the device according to the invention shown in figure 1;
Fig. 4 is a schematic perspective view of an embodiment of a gripping construction according to the invention;
Fig. 5 is a schematic side view of the embodiment of the gripping construction according to the invention shown in figure 4;
Fig. 6 is a schematic top view of the embodiment of the gripping construction according to the invention shown in figure 4; and
Fig. 7A and 7B show schematic representations of possible embodiments of the movement-damping means according to the invention.

[0031] Referring to figures 1, 2 and 3, a device 1 is shown for placing a monopile 3 on an underwater bottom 2. The device is likewise suitable for placing other objects with a longitudinal direction, such as for instance transition pieces 4 of a wind turbine mast, onto each other or onto another ground surface. A ground surface can thus comprise any structure on which a sizeable, slender ob-

ject can be placed. In the shown embodiment device 1 comprises a support structure in the form of a jack-up platform 5. Jack-up platform 5 comprises a vessel which can navigate autonomously and which can be positioned and fixed at a desired position by lowering a number of spud poles 50 onto underwater bottom 2. Spud poles 50 are for this purpose moved by means of a rack and pinion drive down against the underwater bottom and further so that platform 5 is raised out of the water as shown in figures 1, 2 and 3, wherein work deck 51 of platform 5 lies metres above water surface 20. Spud poles 50 are provided with so-called spudcans 52 to prevent spud poles 50 penetrating into underwater bottom 2.

[0032] Provided on work deck 51 of platform 5 are components to be placed, such as for instance a number of transition pieces 4 and monopiles 3. Work deck 51 of jack-up platform 5 is further provided with a lifting means in the form of a crane 6 with double boom (60a, 60b) for the purpose of absorbing considerable forces. Crane 6 is pivotable around a substantially vertical axis 62 on a base 61. Crane 6 is provided with a set of hoisting cables (63a, 63b) which can be taken in or payed out over a top part 65 of crane 6 using winches (not shown) and which is provided at the free outer end with a hoisting block 66 with hook, from which a monopile 3 is suspended in use. Monopile 3 is provided for this purpose with a hoisting construction, removable if desired, at a lifting point 33. The angular position of booms (60a, 60b) can if desired be adjusted by a set of traction cables (64a, 64b) which connect top part 65 to base 61. Traction cables (64a, 64b) can likewise be taken in or payed out using winches (not shown).

[0033] Work deck 51 of platform 5 further comprises a gripping construction 10 separate from crane 6. Parts of gripping construction 10 are received in a housing 100, as shown in figures 1, 2 and 3. Gripping construction 10 is configured to engage a peripheral part 32 of a monopile 3 suspended from crane 6, as will be further elucidated below. Gripping construction 10 is further connected by means of a movement-damping connection to (work deck 51 of) jack-up platform 5. Jack-up platform 5 functions here as a stable support structure for gripping construction 10, among other reasons because of the great weight thereof and because spud poles 50 support on underwater bottom 2.

[0034] An embodiment of gripping construction 10 is shown in detail in figure 4. Housing 100 is omitted here so as to make the components visible. The connection between gripping construction 10 and work deck 51 of jack-up platform 5 is formed in the shown embodiment by a lattice frame 7 of ribs 70 coupled rigidly to each other. Lattice frame 7 is connected for rotation around a horizontal axis 71 to work deck 51 by means of hinge connections 72. As shown in figure 4, lattice frame 7 can be rotated relative to work deck 51 between a rest position, in which lattice frame 7 and gripping construction 10 coupled thereto are folded upward (this rest position is shown in broken lines in figure 4), and a position of use in which a part of lattice frame 7 rests on work deck 51 and another part overhangs along a vertical side edge 52 of work deck 51. The downward hanging underside of lattice frame 7 comes to lie here roughly at the position of a lower edge 53 of side edge 52, which lower edge can lie 10 m or more lower than work deck 51. Gripping construction 10 extends in the position of use beyond side edge 52, whereby a monopile suspended from lifting means 6 can hang downward along jack-up platform 5. Provided for the purpose of fixing lattice frame 7 in the position of use are brackets 73 which are connected to work deck 51 and can be opened when lattice frame 7 has to be moved to the rest position.

[0035] So as to be able to absorb the considerable forces in lattice frame 7 the downward hanging underside of lattice frame 7 comprises a main beam 74 provided with winches 75. Winches 75 are configured to change the orientation (the heading) of a pile about its longitudinal axis. A cable (not shown) is for this purpose trained round the pile and the heading of the pile about its longitudinal axis can be changed by tightening the cable using a winch 75.

[0036] In the shown embodiment gripping construction 10 comprises first gripping members in the form of a set of arms (12a, 12b) which extend in the downward folded position of use in a horizontal plane 31 which runs transversely of the longitudinal direction 30 of a monopile 3 received in gripping construction 10 (see for instance figures 3 and 5). The two arms (12a, 12b) are moved toward each other parallel to transverse direction 15 by movement-damping means, further elucidated below, in order to clamp round a peripheral part 32 of a monopile 3 suspended from hoisting block 66 of crane 6. The arms (12a, 12b) are for this purpose movable relative to each other between a free position a distance from the peripheral part (32), in which the peripheral part is released, and a clamping position in which the peripheral part (32) is clampingly received. The movement of arms (12a, 12b) takes place by means of first movement-damping means in the form of hydraulic double-action cylinders (11a, 11b). Arms (12a, 12b) are further provided with second gripping members (23a, 23b) which are movable together with arms (12a, 12b) via cylinders (11a, 11b) between a clamping position as shown in figure 6, in which a peripheral part 32 of monopile 3 is clampingly received between gripping members (23a, 23b) with a clamping force which can rise to 50 tons and more, and a free position (not shown) in which gripping members (23a, 23b) are at a distance from peripheral part 32, whereby peripheral part 32 is released and monopile 3 can move freely relative to gripping members (23a, 23b) and the whole gripping construction 10.

[0037] Arms (12a, 12b) can be moved individually (for clamping) as well as jointly using the hydraulic double-action cylinders (11a, 11b). The joint movement can be 'active', for instance in order to adjust the angular position of an already placed object, or 'passive', wherein a displacement of arms (12a, 12b) in the direction 15 as a

result of a swinging movement of an object received in arms (12a, 12b) is damped. In addition to the hydraulic double-action cylinders (11a, 11b), the movement-damping means here also comprise throttle means for hydraulic liquid present in the piston cylinders. Cylinders (11a, 11b) are connected with their casing (13a, 13b) to main beam 74, while a piston rod (14a, 14b) of the two cylinders (11a, 11b) engages on a corresponding arm (12a, 12b). The set of arms (12a, 12b) is movable relative to work deck 51 in the direction 15 running transversely of the longitudinal direction 30 of a monopile 3 received in arms (12a, 12b), and substantially parallel to side edge 52 of work deck 51 of the jack-up platform. Such a movement of arms (12a, 12b) is damped by the action of cylinders (11a, 11b) extending with a longitudinal direction (and piston rods (14a, 14b)) parallel to side edge 52. It is indeed the case that, if the set of arms (12a, 12b) is moved to the left by for instance a swinging movement of a monopile received in arms (12a, 12b), piston rod 14a of cylinder 11a will then be pushed in, while piston rod 14b of cylinder 11b will be pushed out. These movements of piston rods (14a, 14b) are counteracted by hydraulic throttle means which are for instance connected to openings arranged in casings (13a, 13b) on either side of a piston (not visible), whereby the transverse movement of arms (12a, 12b) - and so also of monopile 3 - is damped. The swinging movements of a monopile 3 received in arms (12a, 12b) in a direction transversely of the longitudinal direction 30 thereof are in this way damped in effective manner. Suitable throttle means for instance comprise optionally controllable throttle valves.

[0038] A suitable embodiment of the movement-damping means (11a, 11b) for arms (12a, 12b) is shown in figure 7A. The two cylinders (11a, 11b) are connected to a hydraulic circuit as shown, which comprises a pump 110 and a throttle valve 113, and further a number of valves (111, 112). When valves 111 are closed the cylinders act as movement dampers. As a result of a movement of arms (12a, 12b) the two pistons 114 are displaced and oil is pumped round via throttle valve 113. Kinetic energy is converted to thermal energy here by heating of the oil. In order to prevent too great a temperature increase the hydraulic circuit can further be provided with cooling means (not shown). When valves 111 are open and valves 112 are closed, oil can be pumped 'actively' to the cylinders with pumps 110, whereby pistons 114, and so also arms (12a, 12b), are 'actively' displaced. This can take place both jointly and separately, depending on how valves 111 are controlled. In the hydraulic double-action cylinders (11a, 11b) the stroke volume 115a on the rod side differs from the stroke volume 115b on the disc side. The stroke volumes 115a of the rod side of the hydraulic double-action cylinders (11a, 11b) are mutually connected, as are the stroke volumes 115b of the disc side, whereby the volumes remain relatively equal.

[0039] The second gripping members (23a, 23b) can be moved jointly in direction 16 using the hydraulic synchronous cylinders (24a, 24b). The joint movement can be 'active', for instance in order to adjust the angular position of an already placed object, or 'passive', wherein a displacement of gripping members (23a, 23b) in direction 16 as a result of a swinging movement of an object received in gripping members (23a, 23b) is damped.

[0040] A suitable embodiment of the movement-damping means (11a, 11b) for gripping members (23a, 23b) is shown in figure 7B. Synchronous cylinder 24a (and 24b) is connected to a hydraulic circuit as indicated which comprises a pump 240, two valves (241, 242) and a throttle valve 243. When valves (241, 242) are closed, the synchronous cylinder acts as movement damper. As a result of a movement of gripping members (23a, 23b) a piston 244 is displaced and oil is pumped around via throttle valve 243. Kinetic energy is converted to thermal energy here by heating of the oil, wherein too great a temperature increase is prevented by providing the hydraulic circuit with cooling means (not shown). When valves (241, 242) are open, oil can be 'actively' pumped to the cylinder with pump 240, whereby piston 244, and so also gripping members (23a, 23b), are 'actively' displaced.

[0041] It will be apparent that the above described embodiments have to be provided with peripheral equipment such as for instance hydraulic and electric power sources, feed conduits therefor and the like. This peripheral equipment is not described in further detail.

[0042] With the embodiment of the invented device described in detail above a sizeable, slender object, in particular a monopile 3, of a wind turbine can be placed on a ground surface, in particular an underwater bottom 2, this in worse weather conditions than is possible with the known method.

[0043] A suitable embodiment of the method comprises of taking up monopile 3 by a lifting point 33 (see figures 1 and 2) using a lifting means suitable for the purpose, such as crane 6. Monopile 3 is then lowered to a height at which a peripheral part 32 of monopile 3 lying at a distance from lifting point 33 is engaged by the above described gripping members (12a, 12b, 23a, 23b). Gripping members (12a, 12b, 23a, 23b) are connected here via lattice frame 7 to the jack-up platform by means of movement-damping connections acting in two directions 15 and 16. The movement-damping means acting in direction 15 comprise a hydraulic circuit incorporating cylinders (11a, 11b) as well as throttle valves 113, valves (111, 112) and pumps 110. The movement-damping means acting in direction 16 comprise a hydraulic circuit incorporating synchronous cylinders (24a, 24b) as well as throttle valves 243, valves (241, 242) and pumps 240.

[0044] During further lowering of monopile 3 swinging movements thereof in two mutually perpendicular directions 15 and 16, both running transversely of longitudinal direction 30 of monopile 3, are damped by applying the movement-damping means. This situation is maintained until the underside of monopile 3 reaches underwater bottom 2 or penetrates to limited extent therein. The orientation (angular position) of monopile 3 relative to the vertical direction can if desired be adjusted in this situa-

tion by actively displacing the arms (12a, 12b) and gripping members (23a, 23b) in direction 15 and/or 16 with the hydraulic synchronous cylinders (11a, 11b) and (24a, 24b). If monopile 3 is here anchored to some extent in the underwater bottom, the angular position of monopile 3 can thus be adjusted relative to the vertical direction. Once monopile 3 is located in the correct position and has been properly (vertically) aligned, monopile 3 is fixed relative to underwater bottom 2, for instance by driving monopile 3 further into the underwater bottom using a hydraulic hammer, preferably under the guidance of gripping construction 10. Once the fixing has been performed as desired, monopile 3 is uncoupled from gripping construction 10 by retracting the arms (12a, 12b) provided with gripping members (23a, 23b) from peripheral part 32 and rotating gripping construction 10 around hinges 72 into the rest position.

Claims

1. Device (10) for placing a sizeable, slender object (3) with a longitudinal direction on a ground surface, wherein the device comprises a lifting means (10) with which the object can be taken up, and a gripping construction (23a,b) which is separate from the lifting means and which is connected to a support structure, comprises gripping members movable relative to this support structure and configured to engage a peripheral part of the object suspended from the lifting means, and comprises movement-damping means configured to damp movements of the gripping members relative to the support structure.

2. Device (10) as claimed in claim 1, wherein the movement-damping means are configured to convert the kinetic energy of the gripping members moving relative to the support structure to thermal energy.

3. Device (10) as claimed in claim 1 or 2, wherein the movement-damping means comprise a hydraulic piston cylinder (14a) and throttle means for hydraulic liquid present in the piston cylinder.

4. Device (10) as claimed in claim 3, wherein the piston cylinder comprises a hydraulic synchronous cylinder (11a,11b).

5. Device (10) as claimed in any of the foregoing claims, wherein the device comprises cooling means for the movement-damping means.

6. Device (10) as claimed in any of the foregoing claims, wherein the gripping construction comprises a lattice frame connected rotatably to the support structure.

7. Device (10) as claimed in any of the foregoing claims, wherein the gripping members (23a,b) comprise a set of arms, wherein the arms extend transversely of the longitudinal direction of the object and are movable relative to each other between a free position at a distance from the peripheral part in which the peripheral part is released, and a clamping position in which the peripheral part is clampingly received.

8. Device (10) as claimed in claim 7, wherein the movement-damping means are configured to damp the movement of the arms jointly relative to the support structure.

9. Device (10) as claimed in claim 7 or 8, wherein the arms are provided with second gripping members movable in a longitudinal direction of the arms, wherein the movement-damping means (23a,b) are configured to damp the movement of the second gripping members jointly relative to the support structure.

10. Device (10) as claimed in any of the foregoing claims, wherein the movement-damping means are configured to damp the movement of the gripping members in two mutually differing directions.

11. Device (10) as claimed in any of the foregoing claims, wherein the movement-damping means are configured to actively move the gripping members relative to the support structure.

12. Device (10) as claimed in any of the foregoing claims, wherein the support structure has a peripheral edge, the gripping members extend beyond the peripheral edge, whereby an object suspended from the lifting means can hang downward along the support structure, and first movement-damping means act parallel to the peripheral edge.

13. Device (10) as claimed in claim 12, wherein second movement-damping means act perpendicularly of the peripheral edge.

14. Device (10) as claimed in any of the foregoing claims, wherein it comprises a lifting means with which the object can be taken up at a lifting point, and the gripping construction is configured to engage the object suspended from the lifting means at a distance from the lifting point.

15. Device (10) as claimed in any of the foregoing claims, wherein the support structure comprises a vessel, in particular a jack-up platform.

16. Device (10) as claimed in any of the foregoing claims, wherein the object is the monopile of a wind turbine, and the ground surface an underwater bottom.

17. Method for placing a sizeable, slender object (3) with

a longitudinal direction on a ground surface, wherein the method comprises the steps of

a) providing an object and a device as claimed in any of the foregoing claims;
b) taking up the object with the lifting means.
c) gripping with the gripping members (23a,b) a peripheral part of the object suspended from the lifting means, wherein the gripping members are connected by means of the movement-damping connection to the support structure, whereby movements of the gripping members relative to the support structure are damped;
d) lowering the object onto or into the ground surface;
e) fixing the object relative to the ground surface; and
f) uncoupling the object from the device.

18. Method as claimed in claim 17, wherein prior to step e) the angular position of the object (3) is adjusted by actively moving the gripping members by means of the movement-damping means.

Patentansprüche

1. Einheit (10) zum Aufsetzen eines größeren schmalen Gegenstandes (3) mit einer Längsrichtung auf eine Bodenoberfläche, wobei die Einheit ein Hebemittel (10) umfasst, mit dem der Gegenstand aufgenommen werden kann, sowie eine Greifkonstruktion (23a,b), die getrennt vom Hebemittel angeordnet und mit einer Trägerstruktur verbunden ist, Greifglieder umfasst, die in Bezug auf diese Trägerstruktur bewegbar und so konfiguriert sind, dass sie in einen äußeren Teil des vom Hebemittel herabhängenden Gegenstandes greifen, und ein Mittel zur Dämpfung von Bewegungen umfasst, das so konfiguriert ist, dass Bewegungen der Greifglieder in Bezug auf die Trägerstruktur gedämpft werden.

2. Einheit (10) nach Anspruch 1, wobei das Mittel zur Dämpfung von Bewegungen so konfiguriert ist, dass die kinetische Energie der Greifglieder, die sich in Bezug auf die Trägerstruktur bewegen, in Wärmeenergie umgewandelt wird.

3. Einheit (10) nach Anspruch 1 oder 2, wobei das Mittel zur Dämpfung von Bewegungen einen Hydraulikkolbenzylinder (14a) und ein Drosselmittel für im Kolbenzylinder enthaltene Hydraulikflüssigkeit umfasst.

4. Einheit (10) nach Anspruch 3, wobei der Kolbenzylinder einen Hydraulikgleichlaufzylinder (11a, 11b) umfasst.

5. Einheit (10) nach einem der vorherigen Ansprüche, wobei die Einheit ein Kühlmittel für das Mittel zur Dämpfung von Bewegungen umfasst.

6. Einheit (10) nach einem der vorherigen Ansprüche, wobei die Greifkonstruktion einen drehbar mit der Trägerstruktur verbundenen Gitterrahmen umfasst.

7. Einheit (10) nach einem der vorherigen Ansprüche, wobei die Greifglieder (23a, b) eine Gruppe von Armen umfassen, wobei sich die Arme quer zur Längsrichtung des Gegenstandes erstrecken und zwischen einer freien Position in einem Abstand vom äußeren Teil, in dem der äußere Teil freigegeben wird, und einer Klammerposition, in der der äußere Teil durch Festklammern gehalten wird, zueinander beweglich sind.

8. Einheit (10) nach Anspruch 7, wobei das Mittel zur Dämpfung von Bewegungen so konfiguriert ist, dass die Bewegung der Arme in Bezug auf die Trägerstruktur gemeinsam gedämpft wird.

9. Einheit (10) nach Anspruch 7 oder 8, wobei die Arme mit zweiten in Längsrichtung der Arme beweglichen Greifgliedern versehen sind, wobei die Mittel zur Dämpfung von Bewegungen (23a, b) so konfiguriert sind, dass sie die Bewegung der zweiten Greifglieder in Bezug auf die Trägerstruktur gemeinsam dämpfen.

10. Einheit (10) nach einem der vorherigen Ansprüche, wobei das Mittel zur Dämpfung von Bewegungen so konfiguriert ist, dass es die Bewegung der Greifglieder in zwei zueinander unterschiedliche Richtungen dämpft.

11. Einheit (10) nach einem der vorherigen Ansprüche, wobei das Mittel zur Dämpfung von Bewegungen so konfiguriert ist, dass es die Greifglieder in Bezug auf die Trägerstruktur aktiv bewegt.

12. Einheit (10) nach einem der vorherigen Ansprüche, wobei die Trägerstruktur einen peripheren Rand hat, die Greifglieder sich über den peripheren Rand hinaus erstrecken, wobei ein Gegenstand, der vom Hebemittel herabhängt, entlang der Trägerstruktur nach unten hängen kann, und das erste Mittel zur Dämpfung von Bewegungen parallel zum peripheren Rand wirkt.

13. Einheit (10) nach Anspruch 12, wobei das zweite Mittel zur Dämpfung von Bewegungen senkrecht zum peripheren Rand wirkt.

14. Einheit (10) nach einem der vorherigen Ansprüche, wobei diese ein Hebemittel umfasst, mit dem der Gegenstand auf einen Hebepunkt angehoben werden kann, und die Greifkonstruktion so konfiguriert ist,

dass sie in einem Abstand zum Hebepunkt in den vom Hebemittel herabhängenden Gegenstand greifen kann.

15. Einheit (10) nach einem der vorherigen Ansprüche, wobei die Trägerstruktur ein Schiff, insbesondere eine Hubinsel, umfasst.

16. Einheit (10) nach einem der vorherigen Ansprüche, wobei der Gegenstand der Monopile einer Windturbine und die Bodenoberfläche ein Unterwassergrund ist.

17. Verfahren zum Aufsetzen eines größeren schmalen Gegenstandes (3) mit einer Längsrichtung auf eine Bodenoberfläche, wobei das Verfahren folgende Schritte umfasst:

a) Bereitstellen eines Gegenstandes und einer Einheit nach einem der vorherigen Ansprüche;
b) Aufnahme des Gegenstandes mit dem Hebemittel;
c) Greifen mit den Greifgliedern (23a, b) in einen äußeren Teil des vom Hebemittel herabhängenden Gegenstandes, wobei die Greifglieder über die bewegungsdämpfende Verbindung mit der Trägerstruktur verbunden sind, wodurch Bewegungen der Greifglieder in Bezug auf die Trägerstruktur gedämpft werden;
d) Herabsenken des Gegenstandes auf oder in die Bodenoberfläche;
e) Befestigen des Gegenstandes in Bezug auf die Bodenoberfläche; und
f) Loslösen des Gegenstandes von der Einheit.

18. Verfahren nach Anspruch 17, wobei vor Schritt e) die Winkelposition des Gegenstandes (3) durch aktives Bewegen der Greifglieder mit dem Mittel zur Dämpfung von Bewegungen eingestellt wird.

Revendications

1. Dispositif (10) permettant de placer sur la surface d'un sol un objet (3) élancé, assez grand, ayant un sens longitudinal, étant entendu que le dispositif comprend un moyen de levage (10) avec lequel l'objet peut être soulevé, et une construction de saisie (23a, b) qui est séparée du moyen de levage et qui est reliée à une structure de support, comprend des organes de saisie déplaçables par rapport à cette structure de support et configurés pour entrer en contact avec une partie périphérique de l'objet suspendu au moyen de levage, et comprend des moyens amortisseurs de mouvements configurés pour amortir les mouvements des organes de saisie par rapport à la structure de support.

2. Dispositif (10) selon la revendication 1, dans lequel les moyens amortisseurs de mouvements sont configurés pour convertir en énergie thermique l'énergie cinétique des organes de saisie se déplaçant par rapport à la structure de support.

3. Dispositif (10) selon la revendication 1 ou 2, dans lequel les moyens amortisseurs de mouvements comprennent un vérin à piston hydraulique (14a) et des moyens de régulation à papillon pour le liquide hydraulique présent dans le vérin à piston.

4. Dispositif (10) selon la revendication 3, dans lequel le vérin à piston comprend un vérin synchrone hydraulique (11a, 11b).

5. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel le dispositif comprend des moyens de refroidissement pour les moyens amortisseurs de mouvements.

6. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel la construction de saisie comprend un cadre en treillis relié rotatif à la structure de support.

7. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel les organes de saisie (23a, b) comprennent un ensemble de bras, étant entendu que les bras s'étendent transversalement au sens longitudinal de l'objet et qu'ils sont déplaçables les uns par rapport aux autres entre une position libre à une certaine distance de la partie périphérique dans laquelle la partie périphérique est relâchée, et une position de serrage dans laquelle la partie périphérique est reçue par serrage.

8. Dispositif (10) selon la revendication 7, dans lequel les moyens amortisseurs de mouvements sont configurés pour amortir conjointement le mouvement des bras par rapport à la structure de support.

9. Dispositif (10) selon la revendication 7 ou 8, dans lequel les bras sont dotés de seconds organes de saisie déplaçables dans un sens longitudinal des bras, étant entendu que les moyens amortisseurs de mouvements (23a, b) sont configurés pour amortir conjointement le mouvement des seconds organes de saisie par rapport à la structure de support.

10. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel les moyens amortisseurs de mouvements sont configurés pour amortir le mouvement des organes de saisie dans deux directions différant l'une de l'autre.

11. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel les moyens amor-

tisseurs de mouvements sont configurés pour déplacer activement les organes de saisie par rapport à la structure de support.

12. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel la structure de support a un bord périphérique, les organes de saisie s'étendant au-delà du bord périphérique, de sorte qu'un objet suspendu au moyen de levage peut pendre vers le bas le long de la structure de support, et les premiers moyens amortisseurs de mouvements agissent parallèlement au bord périphérique.

13. Dispositif (10) selon la revendication 12, dans lequel des seconds moyens amortisseurs de mouvements agissent perpendiculairement au bord périphérique.

14. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel il comprend un moyen de levage avec lequel l'objet peut être soulevé en un point de levage et la construction de saisie est configurée pour entrer en contact avec l'objet suspendu au moyen de levage à une certaine distance du point de levage.

15. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel la structure de support consiste en un navire, en particulier une plateforme autoélévatrice.

16. Dispositif (10) selon l'une quelconque des revendications précédentes, dans lequel l'objet est le monopieu d'une éolienne et la surface du sol, un fond sous-marin.

17. Procédé permettant de placer sur la surface d'un sol un objet (3) élancé, assez grand, ayant un sens longitudinal, étant entendu que le procédé comprend les étapes consistant :

a) à mettre à disposition un objet et un dispositif selon l'une quelconque des revendications précédentes ;
b) à soulever l'objet avec le moyen de levage ;
c) à saisir avec les organes de saisie (23a, b) une partie périphérique de l'objet suspendu au moyen de levage, étant entendu que les organes de saisie sont reliés à la structure de support au moyen de la liaison amortisseuse de mouvements, de sorte que les mouvements des organes de saisie par rapport à la structure de support soient amortis ;
d) à faire descendre l'objet jusque sur ou jusque dans la surface du sol ;
e) à fixer l'objet par rapport à la surface du sol, et
f) à décrocher l'objet du dispositif.

18. Procédé selon la revendication 17, dans lequel, préalablement à l'étape e), on ajuste la position angulaire de l'objet (3) en déplaçant activement les organes de saisie au moyen des moyens amortisseurs de mouvements.

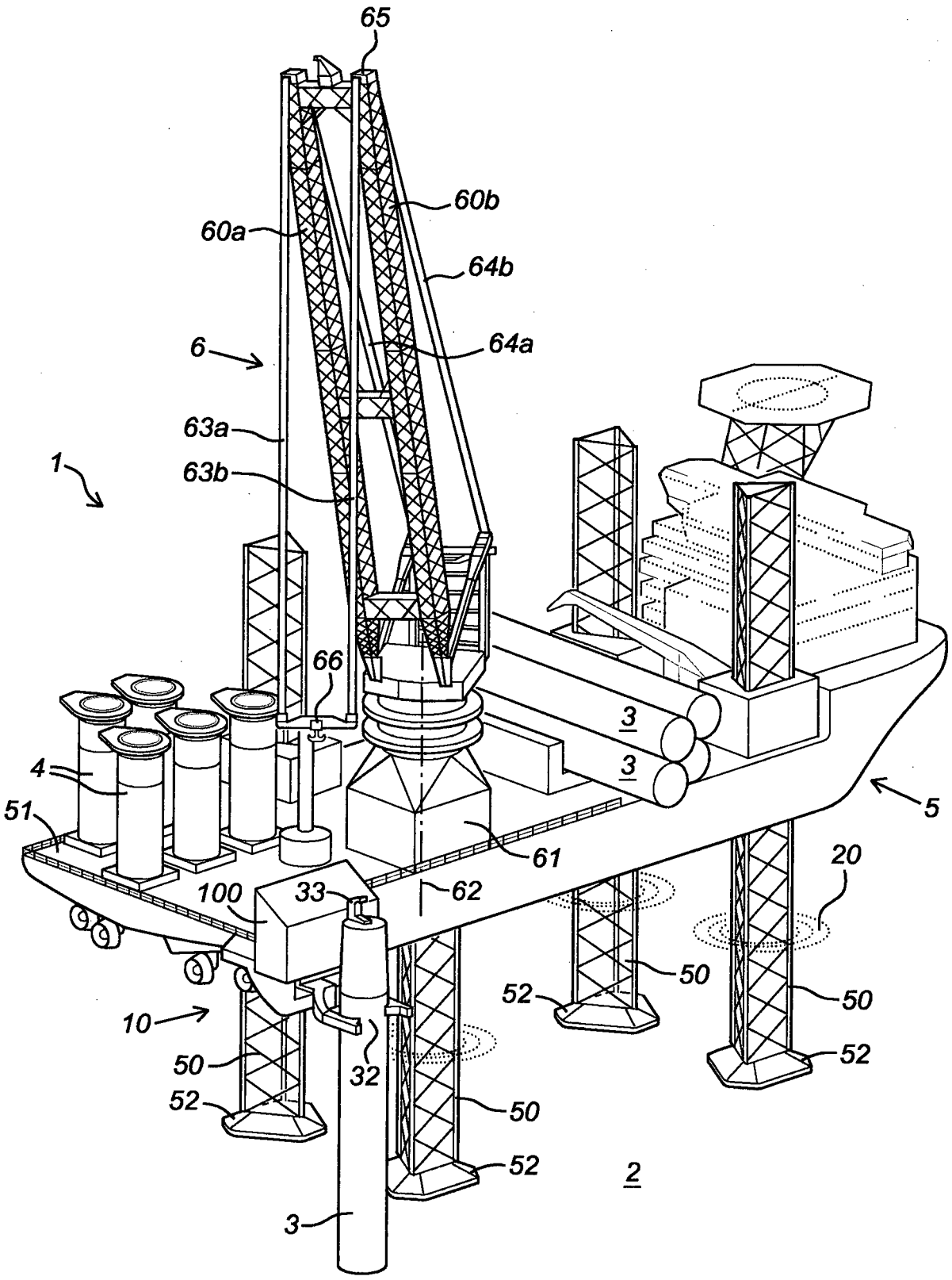
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Fig. 1

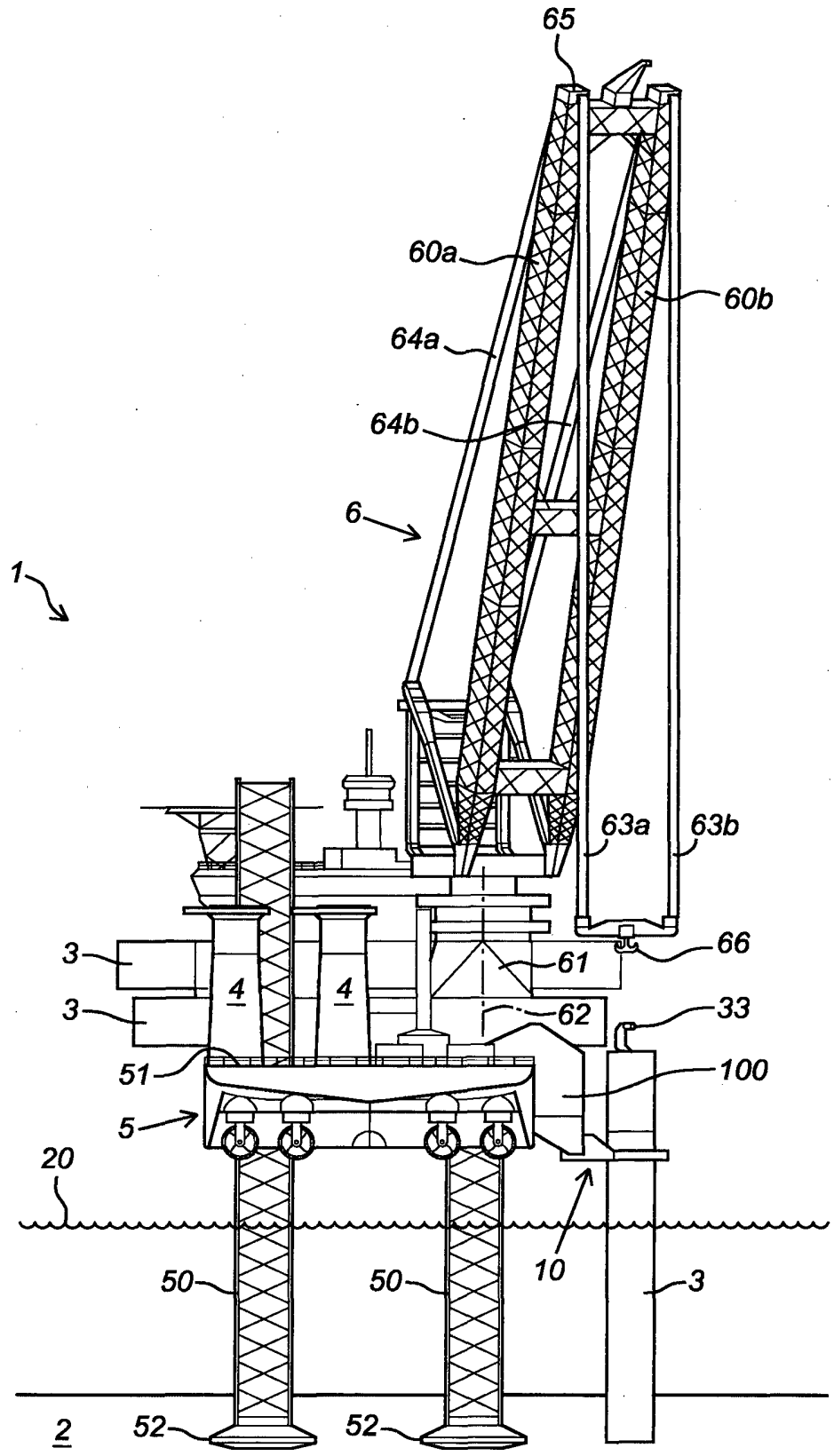
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Fig. 2

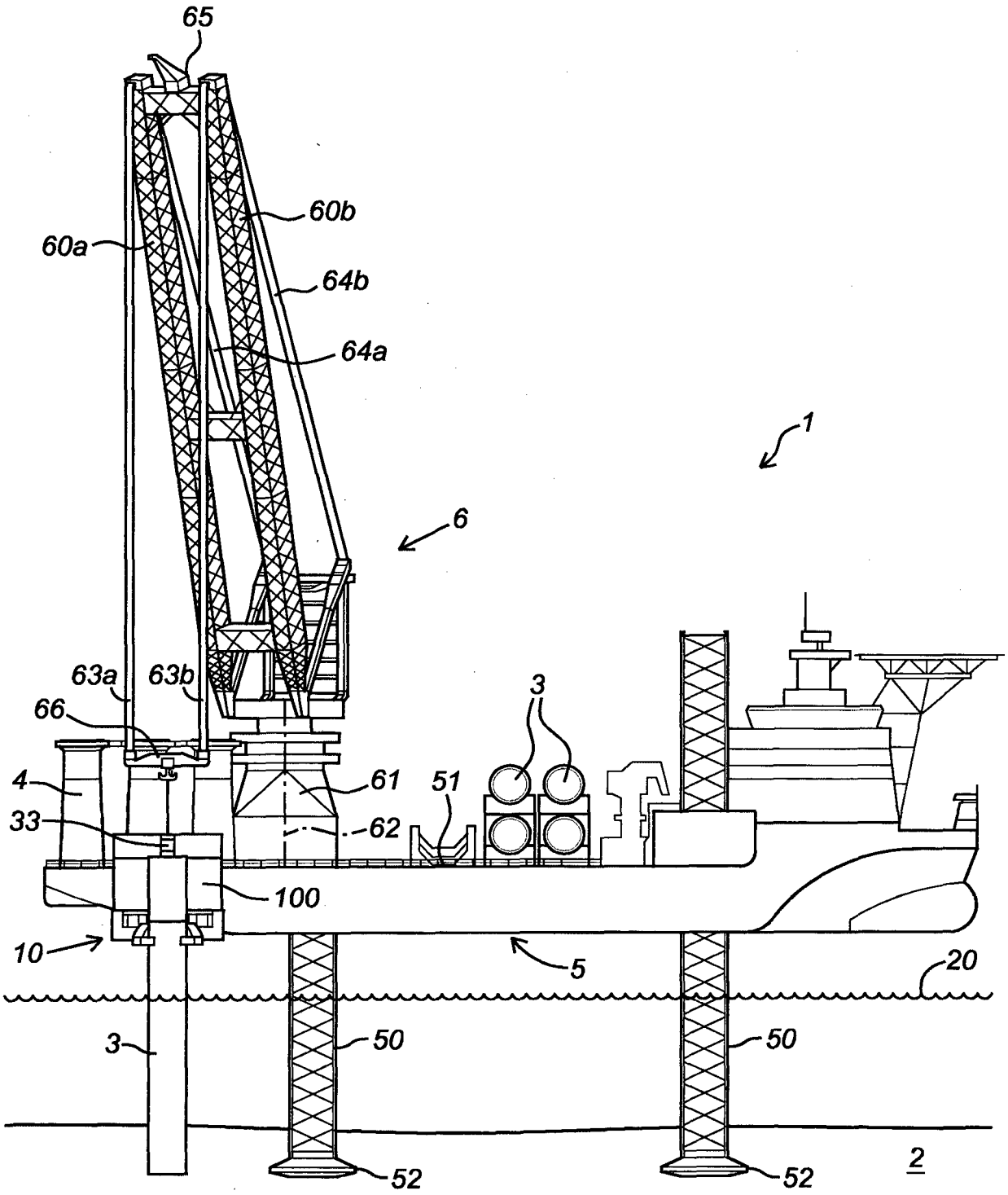
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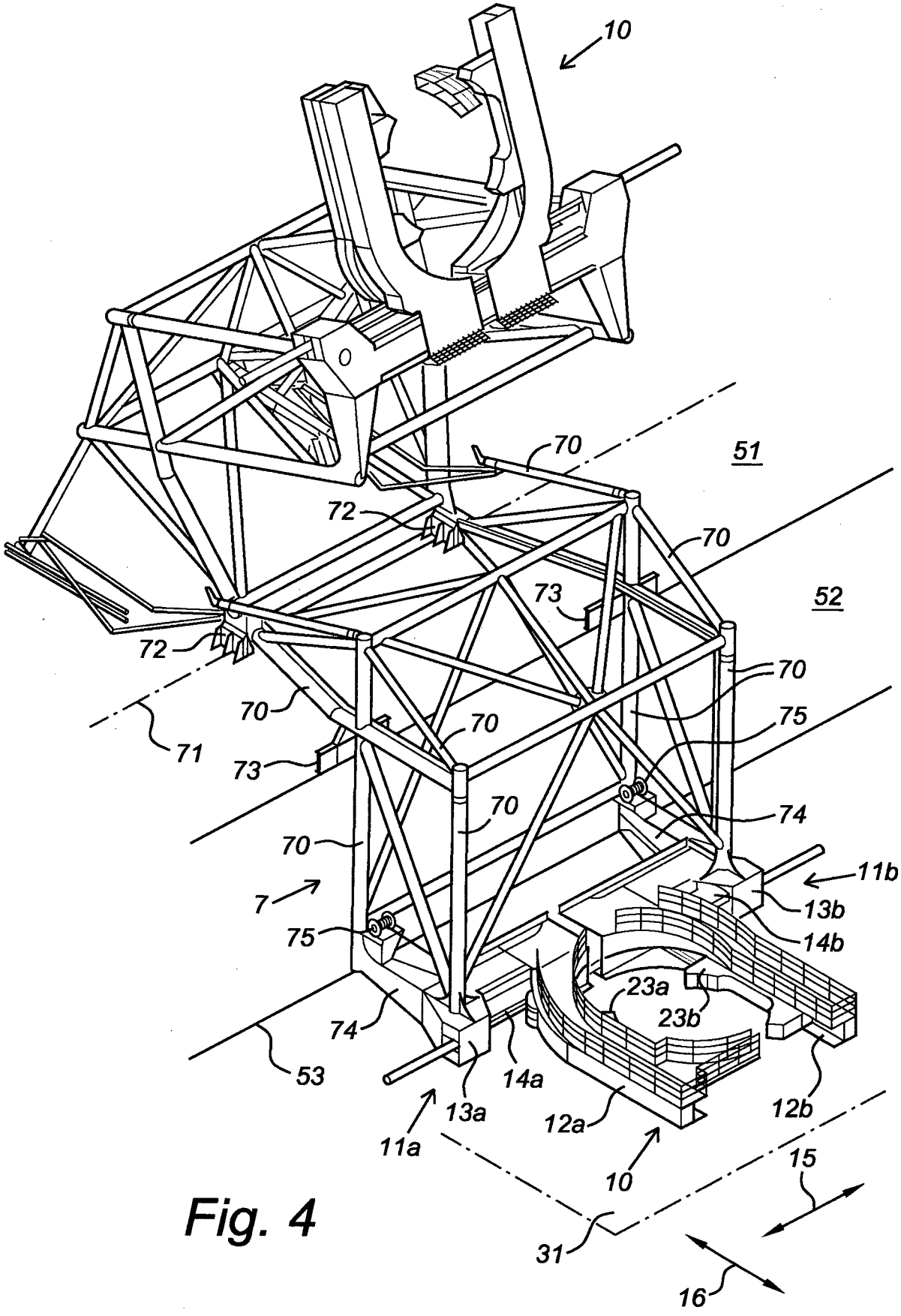
Fig. 3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16

Fig. 4

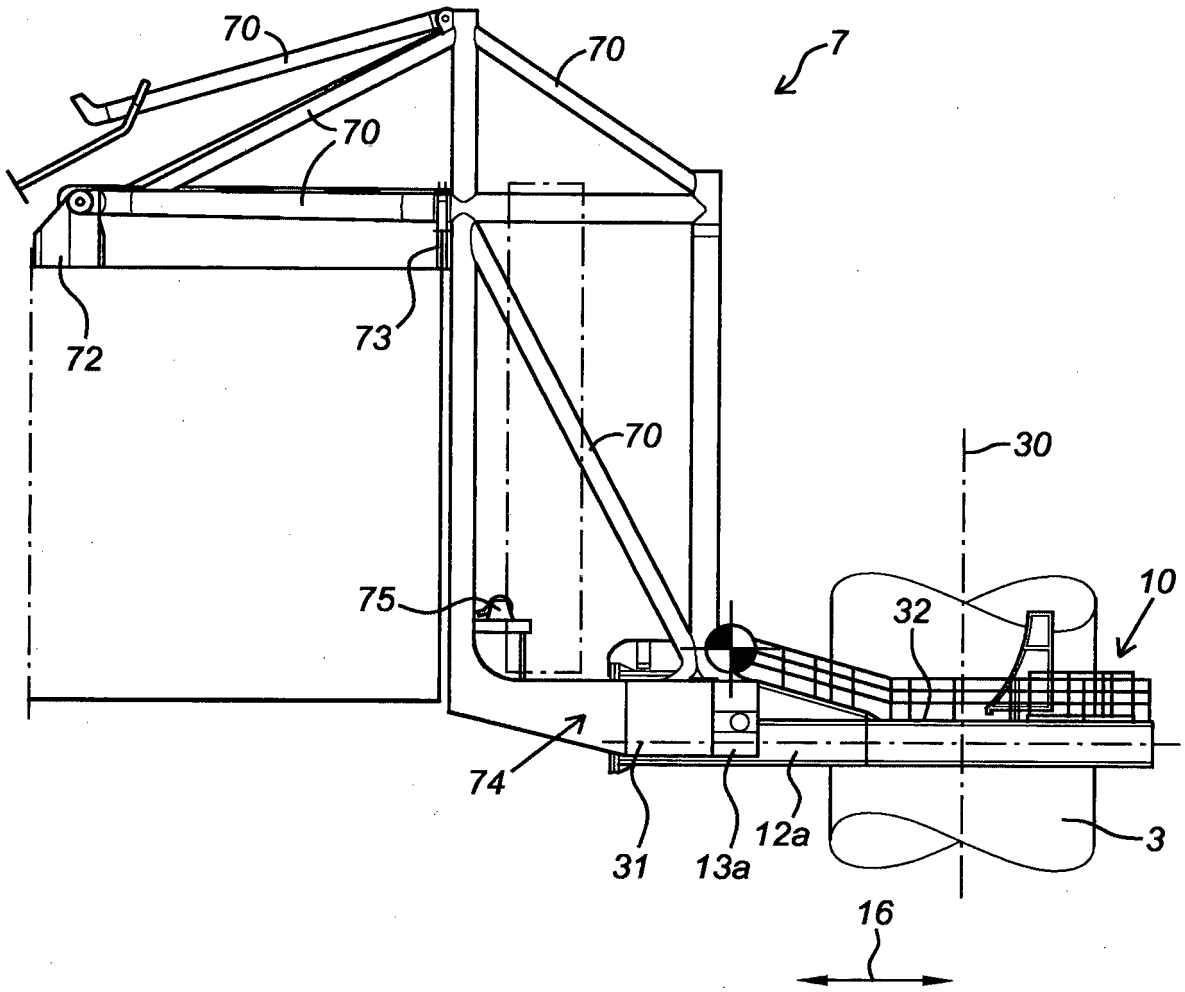
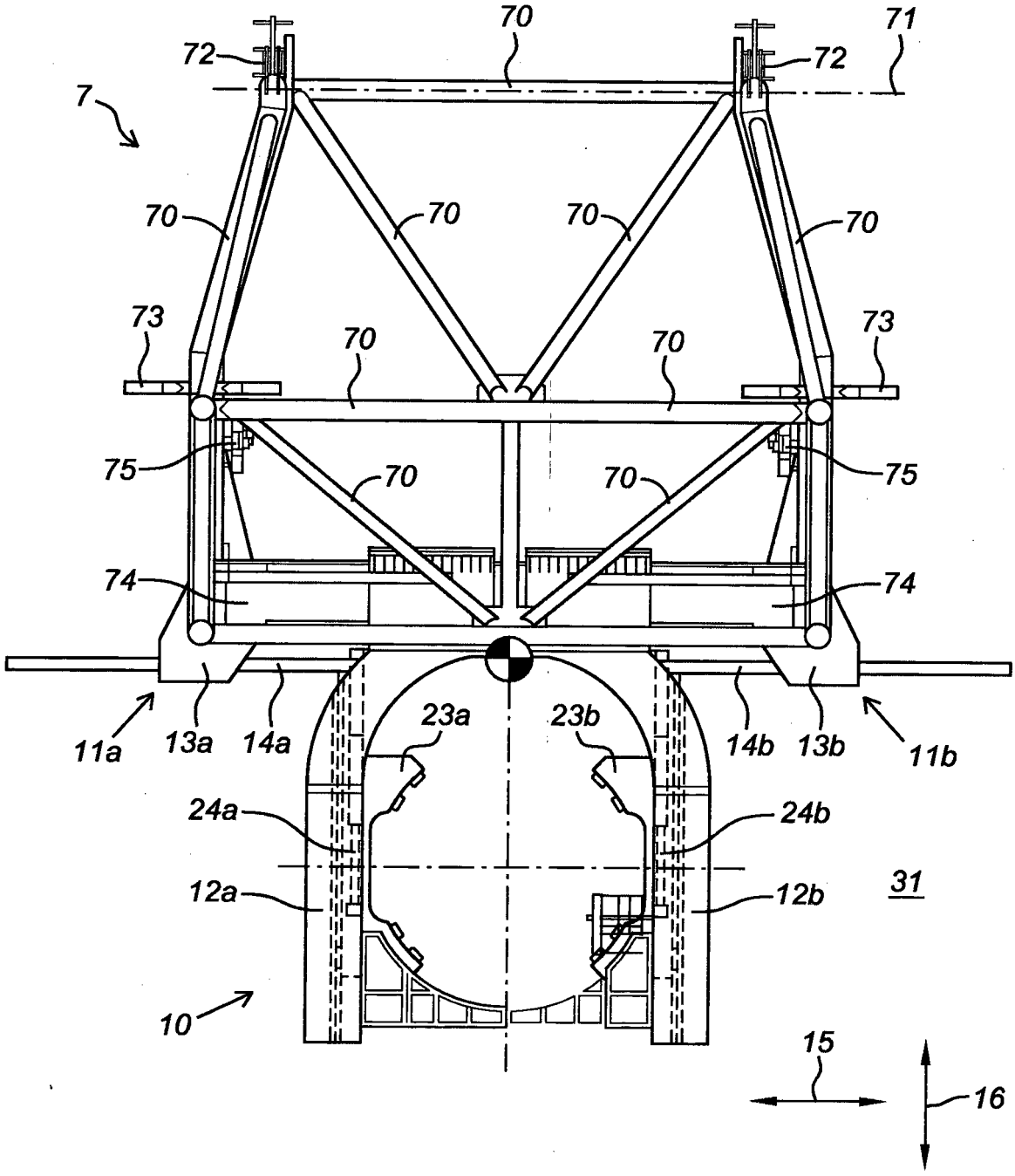


Fig. 5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24b
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12b
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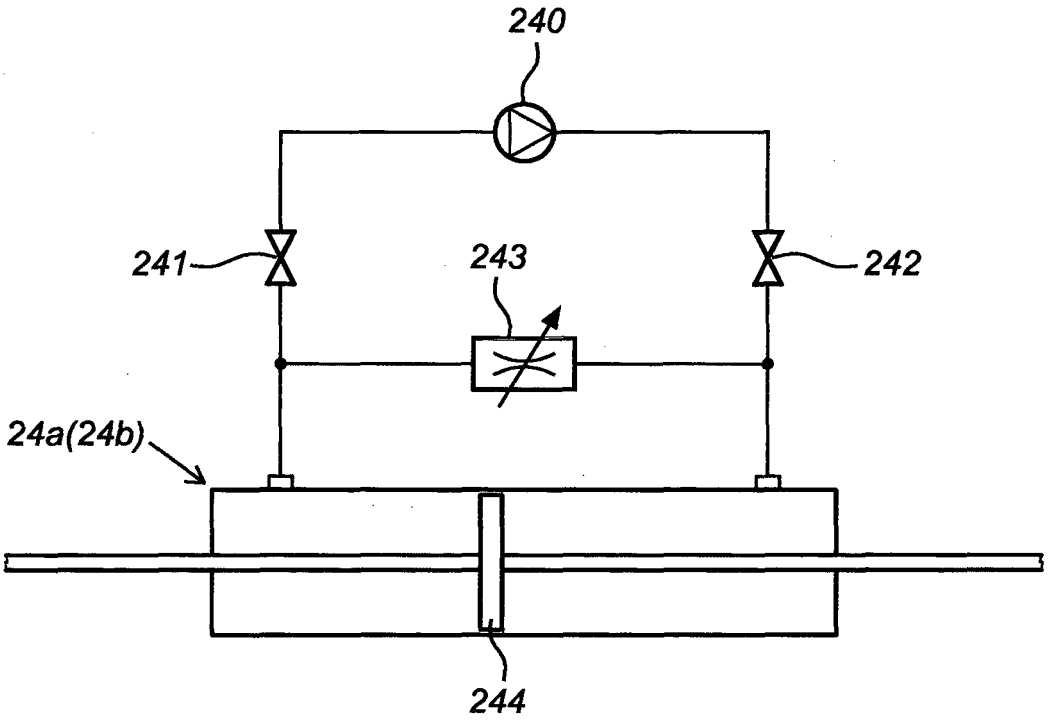
16

Fig. 6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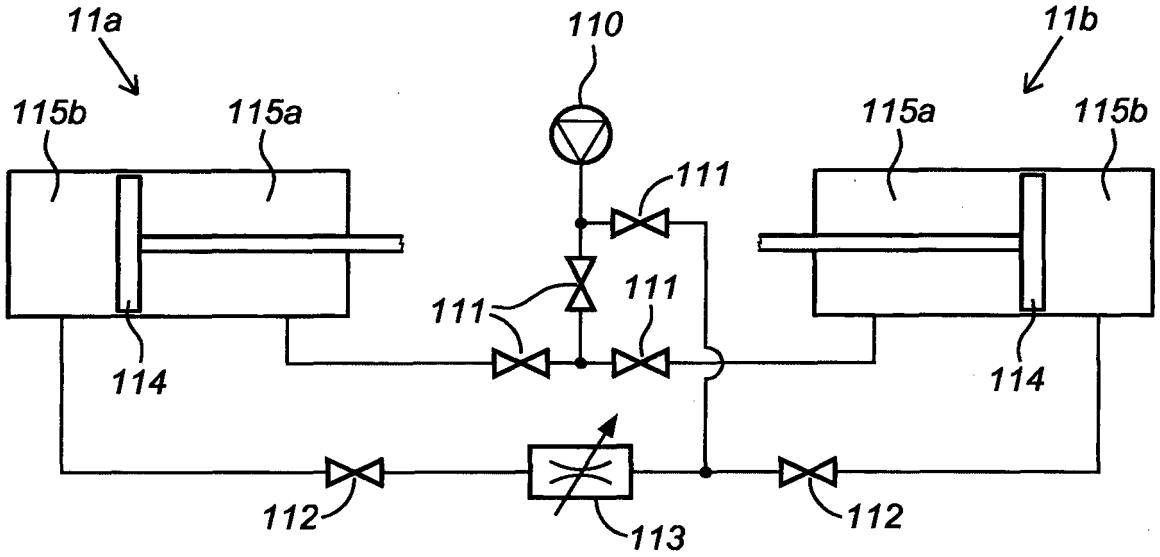
24a(24b)
244

Fig. 7B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112

Fig. 7A

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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