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(71) Applicant: **GeoSea NV**
2070 Zwijndrecht (BE)

(72) Inventor: **Rabaut, Dieter**
9000 Gent (BE)

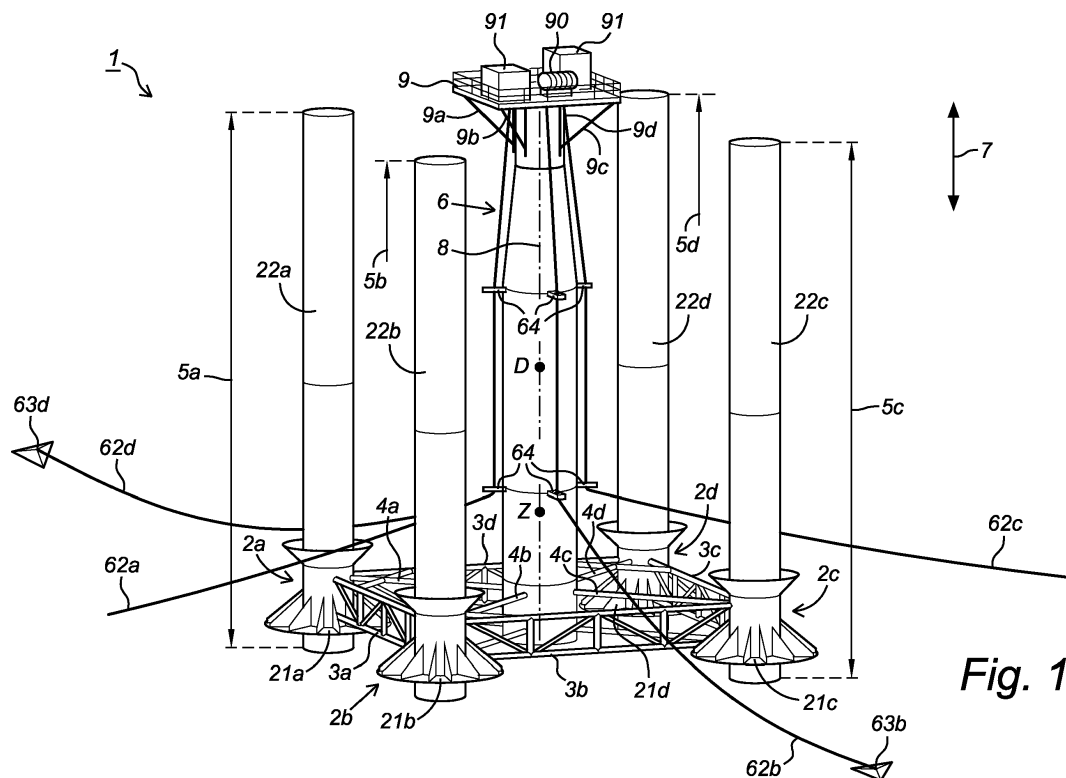
(74) Representative: **Brouwer, Hendrik Rogier et al**
Arnold & Siedsma
Bezuidenhoutseweg 57
2594 AC The Hague (NL)

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(54) **Positioneerraamwerk**

(57) The invention relates to a positioning framework for arranging in an underwater bottom foundation piles arranged in a geometric pattern. The positioning framework comprises mutually connected guide tubes arranged in the geometric pattern for the foundation piles, floating means which impart buoyancy to the positioning

framework, and control means which can adjust the buoyancy of the positioning framework. The invention also relates to a method for arranging the foundation piles in an underwater bottom, and an assembly of a floating platform and a positioning framework optionally coupled thereto.



Description

[0001] The invention relates to a positioning framework and a method for arranging in an underwater bottom foundation piles arranged in a geometric pattern. The invention also relates to an assembly of a floating platform and the positioning framework with which the method can be performed.

[0002] The invention will be elucidated hereinbelow with reference to an offshore wind turbine. The reference to a wind turbine does not imply that the invention is limited to the use in the context of such a wind turbine. The positioning framework and the method can likewise be applied on any other structure, such as jetties, radar and other towers, platforms and the like. The support structure of a wind turbine normally has a slender design, for instance in the form of a tube or pillar. This pillar structure has to be coupled to a foundation in the ground. For offshore wind turbines, which are placed in relatively shallow water, it is possible to make use of one mast extending from the machinery housing of the wind turbine to the foundation. In addition to such a monopile construction, the support structure of an offshore wind turbine can also comprise a tubular upper part and a lower part in the form of a lattice structure, also referred to as a jacket. A large part of the jacket extends underwater, where the jacket finds support on a foundation arranged in the underwater bottom.

[0003] A known method for arranging foundation piles in an underwater bottom makes use of an offshore platform which is fixed relative to the underwater bottom by means of spud poles resting on the underwater bottom. A positioning framework is then lowered from the platform onto the underwater bottom. A known positioning framework comprises mutually connected guide tubes for foundation piles arranged in a geometric pattern. The foundation piles are subsequently carried through the guide tubes using a crane present on the platform and driven into the underwater bottom, for instance with pile-driving means. Once all foundation piles have been arranged in the underwater bottom, the jacket is arranged on the formed foundation by arranging legs of the jacket in the piles (also referred to as pin piling) or around the piles (also referred to as sleeve piling). The foundation piles and the legs of the jacket are configured to bring about a mutual connection. Hollow foundation piles are for instance thus provided in the case of pin piling, and hollow legs of the jacket in the case of sleeve piling.

[0004] It is of great importance to arrange the foundation piles into the underwater bottom at the correct positions and to ensure that the foundation piles are arranged at a precisely determined angle in the underwater bottom. It is thus only possible in many cases to allow a maximum angular deviation of 1° relative to the vertical direction. Use is therefore made in the known method of a platform and positioning framework resting on the underwater bottom.

[0005] The known method is however less suitable

when a foundation must be formed in a relatively soft underwater bottom. Due to the reduced load-bearing capacity of at least an upper layer of the underwater bottom there is the risk of the platform and/or positioning framework sinking into the upper layer, which is undesirable.

[0006] The invention has for its object to provide a device and method for arranging foundation piles in accurate manner in an underwater bottom with reduced load-bearing capacity.

[0007] The invention provides for this purpose a positioning framework for arranging in an underwater bottom foundation piles arranged in a geometric pattern, comprising mutually connected guide tubes arranged in the geometric pattern for the foundation piles, floating means which impart buoyancy to the positioning framework, and control means which can adjust the buoyancy of the positioning framework. The floating means not only impart a buoyancy to the positioning framework, whereby the positioning framework can be transported relatively easily in floating manner to a desired location, but also allow the positioning framework to be positioned at different depths underwater by means of the control means. It is thus possible for instance to carry the positioning framework to a small height above the underwater bottom without it supporting on the underwater bottom. In order to enable accurate positioning of the positioning framework it is no longer necessary according to the invention to have the positioning framework rest on the underwater bottom. Using the invented positioning framework it becomes possible to arrange foundation piles in an underwater bottom with at least an upper layer which has relatively little load-bearing capacity. Possible sinking of a positioning framework placed on an underwater bottom is likewise reduced or even prevented.

[0008] A further advantage of the invented positioning framework is the relatively small amount of space it occupies. It is indeed not necessary to provide the positioning framework with wide foot supports in order to prevent sinking into the underwater bottom. The positioning framework can therefore advantageously be applied at locations where relatively little space is available.

[0009] The positioning framework according to the invention preferably comprises a lattice structure with a number of guide tubes which are disposed spaced apart at the corner points thereof and which are connected by tubular lattice elements. In a preferred embodiment of the device the floating means are accommodated rigidly in the positioning framework. The floating means can for instance be connected herein to the guide tubes with lattice elements.

[0010] In an embodiment suitable floating means comprise a preferably rigid floating body with an internal cavity. The rigid floating body ensures that the positioning framework can be positioned in stable manner under water.

[0011] A further preferred embodiment comprises a positioning framework, the control means of which comprise means for supplying a medium to the internal cavity

of the floating body and/or discharging a medium from the internal cavity. It will be apparent that the skilled person has a number of control means at his disposal for the above stated purpose. Suitable control means comprise supply and/or discharge means in the form of pump means and/or valves in a wall of the floating body. The buoyancy of the positioning framework can for instance be reduced by supplying to an internal cavity of the floating body a medium with a density at least equal to the density of water, preferably water itself. This can take place in suitable manner by opening a valve in a wall of the floating body, whereby ambient water flows into the internal cavity of the floating body. The valve is closed again when the desired depth position has been reached. The buoyancy can be increased by supplying to the internal cavity of the floating body a medium with a density lower than the density of water and/or discharging from the internal cavity a medium with a density at least equal to the density of water. This can take place for instance by pumping compressed air under pressure into the internal cavity, wherein the water present in the internal cavity is brought under pressure. The water can escape from the internal cavity by opening a valve.

[0012] A floating state of the positioning framework is understood in the context of this application to mean a position in which a greater part of the positioning framework is situated above water and a smaller part under water. An immersed state of the positioning framework is understood to mean a position in which a greater part of the positioning framework is situated under water. The operative state is understood to mean a position in which the positioning framework is situated substantially wholly under water, with the possible exception of top portions of the guide tubes and the floating body.

[0013] The floating body can comprise one internal cavity or a plurality of mutually separated internal cavities. Provided in a suitable embodiment of the invention is a positioning framework in which the floating body is divided into a number of mutually connected, closable internal cavities. It hereby becomes possible to more precisely control the depth position of the positioning framework under water.

[0014] The dimensions of the positioning framework in the plane are in principle greater than the dimensions out of the plane, wherein the direction out of the plane corresponds to a direction parallel to the lowering direction of the positioning framework. The guide tubes are configured to receive and guide the foundation piles for arranging in the underwater bottom and preferably comprise cylindrical casings, the longitudinal axis of which runs parallel to the direction of the positioning framework out of the plane. The guide tubes are arranged in a geometric pattern, wherein this pattern corresponds to the desired geometric pattern of the foundation piles. The tubular lattice elements extending between the guide tubes and the floating body ensure that the guide tubes and the floating body remain substantially in position during raising and lowering of the positioning framework. It

is optionally possible to make the positioning framework geometrically adaptable, for instance by applying lattice elements adjustable in length.

[0015] In an embodiment the positioning framework comprises measuring means configured to determine the inclination of the positioning framework and/or the height position of foundation piles arranged in the underwater bottom. It is also possible to equip the positioning framework with drive means such as for instance thrusters in order to enable an accurate positioning.

[0016] A further preferred embodiment comprises a positioning framework in which the floating body is formed such that the centre of buoyancy of the positioning framework lies above the centre of gravity of the positioning framework, at least in floating state, and preferably also in immersed state, most preferably in the operative state. The centre of buoyancy of a body is understood to mean the geometric centre of gravity of that part of the body located underwater. This corresponds to the centre of gravity of the water mass displaced by the body. It is noted that the degree to which (the internal cavity (cavities) of the floating body of) the positioning framework is filled will differ in the floating and the immersed states, so also the position of the centre of gravity and centre of buoyancy.

[0017] An embodiment of the invention relates to a positioning framework in which the floating body comprises an elongate body, a longitudinal axis of which extends substantially parallel to a central axis of the guide tubes. It is advantageous for the longitudinal axis of the floating body to run through the centre of gravity of the positioning framework. This can be realized in simple manner by accommodating the floating body centrally in the positioning framework. It is also possible to accommodate a plurality of floating bodies in the positioning framework. This achieves that the positioning framework only moves minimally under the influence of the action of waves and current.

[0018] Another embodiment relates to a positioning framework in which the guide tubes comprise an elongate body of a length such that they extend above the water surface during use. This embodiment has the advantage that it becomes simpler, from a floating platform and with the positioning framework in an immersed position or position of use, to guide the foundation piles through the guide tubes. The tops of the guide tubes are after all visible to the operator of the crane who has to place the foundation piles.

[0019] In a further preferred embodiment a positioning framework is provided according to the invention in which the guide tubes are sound-damping. This can be achieved for instance by giving the guide tubes a double-walled form and by introducing air between or along both walls, preferably from below. The thus created air bubble curtain ensures that the sound waves occurring during arranging of the foundation piles in the underwater bottom are damped. This is favourable for organisms living in the surrounding area. In this embodiment the guide

tubes preferably extend from the underwater bottom to a position above the water surface. In a suitable embodiment the guide tubes are therefore height-adjustable relative to other parts of the positioning framework, such as for instance the lattice elements and/or the floating body. The guide tubes can have the desired height, although it is also possible to provide the positioning framework with guide tubes of a relatively small height, and to adapt the height of the guide tubes by arranging extension tubes of a greater length therein or by connection thereof in other manner. In this embodiment the extension tubes can take a sound-damping form in accordance with the above stated principles.

[0020] The invention also relates to an assembly of a floating platform and a positioning framework according to the invention optionally coupled to the platform. It is possible to suspend the positioning framework from a number of traction cables from the platform, wherein the cables can be varied in length by for instance winches arranged on the work deck of the platform. The cable length can be shortened or lengthened using the winches, wherein the positioning framework is respectively lifted or lowered from the platform. The positioning framework can optionally be coupled here to the platform. The positioning framework is preferably aligned substantially horizontally in the position of use. This can for instance take place by suspending the positioning framework by means of three, and preferably by means of four cables, wherein each cable can be varied in length independently of the other cables by winches. This is particularly important because the positioning framework preferably does not rest completely on the underwater bottom.

[0021] The advantages of the positioning framework according to the invention are most clearly manifest when the positioning framework is lowered independently of the platform. The platform preferably comprises a floating platform without spud poles. Such an embodiment provides an assembly which need not rest on the underwater bottom, so that the load-bearing capacity of the underwater bottom is not a particular factor and the device and method according to the invention are also readily applicable in the case of underwater bottoms with a relatively soft upper layer. The positioning framework preferably comprises anchor means here for connecting the positioning framework to the underwater bottom so that it remains in its place and can be positioned accurately.

[0022] In an embodiment the anchor means comprise traction cables which run via guide means mounted on the floating body and which can be tightened by means of winches and comprise an anchor on an outer end. In an embodiment the winches and other auxiliary means such as for instance the pump means, in addition to the control for possible valves and the like are situated on a support floor which is connected to the floating body on an upper side thereof and is held above water level during use.

[0023] The invention also relates to a method for arranging in an underwater bottom foundation piles ar-

ranged in a geometric pattern for the purpose of manufacturing a foundation for a mass situated at height, such as the jacket of a wind turbine or a jetty. The invented method comprises of providing a positioning framework according to the invention or an assembly thereof with a floating platform, decreasing the buoyancy of the positioning framework by means of the control means so that it is lowered from a high position to a lower position onto or into the immediate vicinity of the underwater bottom; and driving the piles into the underwater bottom through the guide tubes of the positioning framework in the lower position.

[0024] The method more particularly comprises of firstly establishing the position for at least one foundation pile and positioning the positioning framework using the floating body and the anchor means such that at least one guide tube of the positioning framework is situated directly above said pile position. In an embodiment the positioning framework is connected to the underwater bottom by means of anchor means. The arranging of a first pile through the at least one guide tube fixes the positioning framework. The positioning framework can likewise be fixed by lowering the guide tubes, optionally in co-action with the anchor means, without it being necessary to arrange a first pile through a guide tube. In a fixed position the guide tubes for the other piles will be automatically located in their correct positions since their relative positions are defined by the geometric design of the positioning framework. A position determination for each individual pile is hereby no longer necessary.

[0025] It is advantageous that the work deck of the platform be provided with at least one opening (also referred to as moon pool) which is configured for passage of a pile and which is vertically aligned with one of the guide tubes of the positioning framework, wherein an assembly of platform and positioning framework is positioned such that the opening is located directly above said pile position and is aligned with one of the guide tubes.

[0026] In an embodiment of the method according to the invention the guide tubes extend above the water surface in the lower position of the positioning framework. This enhances accurate insertion of the foundation piles into the guide tubes.

[0027] The foundation piles can be arranged in the underwater bottom in any manner, such as for instance by means of a pneumatic or hydraulic hammer, generally from the platform.

[0028] Once the foundation piles have been arranged in the underwater bottom, the positioning framework can if desired be removed by being lifted with lifting means present on the platform, but preferably by increasing the buoyancy of the positioning framework so that it rises from the lower position to a higher position, optionally a position corresponding to the floating state of the framework. The buoyancy also ensures that the guide tubes are released. The positioning framework can if desired be transported away in the floating state.

[0029] The invention further relates to a method for in-

stalling on a foundation a mass located at height, such as the jacket of a wind turbine or a jetty, wherein the foundation comprises a number of foundation piles arranged by means of the above described method in an underwater bottom, the method comprising of arranging legs of the mass located at height into or around the piles and anchoring the legs to the foundation piles by means of grouting.

[0030] The method according to the invention is particularly suitable for application with cylindrical (optionally) hollow foundation piles having an outer diameter of at least 1.2 m, more preferably at least 1.5 m, and most preferably at least 1.8 m, and with an (optional) wall thickness of 0.01 to 0.1 m, more preferably of 0.02 to 0.08 m, and most preferably of 0.04 to 0.06 m.

[0031] The method according to the invention is further particularly suitable for cylindrical (hollow) foundation piles with a length of more than 20 m, more preferably at least 25 m and most preferably at least 30 m, and a weight of 20 to 250 tonnes, more preferably of 60 to 200 tonnes and most preferably of 75 to 180 tonnes.

[0032] The invention will now be elucidated in more detail with reference to the drawings, without otherwise being limited thereto. In the figures:

Fig. 1 is a schematic perspective view of an embodiment of the positioning framework according to the invention;

Fig. 2 is a schematic side view of the embodiment shown in figure 1 of the positioning framework according to the invention with raised extension tubes;

Fig. 3 is a schematic side view of the embodiment shown in figure 1 of the positioning framework according to the invention with lowered extension tubes;

Fig. 4 and 5 are schematic side views of a number of embodiments of the positioning framework;

Fig. 6-11 are schematic side views of a number of embodiments of method steps for arranging foundation piles in an underwater bottom through the guide tubes of the positioning framework in the position of use; and

Fig. 12 shows schematically a jacket of a wind turbine placed according to the invention on a foundation of piles.

[0033] A positioning framework 1 according to the invention is shown with reference to figure 1. In the shown embodiment positioning framework 1 comprises at corner points four cylindrical guide tubes (2a, 2b, 2c, 2d) configured to receive and guide a pile. Guide tubes (2a, 2b, 2c, 2d) are rigidly connected to each other by side lattices (3a, 3b, 3c, 3d) which are constructed from tubular structural elements. Cross braces (4a, 4b, 4c, 4d) connect guide tubes (2a, 2b, 2c, 2d) rigidly to a central floating body 6, whereby the lattice gains structural stiffness. Additional lattice elements can be added if desired in order to build up sufficient stiffness.

[0034] Guide tubes (2a, 2b, 2c, 2d) are held in a fixed position relative to each other by side lattices (3a, 3b, 3c, 3d) and cross braces (4a, 4b, 4c, 4d), this such that guide tubes (2a, 2b, 2c, 2d) are arranged in a geometric pattern, this pattern being in the embodiment shown in figure 1 a quadrilateral with a side of about 20 m. Any other geometric pattern is however possible, such as a triangle or other polygon, or for instance a circle.

[0035] Each guide tube (2a, 2b, 2c, 2d) is supported by a base plate (21a, 21b, 21c, 21d) and further comprises a cylindrical extension tube (22a, 22b, 22c, 22d) which if desired is arranged slidably in height direction 7 in guide tube (2a, 2b, 2c, 2d). It is also possible that guide tubes (2a, 2b, 2c, 2d) can slide relative to base plates (21a, 21b, 21c, 21d). Base plates (21a, 21b, 21c, 21d) have a movement-damping function. Shown in figures 2 and 3 for instance is that extension tubes 22b and 22c (tubes 22a and 22d are not visible) are in an elevated position (figure 2) relative to guide tubes 2b and 2c and in figure 3 are in a lowered position. In the lowered position the extension tubes (22a, 22b, 22c, 22d) optionally rest on the underwater bottom 30. Extension tubes (22a, 22b, 22c, 22d) each form an elongate body with a length (5a, 5b, 5c, 5d) such that the guide tubes extend in use to a position above water surface 32, as shown for instance in figures 2 and 3. Guide tubes (2a, 2b, 2c, 2d) are sound-damping in the shown embodiment. This can for instance be achieved by giving the extension tubes (22a, 22b, 22c, 22d) a double-walled form and by introducing air between the two walls from below. Air supply means (not shown) are present for this purpose. The length (5a, 5b, 5c, 5d) of extension tubes (22a, 22b, 22c, 22d) can be chosen within broad limits depending on the situation on site, but can for instance amount to 20-30 m and more. It is also possible to embody guide tubes (2a, 2b, 2c, 2d) and extension tubes (22a, 22b, 22c, 22d) as an integral whole.

[0036] The rigid floating body 6 comprises in the shown embodiment an elongate body which extends in height direction 7 and a longitudinal axis 8 of which extends substantially parallel to a central axis of guide tubes (2a, 2b, 2c, 2d). Floating body 6 is accommodated centrally in positioning framework 1, whereby the longitudinal axis 8 of floating body 6 runs through the centre of gravity Z of the whole positioning framework 1. Floating body 6, which is for instance manufactured from metal or concrete, comprises an internal cavity (not shown). Provided on the upper side of floating body 6 is a support floor 9 which is connected by means of pressure-loaded rods (9a, 9b, 9c, 9d) to the casing surface of floating body 6. Situated on support floor 9 are control means which comprise at least pump means 91 for supplying compressed air under pressure to the internal cavity of floating body 6. The peripheral wall and/or the bottom wall of floating body 6 is provided with valves (not shown) for exchanging ambient water between the internal cavity of floating body 6 and the surrounding area. In order to reduce the buoyancy of positioning framework 1 and allow positioning framework 1 to be lowered into the water in the direction

of underwater bottom 30, at least one valve is opened whereby ambient water flows into the internal cavity and positioning framework 1 takes on weight. In order to increase the buoyancy of positioning framework 1 and to carry positioning framework 1 in the direction of water surface 32, compressed air is introduced with pumps 91 from above into the internal cavity of floating body 6. Water hereby escapes from the internal cavity to the outside and the internal cavity is at least partially filled with air. Positioning framework 1 hereby loses weight, whereby it will take up a less deep position.

[0037] In order to enable more accurate adjustment of the height position of positioning framework 1 the floating body 6 is divided in an embodiment into a number of mutually connected, closable internal cavities. In order to fix positioning framework 1 in the desired position it is further provided with anchor means for connecting the positioning framework to underwater bottom 30. In the shown embodiment the anchor means comprise four traction cables (62a, 62b, 62c, 62d) which are anchored on one side to underwater bottom 30 by means of anchors (63a, 63b, 63c, 63d) and which on the other side run over a number of winches 90 which are situated on support floor 9 and with which traction cables (62a, 62b, 62c, 62d) can be taken in or payed out. Traction cables (62a, 62b, 62c, 62d) run through guide means 64 mounted on floating body 6 in order to ensure that the traction cables run as straight as possible. Floating body 6 is formed such that the centre of buoyancy D of positioning framework 1 lies above the centre of gravity Z of positioning framework 1 in an immersed situation. In the case of rocking caused by current the positioning framework 1 will hereby always return to a stable position.

[0038] Referring to figure 4, an embodiment of the method according to the invention is shown, which method is characterized by providing a floating device 10 provided with lifting means in the form of lifting crane 18. Floating device 10 can for instance comprise a vessel, a platform, a pontoon or a number of pontoons, and may or may not be independently driven. Positioning frame 1 with the mutually connected guide tubes (2b, 2c) arranged in a geometric pattern - the other guide tubes 2a, 2d are not visible in figures 4 to 11 - is lowered via crane 18 and hoisting cables 61 into the vicinity of or onto the underwater bottom 30 into a position of use in which positioning framework 1 is anchored to underwater bottom 30. During lowering of positioning framework 1 the floating body can if desired be further filled with water or other ballast in order to add weight to positioning framework 1. It is also possible to lower the positioning framework without using hoisting cables 61.

[0039] Another embodiment is shown in figure 5. Here positioning frame 1 is positioned and/or oriented by providing framework 1 with an assembly of manoeuvrable thrusters 67 which are able to drive positioning framework 1 in a chosen direction, this depending on the direction in which the manoeuvrable thrusters 67 are oriented. Positioning framework 1 can in this way be placed

accurately in the desired position of use.

[0040] Referring to figure 6, an embodiment is shown in which positioning framework 1 is positioned and/or oriented by engaging the framework 1 with traction cables (62a, 62b, 62c, 62d) provided with anchors (63a, 63b, 63c, 63d), these cables being connected to winches 90 present on support floor 9. By anchoring the traction cables 62 in the bottom 30 using anchors 63 the framework 1 can be accurately positioned by taking in and/or paying out the traction cables 62 by means of winches 90. Positioning framework 1 can be held at the desired depth here by partially filling the internal cavity of floating body 6 with air.

[0041] Once positioning framework 1 has been positioned on or preferably at a certain height above underwater bottom 30 as according to the above described embodiments, foundation piles 40 are arranged in bottom 30 through guide tubes (2a, 2b, 2c, 2d) of positioning framework 1 in the position of use.

[0042] A possible embodiment is shown in figure 6. It is noted that in the shown embodiment positioning framework 1 can be situated in front of, behind or under platform 10, and has been lowered independently of platform 10 into a position on or above underwater bottom 30. If positioning framework 1 is situated under platform 10, work deck 11 of platform 10 is then preferably provided with a moon pool 16b. This is not however essential. As shown in figure 6, a lining tube 41 for a foundation pile 40 can be picked up by lifting crane 18 and placed in moon pool 16b of platform 10 above the desired position 33 of the first foundation pile. Should position 33 be located adjacently of platform 10, this step is then not necessary.

[0043] In a subsequent step of the method (see figure 7) a foundation pile 40 is picked up by lifting crane 18 from a storage rack 42 located on work deck 11 and lowered until the underside of pile 40 is situated at the level of the top side of an extension tube 22b, and subsequently lowered therein to a level 43, this level being relatively close to the level of underwater bottom 30 (see figure 8).

[0044] Once foundation pile 40 has been correctly aligned with guide tube 2b provided with extension tube 22b, foundation pile 40 is lowered further and carried under its own weight into underwater bottom 30, during which process foundation pile 30 is guided through guide tube 2c as shown in figure 9. Referring to figure 10, pile 40 is then driven into bottom 30 until the top of foundation pile 40 has penetrated far into guide tube 2b. Foundation pile 40 can be driven into bottom 30 by means of a pneumatic hammer 44 which is situated in extension tube 22b. Because extension tubes (22a, 22b, 22c, 22d) are sound-damping, the surrounding area suffers less inconvenience from the sound waves generated by the pneumatic hammer.

[0045] The above described sequence of method steps is then repeated a number of times, depending on the desired number of foundation piles 40 which must be arranged in underwater bottom 30. Because guide tubes (2a, 2b, 2c, 2d) of positioning framework 1 are automat-

ically situated in the correct positions, all piles can be driven in efficient manner into bottom 30 without losing time in determining the position for each individual pile. Because positioning framework 1 has buoyancy, this framework 1 need not rest on underwater bottom 30 during arranging of foundation piles 40 into underwater bottom 30. This avoids the positioning framework 1 sinking into the upper layer of underwater bottom 30. It is noted that the immersed positioning framework 1 can be held properly in its place by the anchoring during arranging of foundation piles 40. It has been found that framework 1 is affected relatively little by movements generated by current, which may be described as surprising.

[0046] Once all the foundation piles 40 have been arranged in underwater bottom 30, positioning framework 1 can optionally be removed by filling floating body 6 with air. The buoyancy of framework 1 is hereby reduced, whereby it will make its way to the water surface 32. Prior to removal of positioning framework 1 the position of foundation piles 40 and/or the vertical position of the top of each of the foundation piles 40 can if desired be checked using optical means suitable for the purpose, such as cameras.

[0047] Referring to figure 12, a jacket 150 of a wind turbine 151 can be placed on the foundation realized as described above. This can take place for instance by arranging legs 152 of jacket 150 in or around piles 40 and anchoring the legs 152 to piles 40 by means of grouting.

[0048] The method and positioning framework according to the invention allow a pile foundation to be provided in efficient manner in an underwater bottom, at least an upper layer of which has a reduced load-bearing capacity.

Claims

1. Positioning framework (1) for arranging in an underwater bottom (30) foundation piles (40) arranged in a geometric pattern, comprising mutually connected guide tubes (2a, 2b, 2c, 2d) arranged in the geometric pattern for the foundation piles (40), floating means (6) which impart buoyancy to the positioning framework (1), and control means (90, 91) which can adjust the buoyancy of the positioning framework (1), wherein the floating means comprise a rigid floating body with an internal cavity.
2. Positioning framework as claimed in claim 1, wherein the floating means are accommodated rigidly in the positioning framework.
3. Positioning framework as claimed in claim 1 or 2, wherein the control means comprise means for supplying a medium to the internal cavity of the floating body and/or discharging a medium from the internal cavity.

4. Positioning framework as claimed in claim 3, wherein the supply and/or discharge means comprise pump means and/or valves in a wall of the floating body.
5. Positioning framework as claimed in any of the claims 1-4, wherein the floating body is divided into a number of mutually connected, closable internal cavities.
6. Positioning framework as claimed in any of the claims 1-5, wherein the floating body (6) is formed such that the centre of buoyancy (D) of the positioning framework lies above the centre of gravity (Z) of the positioning framework (1).
7. Positioning framework as claimed in any of the claims 1-6, wherein the floating body (6) comprises an elongate body, a longitudinal axis (8) of which extends substantially parallel to a central axis of the guide tubes (2a, 2b, 2c, 2d).
8. Positioning framework as claimed in claim 7, wherein the longitudinal axis of the floating body runs through the centre of gravity of the positioning framework.
9. Positioning framework as claimed in any of the foregoing claims, wherein the guide tubes (2a, 2b, 2c, 2d) comprise an elongate body of a length (5a, 5b, 5c, 5d) such that they extend above the water surface (32) during use.
10. Positioning framework as claimed in any of the foregoing claims, wherein the guide tubes are sound-damping.
11. Positioning framework as claimed in any of the foregoing claims, comprising anchor means for connecting the positioning framework to the underwater bottom.
12. Positioning framework as claimed in claim 11, wherein the anchor means comprise traction cables which run via guide means mounted on the floating body and which can be tightened by means of winches.
13. Assembly of a floating platform (10) and a positioning framework (1) as claimed in any of the claims 1-12 optionally coupled to the platform.
14. Method for arranging in an underwater bottom foundation piles arranged in a geometric pattern, comprising the steps of:
 - providing a positioning framework according to any of the claims 1-12 or an assembly according to claim 13;
 - decreasing the buoyancy of the positioning

framework by means of the control means so that it is lowered from a high position to a lower position onto or into the immediate vicinity of the underwater bottom; and

- driving the piles into the underwater bottom through the guide tubes of the positioning framework in the lower position. 5

15. Method as claimed in claim 14, wherein the buoyancy is reduced by supplying to an internal cavity of the floating body a medium with a density at least equal to the density of water. 10

16. Method as claimed in claim 14 or 15, wherein the buoyancy is increased by supplying to an internal cavity of the floating body a medium with a density lower than the density of water and/or discharging from the internal cavity a medium with a density at least equal to the density of water. 15

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17. Method as claimed in any of the claims 14-16, wherein the guide tubes extend above the water surface in the lower position of the positioning framework.

18. Method as claimed in any of the claims 14-17, wherein the positioning framework is connected to the underwater bottom by means of anchor means. 25

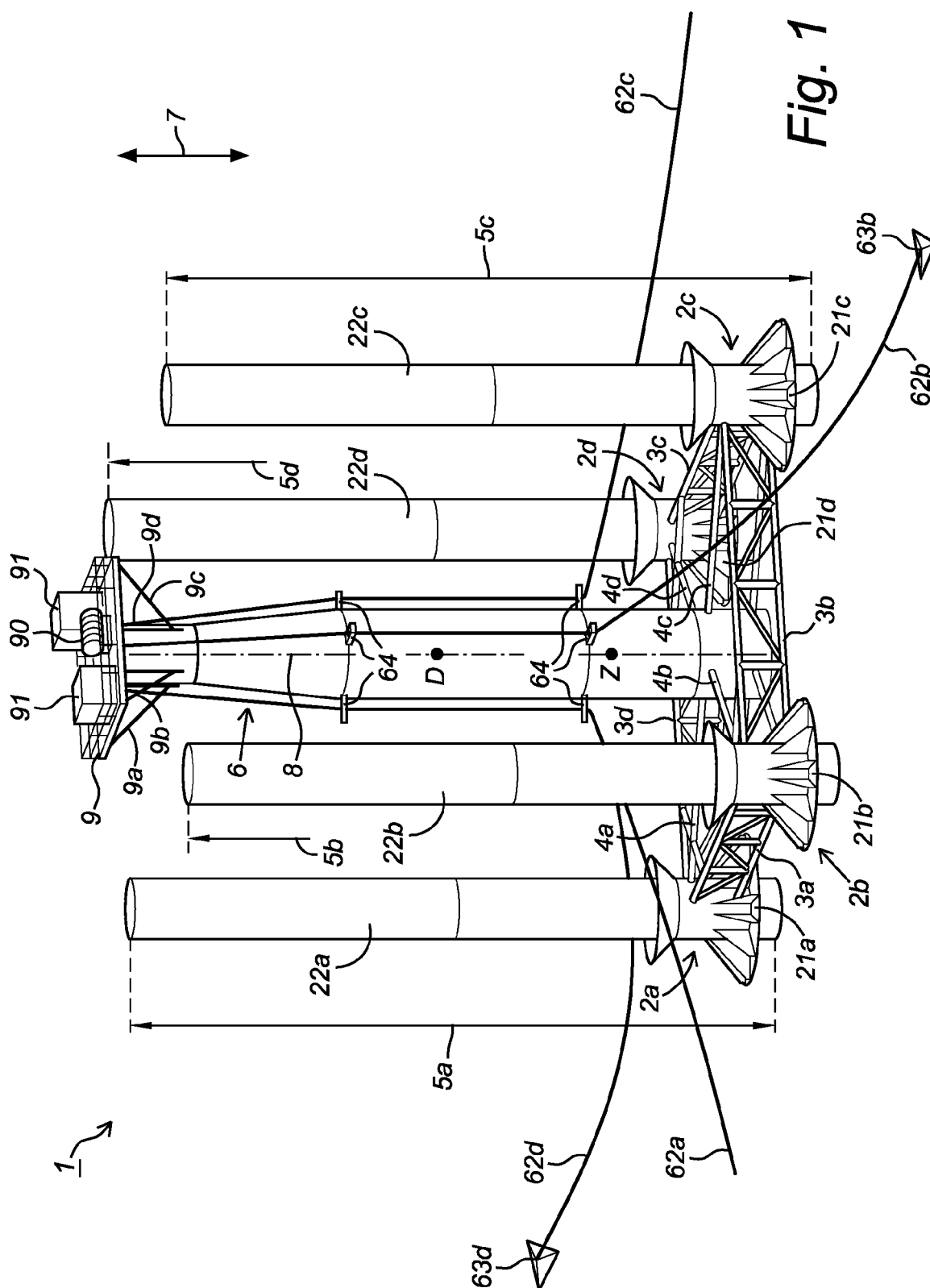
19. Method for installing on a foundation a mass located at height, such as the jacket of a wind turbine or a jetty, wherein the foundation comprises a number of foundation piles arranged by means of the method as claimed in any of the claims 14-18 in an underwater bottom, the method comprising of arranging legs of the mass located at height into or around the foundation piles and anchoring the legs to the foundation piles by means of grouting. 30 35

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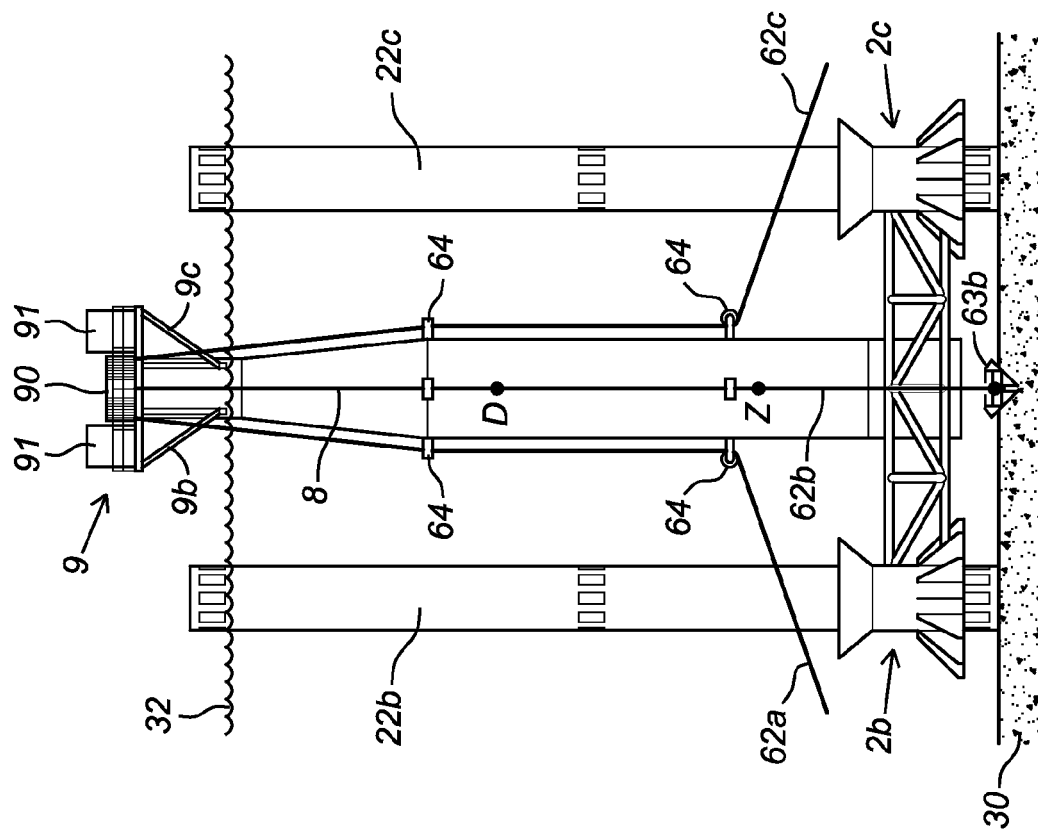


Fig. 3

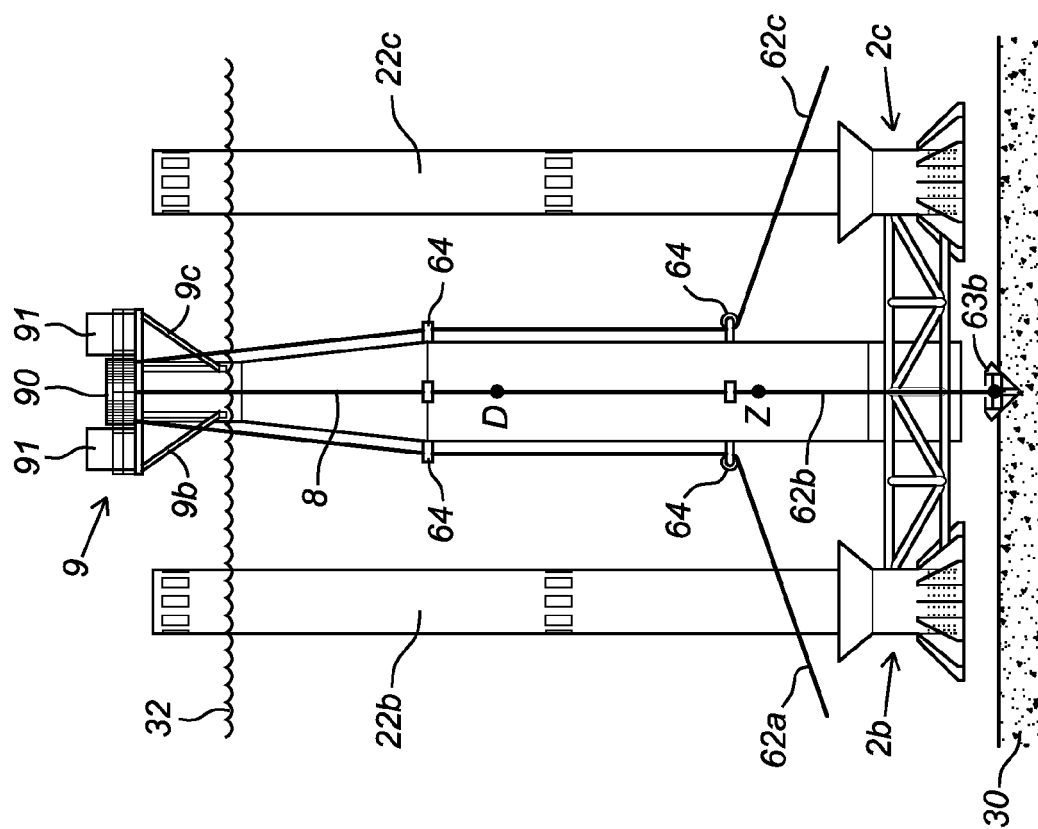


Fig. 2

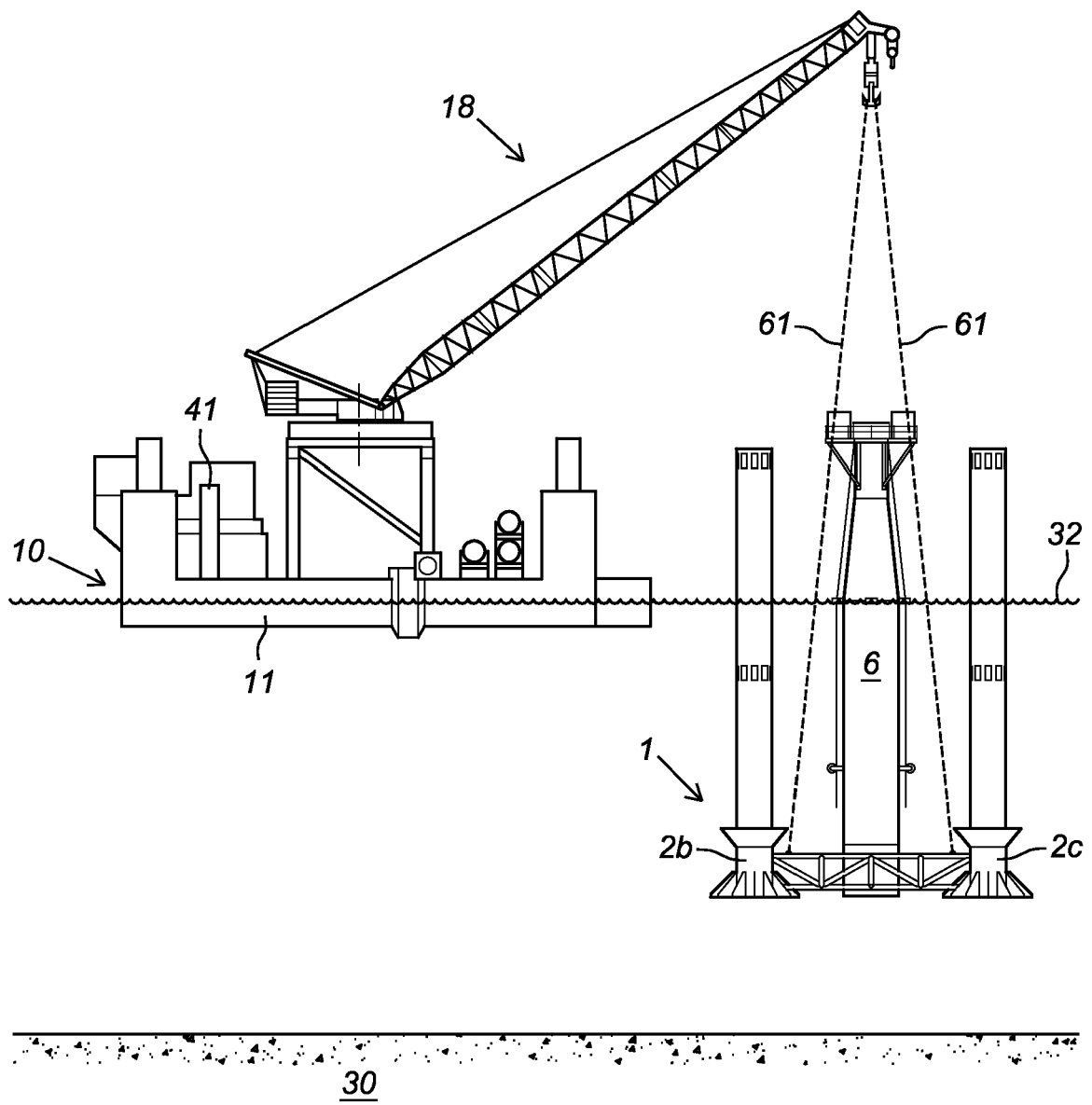


Fig. 4

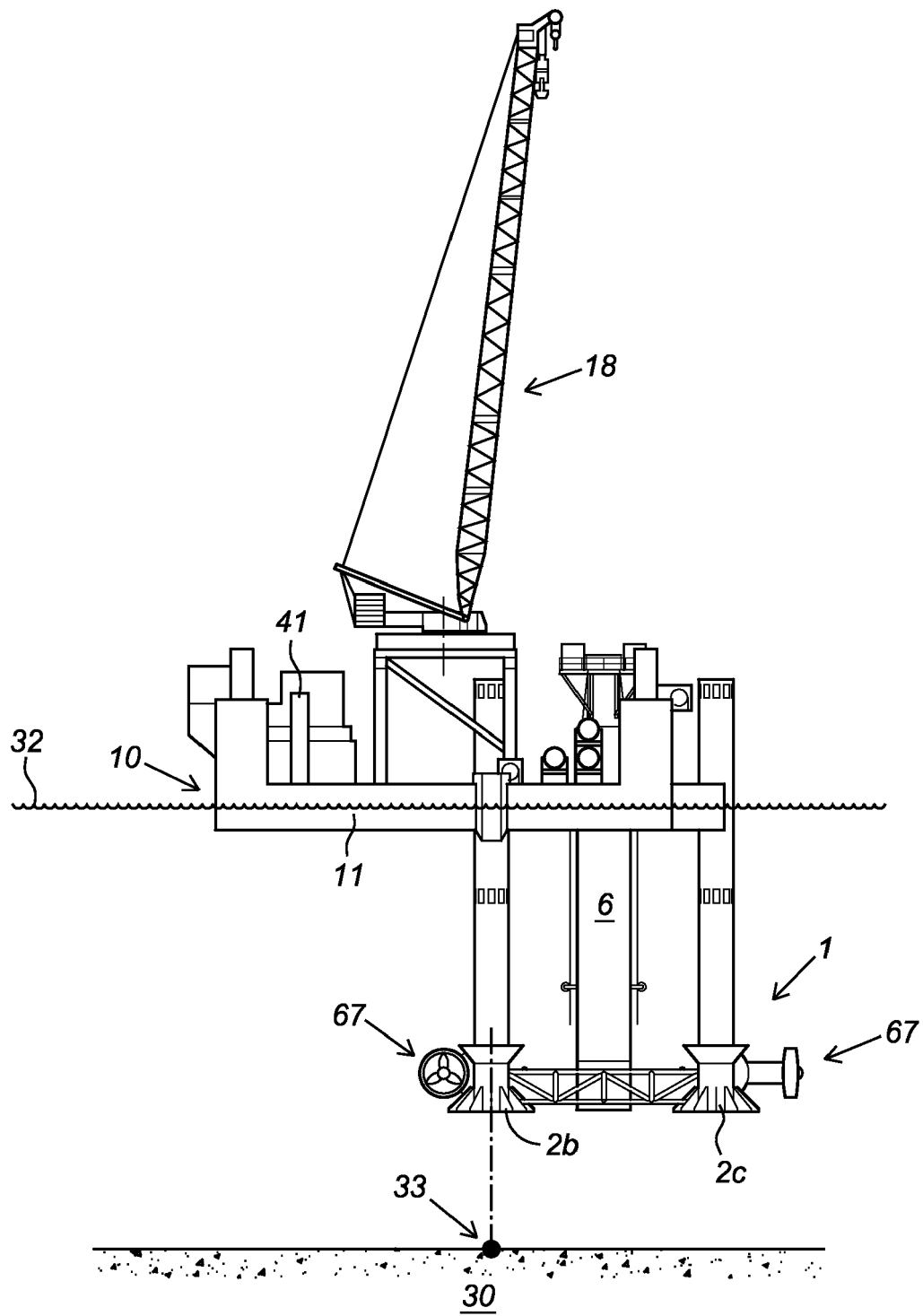


Fig. 5

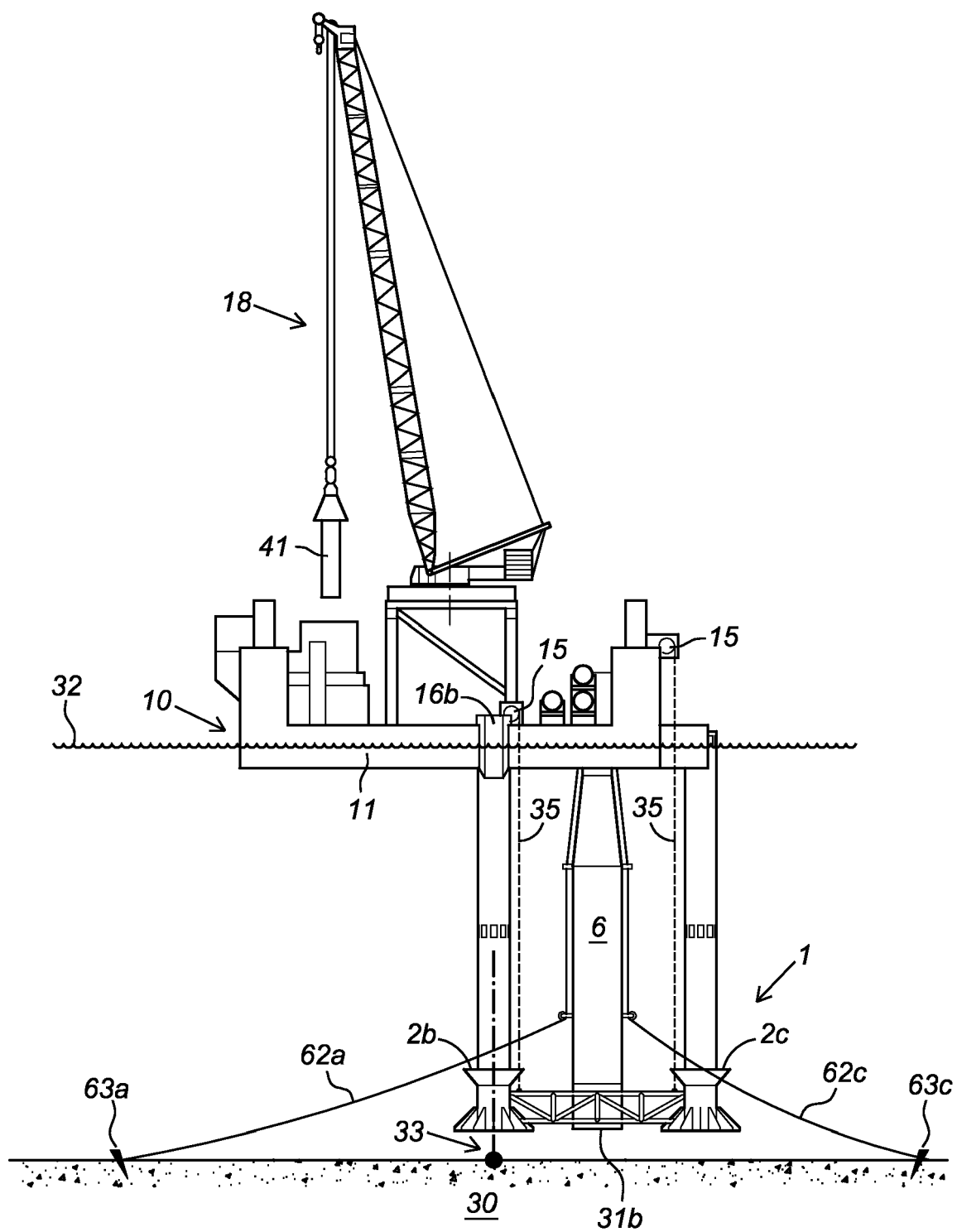


Fig. 6

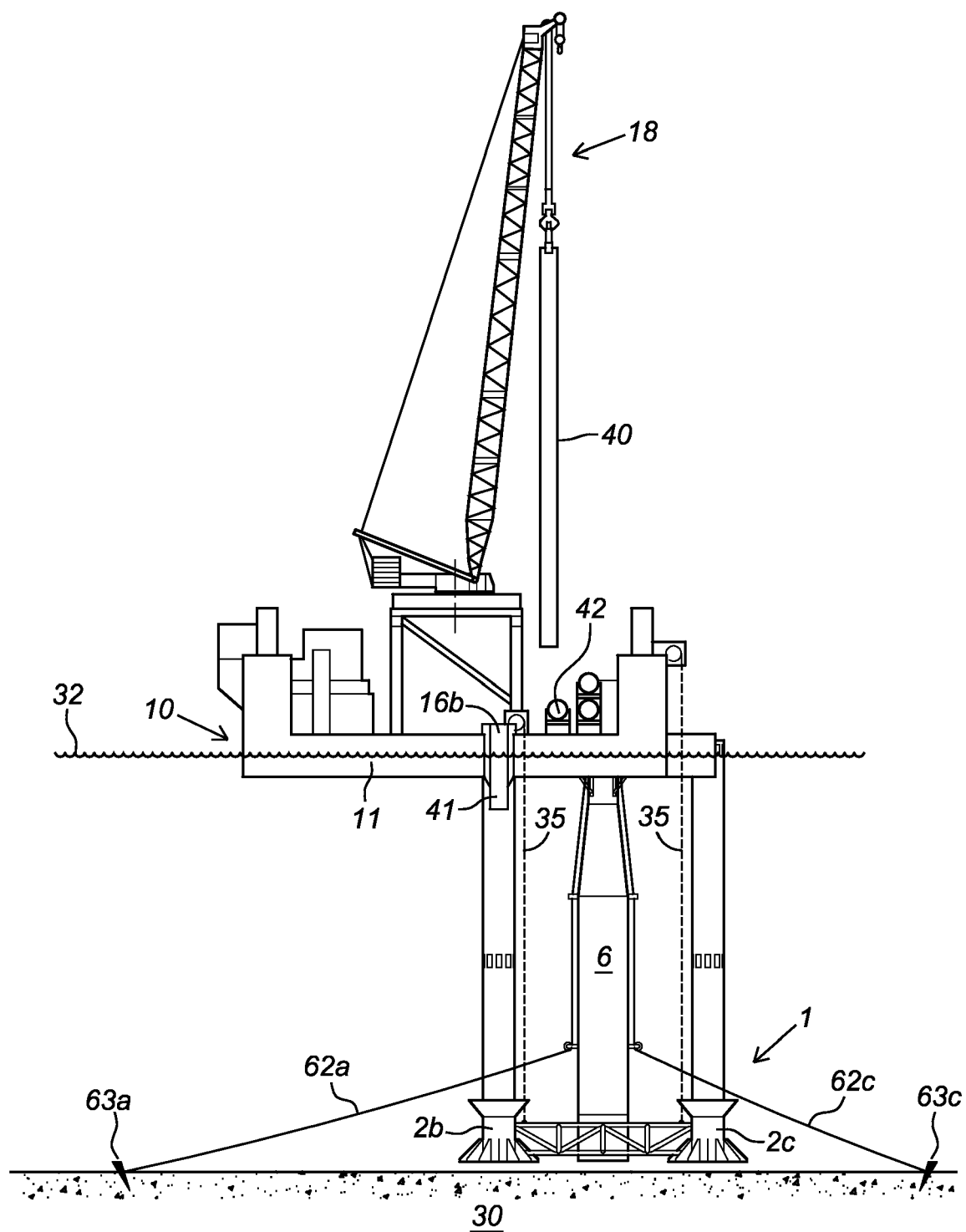


Fig. 7

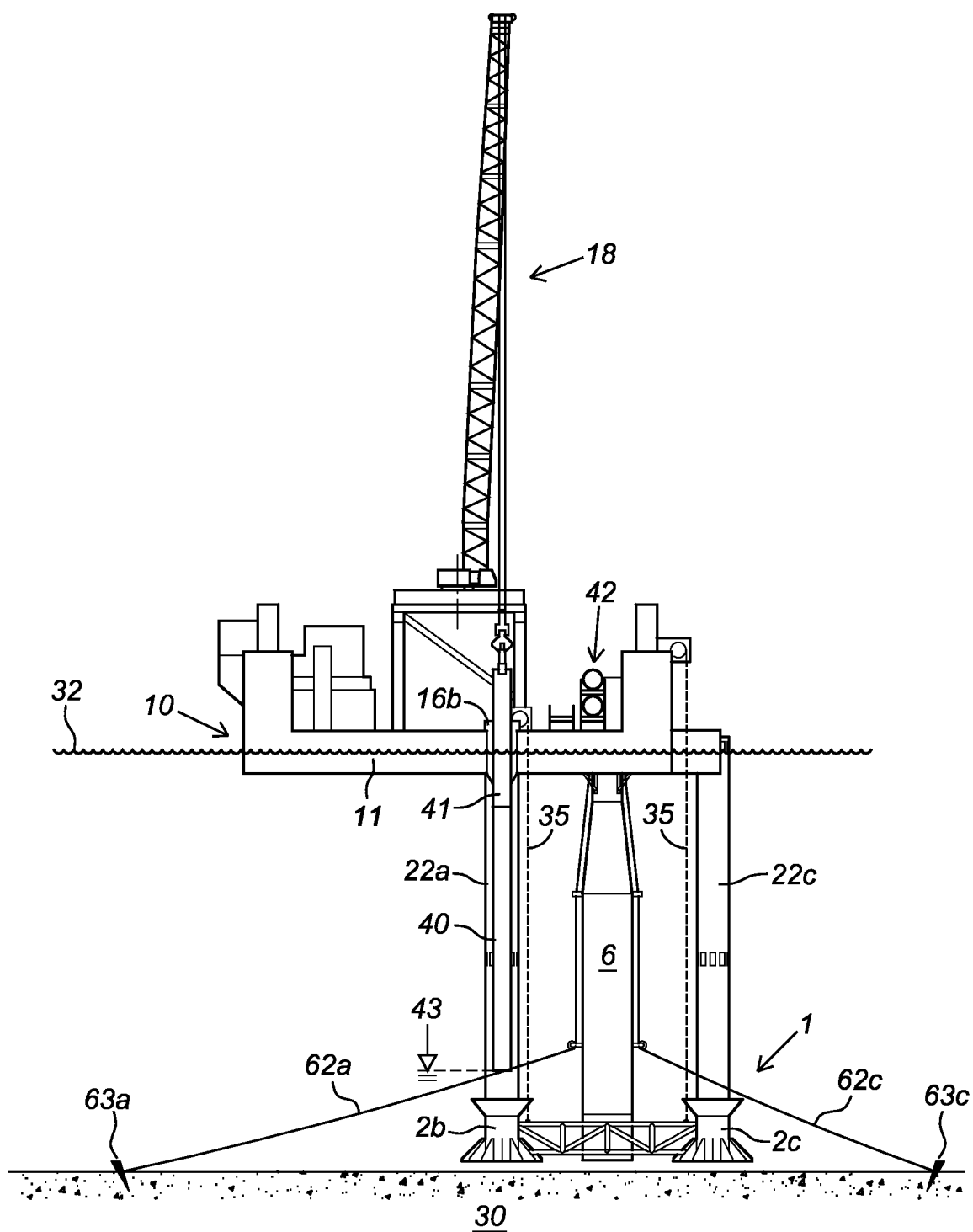


Fig. 8

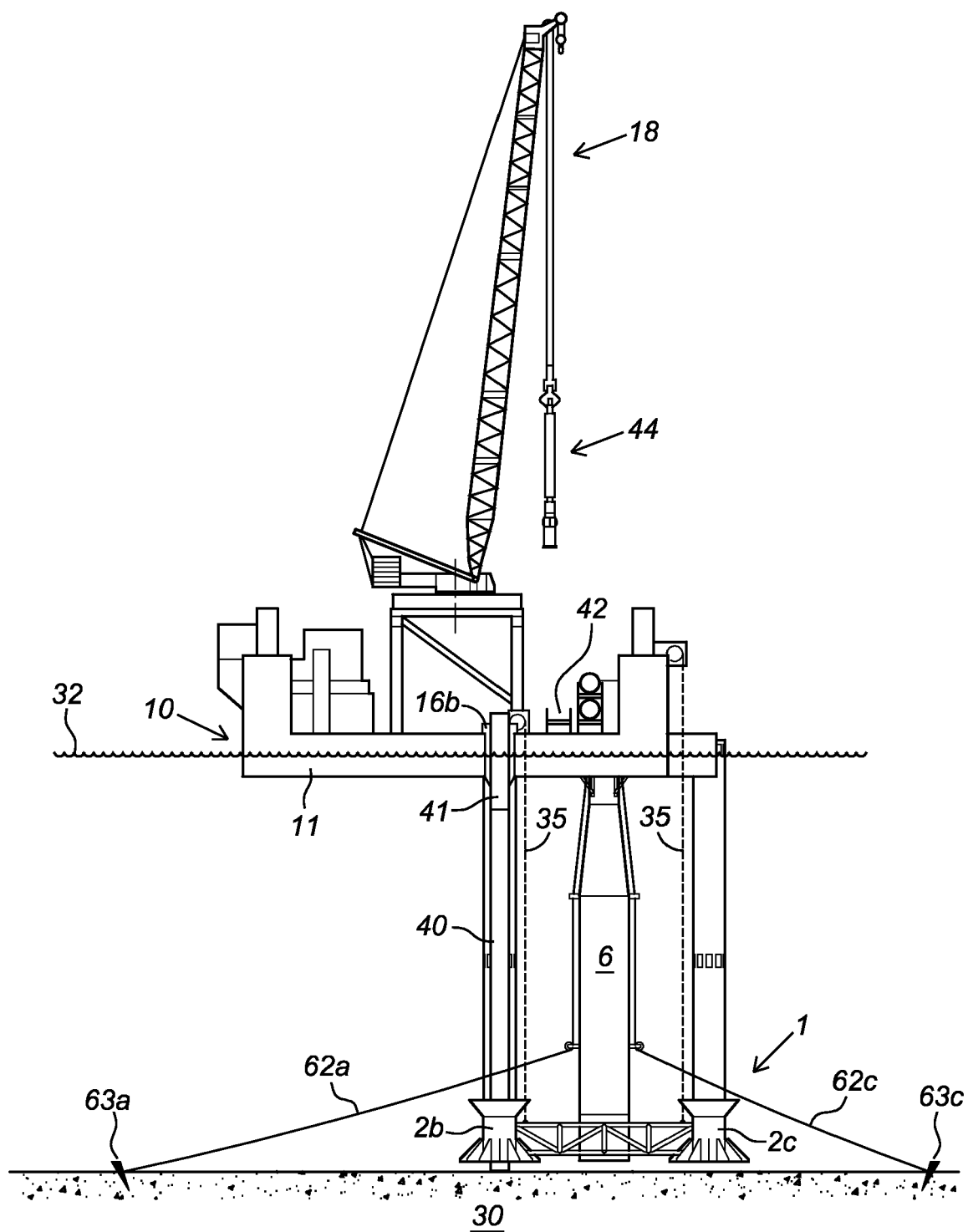


Fig. 9

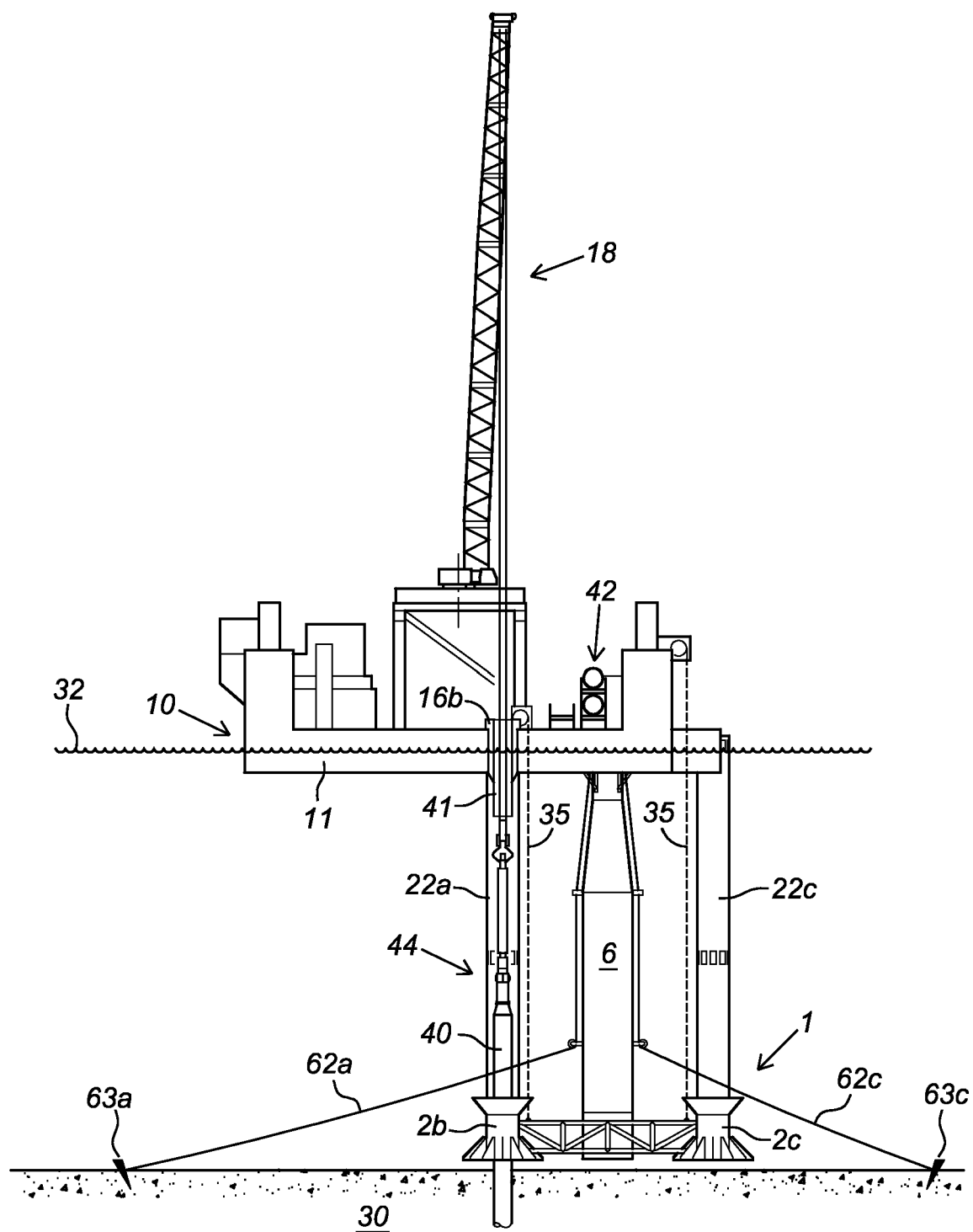


Fig. 10

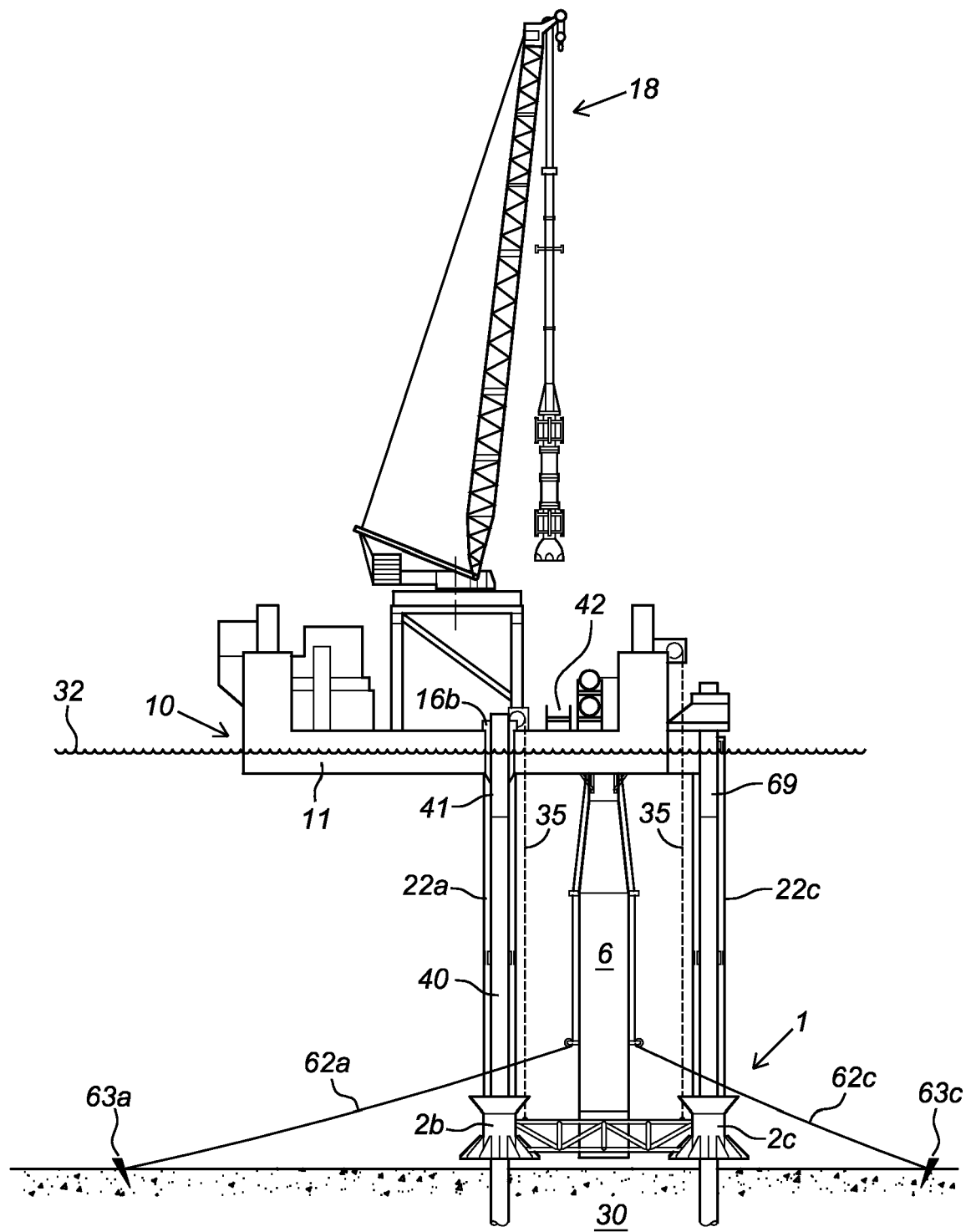


Fig. 11

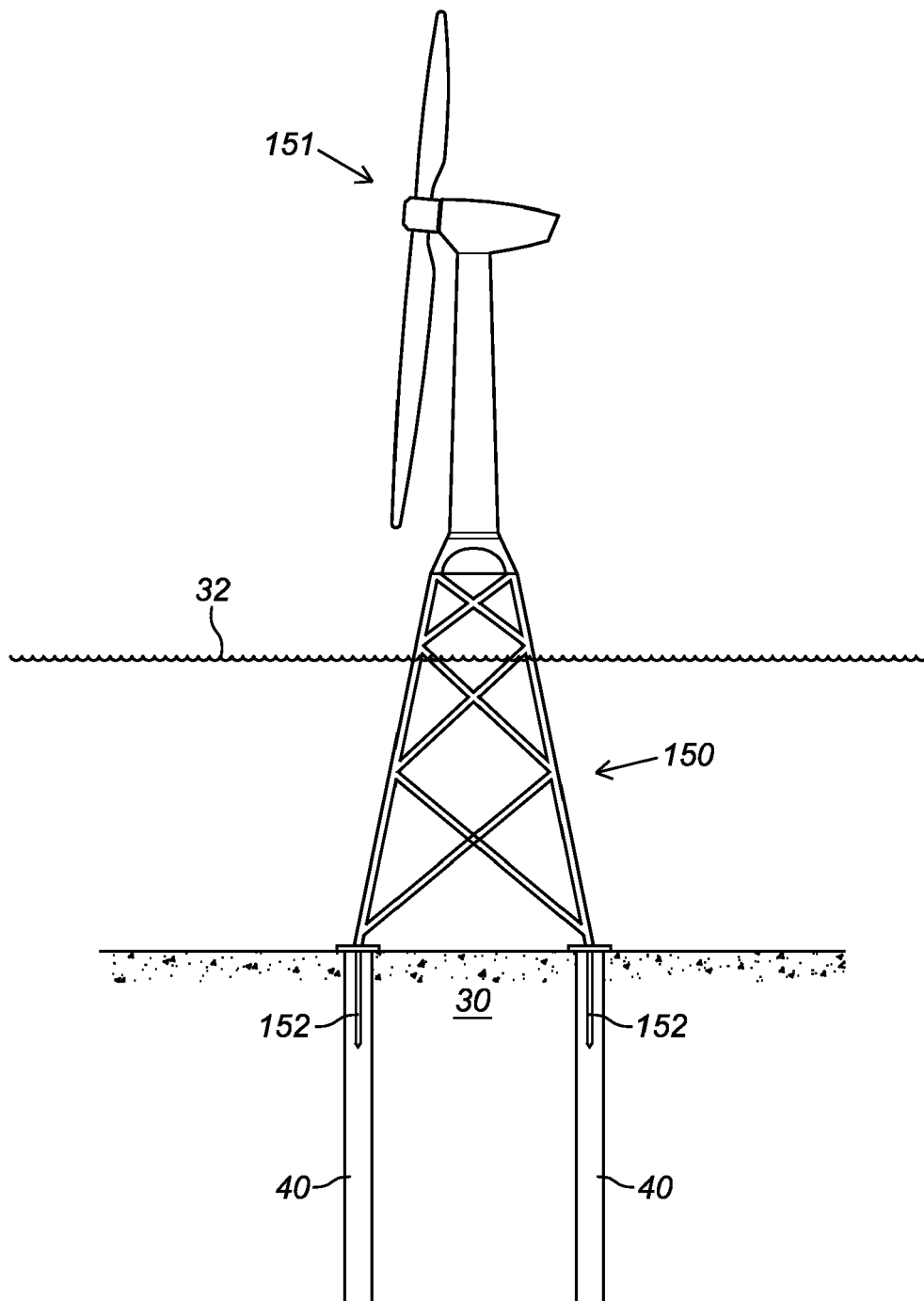


Fig. 12



EUROPEAN SEARCH REPORT

Application Number
EP 14 18 0216

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			TECHNICAL FIELDS SEARCHED (IPC)
			E02D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 February 2015	Examiner Geiger, Harald
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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