

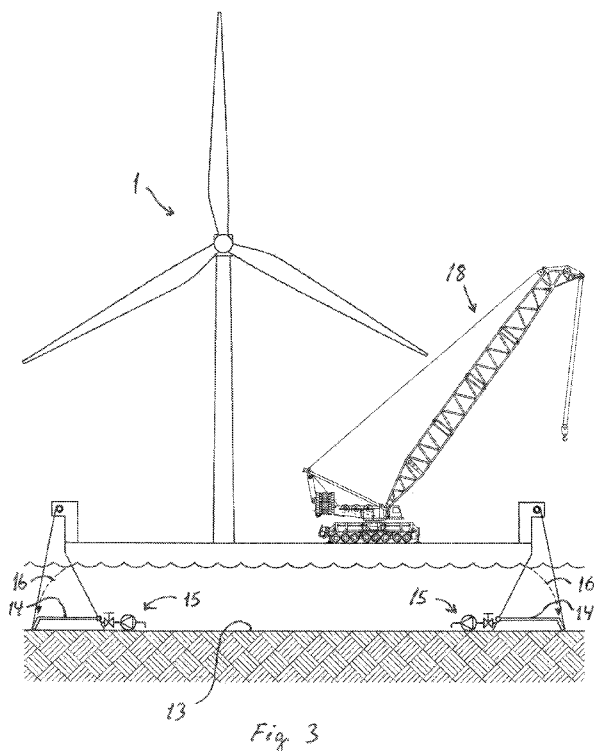


- (51) International Patent Classification:  
B63B 35/00 (2006.01) F03D 13/25 (2016.01)  
F03D 1/00 (2006.01)
- (21) International Application Number:  
PCT/DK2016/050009
- (22) International Filing Date:  
13 January 2016 (13.01.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
PA 2015 70016 14 January 2015 (14.01.2015) DK
- (71) Applicant: ENVISION ENERGY (DENMARK) APS  
[DK/DK]; Torvet 11,2, 8600 Silkeborg (DK).
- (72) Inventors: BUDTZ, Lars; Bækgården 10, 8600 Silkeborg  
(DK). WESTERGAARD, Jan; Fuglevænget 18, 7330  
Brande (DK).
- (74) Agent: PATRADE A/S; Fredens Torv 3A, 8000 Aarhus C  
(DK).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD FOR PROVIDING A STABLE WORKING PLATFORM AND A VESSEL THEREOF



(57) Abstract: The present invention discloses a method and a vessel (7) for providing a stable working platform for an offshore wind turbine (1). The vessel (7) comprises one or more buoyancy chambers configured to be at least partly filled with water so that the vessel (7) remains on the seabed (13) during the servicing or installation process. The buoyancy chambers may be passively filled with water by opening one or more hatches (24) or doors (14) in the hull (8) or actively filled with water by using a pumping system (15). The vessel (7) further comprises an upper deck (17) or raised deck on which one or more lifting units (18) are arranged. The lifting unit (18) is used during the servicing process or the installation process. After the service or installation process is completed, the buoyancy chambers are closed off and the vessel (7) is raised from the seabed (13) and any trapped water is led out of the vessel (7). The vessel (7) is finally moved to another location or back to the harbour.

WO 2016/112919 A1

**Published:**

— *with international search report (Art. 21(3))*

**METHOD FOR PROVIDING A STABLE WORKING PLATFORM AND A VESSEL THEREOF****Field of the Invention**

The present invention relates to a method for providing a stable working platform, where the method comprises the steps of moving a vessel to an offshore wind turbine installation site, positioning the vessel relative to the installation site, and lowering the vessel onto the seabed.

The present invention also relates to a vessel for providing a stable working platform, comprising a hull having at least a flat-bottom which is configured to rest on a seabed, and a deck provided in the hull which defines an outer working platform.

**Background of the Invention**

It is known to install or to service offshore wind turbines by using a ship or barge with multiple jack-up legs. The ship or barge is moved out to the installation site and the legs are then lowered into contact with the seabed. Once in the correct position, the legs are lowered further into contact with the seabed and the ship or barge is raised out of the sea level, thereby providing a stable platform during installation or servicing. After the installation process is completed, the legs are raised out of contact with the seabed and the ship or barge is able to be moved to a new location. The raising and lowering of the jack-up legs are particularly time consuming if the seabed is soft or muddy as the legs require a greater penetration depth to rest firmly on the seabed. Furthermore, a water cleaning process is often required when raising the legs in order to counteract the suction effect generated by the sediments of the seabed.

One way to solve these problems is to use a support mat or spud cans connected to each of the jack-up units which increases the contact area with the seabed, thereby reducing the penetration depth of the jack-up legs. WO 2012/066790 A1 discloses another solution in which the ship has a plurality of individual anchor blocks or a common anchor block connected to a winch system located on the ship. The anchor blocks are lowered out of a cavity in the hull and into contact with the seabed, after which tension is applied to each of the wires so that they form a tension-leg support system during erecting the wind turbine. These solutions all require one or more struc-

tures to be lowered and raised from the seabed, which in turn takes time and adds to the complexity and costs of the system.

5 It is further known to use semi-submersible ships or barges to transport the wind turbine out to the installation site which are lowered and raised relative to the sea level by means of a ballast system. This type of vessel is designed to be submerged to a maximum depth and then raised to a normal transport position using the ballast system. Such a ship, in particular the hull thereof, is not designed to rest on the seabed during work.

10

WO 03/066427 A1 discloses a vessel having a plurality of extendable support legs arranged in the hull of the vessel. The vessel is positioned relative to the installation site and then ballast tanks are filled with water to lower the vessel into position above the seabed. The support legs are afterwards moved out of the hull and into contact with the seabed so that the vessel rests firmly on the seabed. Once the work is completed, the support legs are retracted and the ballast tanks are emptied to raise the vessel. The vessel is then moved to a new location. This vessel is not suitable for use in intertidal zones.

20

It is known to use an installation barge with a flat bottom when erecting wind turbines at an intertidal site. The barge is moved out to the installation site and positioned relative to the foundation at high tide. The barge is then placed on the seabed as the sea level falls during low tide, thereby providing a stable platform during work. The wind turbine is then installed using an on-board crane. As the sea level rises during high tide, the barge then becomes buoyant again and work is halted. This results in an operation time window of just a few hours in which work can be carried out.

25

### **Object of the Invention**

An object of the invention is to provide a solution that solves the above-mentioned problems of the prior art.

30

An object of this invention is to provide a method for providing a stable working platform for an offshore wind turbine which extends the operation time window.

An object of this invention is to provide a vessel that provides a stable working platform and allows the operation time window to be extended.

### **Description of the Invention**

An object of the invention is achieved by a method for providing a stable working  
5 platform, where the method comprises the steps of:

- moving a vessel to an offshore wind turbine installation site,
- positioning the vessel relative to the installation site, e.g. where at least a part  
of a wind turbine is installed at the site,
- lowering the vessel relative to a sea level towards a seabed, and
- 10 - further lowering the vessel into contact with the seabed by at least partially  
filling one or more buoyancy chambers in the vessel with water until the bot-  
tom of the vessel is resting on the seabed so that the vessel provides a stable  
working platform.

15 The generic term “filling” includes passively or actively filling, e.g. flooding, the  
chambers with water, e.g. sea water, to alter the buoyancy of the vessel. The term  
“buoyancy chamber” defines any open or closed chambers configured to be filled with  
water, such as ballast tanks, internal compartments, open decks, or even closed decks.  
Closed decks are defined as decks that are closed off from weather and waves while  
20 open decks are defined as decks exposed to weather and waves at all time.

This provides a simple and easy method for providing a stable work platform that is  
not influenced by changes in the sea level from low tide to high tide, or vice versa.  
This configuration allows for a faster operation turnaround and lower manufacturing  
25 costs compared to any known jack-up vessels. Furthermore, this configuration is suit-  
able for use in a shallow water area, particular an intertidal zone. Also, this configura-  
tion eliminates the need for a complex and heavy jack-up system to raise and lower  
the vessel, thus saving weight and space of the vessel. This configuration allows the  
vessel to form a stable working platform by simply altering the buoyancy of the vessel  
30 so that the vessel rests on the seabed.

The vessel is moved out to the installation site and into position by means of an on-  
board propulsion system, e.g. a motor and one or more propellers. The vessel may

further comprise a dynamic positioning system to move the vessel into the correct position. Alternatively, the vessel may be towed out to the installation site and moved into the correct position by means of one or more external vessels, such as tugboats.

- 5 In one embodiment, the method further comprises the step of lowering the vessel onto the seabed by activating a pumping system, wherein the pumping system actively pumps water into one or more of the buoyancy chambers.

10 The pumping system is controlled by a user operated panel or a control unit which monitors the amount of water in these buoyancy chambers. In this configuration, the buoyancy chambers are one or more ballast tanks or compartments arranged inside the hull. The pumping system comprises at least one pipe or hose arrangement connected to an inlet and an outlet. The pumping system may be a separate pumping system or integrated into the vessel, as described later. Alternatively, two or more pumping systems may be connected to the buoyancy chambers, one for pumping water into the vessel and one for pumping water out of the vessel. This allows the vessel to be lowered into contact with the seabed without having to wait for the low tide. Once the vessel is resting firmly on the seabed, it forms a stable working platform and the service and/or installation process can be initiated.

20

In a further configuration, the pumping system may regulate the amount of water inside the buoyancy chambers based on the height of the sea level. A measuring unit, e.g. a sonar, a radar, a tide gauge, a GPS-receiver, or another sea level sensor, is used to measure the height of the sea level. The measuring unit is electrically connected to the control unit which controls the operation of the pumping system based on the measured sea level. The control unit may start the pumping system to pump water out of the buoyancy chambers as the sea level falls and/or to pump water into the buoyancy chambers as the sea level rises. This allows the vessel to regulate the amount of water inside the buoyancy chambers and thus alter the buoyancy of the vessel based on the rising and falling sea level. This allows the vessel to remain firmly on the seabed while reducing the pressure applied to the seabed, thus preventing the vessel from sinking too deep into the seabed, particularly if the seabed is soft.

25

30

In another embodiment, the method further comprises the step of lowering the vessel onto the seabed by opening one or more hatches and/or doors located in a hull of the vessel, and passively filling one or more of the buoyancy chambers with water via the hatches and/or doors.

5

This allows the vessel to be lowered onto the seabed as well as remaining on the seabed by allowing water to freely flow into and out of the buoyancy chambers, e.g. following the rising or falling sea level. The water is lead into the buoyancy chambers via a predetermined number of hatches located in at least one side of the hull, preferably via hatches on both sides of the hull. The opening of the hatches may be controlled by the control unit so that the vessel is prevented from tilting over during the filling/emptying process. The hatches are moved between an open position and a closed position via an actuator or another opening mechanism controlled by the control unit. The buoyancy chambers may be one or more ballast tanks or compartments arranged inside the hull. This allows the buoyancy chambers to be passively filled without the use of a pumping system. Furthermore, arranging hatches on both sides allows the water to pass through the vessel, thereby preventing the vessel from moving, e.g. rotating or tilting, during the tidal changes, e.g. when there is a change in the sea level from low tide to high tide, and vice versa.

20

Additionally or alternatively, water may also be lead into the vessel via one or more doors located in the bow or the stern of the vessel, preferably in both the bow and stern of the vessel. The doors are moved, e.g. in a vertical plane or in a horizontal plane, between an open position and a closed position via an actuator or another opening mechanism. The buoyancy chamber may be a lower deck, e.g. a well deck, or an open deck, e.g. a weather deck, arranged in the vessel. When not submerged, the doors act as conventional doors providing access for the workers to the lower or open deck. The lower or open deck may act as a conventional deck or working platform during low tide. As mentioned above, this also allows the buoyancy chambers to be passively filled without the use of a pumping system. Furthermore, by using doors in both ends of the vessel allows the water to pass through the vessel, thereby preventing the vessel from moving during the tidal changes.

30

The vessel is positioned in any angle relative to the main direction of the tidal current, the prevailing wind direction, or the prevailing direction of the waves or current. The vessel is preferably positioned substantially parallel or perpendicular relative to the tidal current, the wind direction, or the direction of the waves or current. This allows  
5 the vessel to be placed in a position in which the impact from tides, waves, current or wind is reduced to a minimum.

In one embodiment, the method further comprises the step of moving one or more side elements arranged relative to an upper deck of the vessel between a retracted position  
10 and an extended position, wherein the side elements in the extended position increases the distance between the sea level and a gunwale of the vessel.

The vessel may further comprise a number of side elements arranged relative to the bulwark of the vessel, e.g. of the upper or open deck. The side elements are config-  
15 ured to increase the distance between the railing/gunwale and the sea level, e.g. at high tide, while limiting water from entering the deck. The side elements may be arranged along the entire bulwark of the vessel or along one or more sections thereof, e.g. the midsection of the vessel. The side elements are positioned in the retracted position when they are not used, thereby saving space. Once the vessel is positioned on  
20 the seabed, the side elements are moved, e.g. telescoped or rotated, out to their extended position. This increases the height of the vessel, thereby allowing it to operate at a greater depth or in greater waves.

The side element may be bulwark elements or plates configured to be mounted to the  
25 bulwark and/or to each other via mounting means, e.g. brackets. Alternatively, the side elements may be connected to the bulwark via guide tracks or grooves or via hinges. An actuator may be used to move the side element into position. One or more sealing elements may be arranged between two adjacent side elements and/or the side element and the bulwark. Alternatively, the periphery of the two adjacent side ele-  
30 ments and/or the periphery of the side element and the bulwark may be shaped so that they substantially form a seal. This prevents water from entering the deck.

In a special embodiment, the buoyancy chambers are passively filled and emptied during a tidal change via one or more hatches and/or doors located in a hull of the vessel when the vessel is resting on the seabed.

5 The vessel may be lowered onto the seabed following the tidal change from high tide to low tide. Once the vessel is resting on the seabed, the hatches or doors are opened to allow the rising/falling sea level to freely flow through the vessel and gradually flood the buoyancy chambers. Alternatively, the buoyancy chambers may be gradually  
10 vessel to remain in its position on the seabed as the tide changes from low tide to high tide, or vice versa, thereby allowing the workers to continue to work on the wind turbine or the foundation thereof even during high tides.

In one embodiment, the method further comprises providing one or more lifting units  
15 on an upper deck of the vessel, and at least servicing or replacing one or more wind turbine parts of a pre-installed wind turbine by using the lifting unit.

The vessel comprises one or more lifting units arranged on the upper deck or on a raised deck located above the open deck. The lifting unit is used during the service  
20 process to lift equipment, such as tools, spare parts and other items, from the vessel to the wind turbine or foundation thereof, and vice versa. The equipment is loaded onto the vessel at a loading site and optionally stored away in cabinets or storage compartments. The lifting unit may also be used to lift a damaged wind turbine part onto the deck during the repair process. A new wind turbine part is then connected to the crane  
25 wire and lifted into position on the wind turbine.

In one embodiment, the method further comprises the step of providing one or more lifting units on an upper deck of the vessel, and at least erecting and installing one or more wind turbine parts on an offshore foundation by using the lifting unit.

30 The lifting unit is additionally or alternatively used during an installation process to lift one or more wind turbine parts, e.g. the wind turbine tower, the nacelle, the rotor hub or wind turbine blades, into an installation position relative to a previously installed wind turbine part or the offshore foundation. The wind turbine part is then in-

stalled and a new wind turbine part can be lifted into position. This allows the vessel to function as a multi-purpose vessel which can be used for servicing as well as installation purposes.

5 In a special embodiment, the lifting unit and/or one or more wind turbine parts are loaded onto the vessel at a loading site prior to moving the vessel to the installation site.

10 The lifting unit, e.g. an onshore crane, is preferably loaded onto the vessel at a loading site and fixed prior to moving the vessel out to the installation site. Alternatively, the lifting unit is an on-board unit, e.g. an on-board crane unit, which is installed on the vessel, e.g. at the loading site during the loading process. Other lifting means may be provided on the vessel for lifting the equipment and/or wind turbine parts into position, such as a jack-up system, a winch system or another suitable lifting system.

15 In another special embodiment, the vessel is stabilised during operation of the lifting unit, e.g. by regulating the amount of water in at least one of the buoyancy chambers.

20 During the lifting process, the lifting unit is stabilised to provide a stable lift. The lifting unit may be stabilised by adding one or more weight elements to the back end of the lifting unit. The weight elements may be loaded onto the lifting unit at the loading site or prior to starting the lifting process. The weight elements may also be loaded onto the vessel during the loading process and placed at the opposite end of the lifting unit. Alternatively, one or more stabilising arms may be extended out of the vessel and  
25 brought into contact with the seabed.

The buoyancy chambers may also act as stabilisers during the lifting process. The pumping system is in this configuration used to regulate the amount of water in the buoyancy chambers. All of the buoyancy chambers may be filled with water to stabilise the lifting unit. Alternatively, water is pumped from at least one buoyancy chamber to at least another buoyancy chamber to alter the weight distribution of the vessel. Additional water may be pumped into a selected buoyancy chamber and/or water may  
30 be pumped out of a selected buoyancy chamber.

In one embodiment, the method further comprises the step of raising the vessel by emptying the buoyancy chambers for water by using a pumping system and/or by closing the hatches and/or doors, and thereby achieving positive buoyancy of the vessel.

5

After completing the installation or service process, the vessel is raised and moved to a new installation site, the loading site, e.g. the harbour, or another location. The vessel is raised, e.g. at high tide, by closing the buoyancy chambers and optionally pumping any trapped water out of the buoyancy chambers by using the pumping system.

10

The buoyancy chambers may be closed off by moving the hatches and/or the doors provided in the hull into their closed position, e.g. at low tide, and thereby preventing water from entering the vessel. Alternatively, the hatches and/or doors may be closed at a time where the combined weight of the vessel and the water inside the buoyancy chambers do not exceed the weight of the displaced water, e.g. the vessel is able to achieve positive buoyancy during high tide so that it can be raised from the seabed. If ballast tanks or compartments are used as buoyancy chambers, then water is actively pumped out by using the pumping system to achieve positive buoyancy. This allows the vessel to be raised following the rising sea level or at any time during high tide compared to conventional vessels which are automatically raised by the rising sea level during high tide.

20

Furthermore, this configuration also allows the vessel to be used in shallow water where it is raised and lowered relative to the sea level, e.g. the mean sea level, by altering the buoyancy of the vessel. Conventional vessels require a jack-up system to provide a stable working platform in shallow water. The vessel is raised by actively pumping water out of the buoyancy chambers by using the pumping system. Alternatively or additionally, the hatches and/or doors may be closed at a time, e.g. at low tide, where the vessel is able to achieve positive buoyancy, e.g. at high tide, so that it can be raised from the seabed.

25

30

According to a special embodiment, the installation site is located within an intertidal zone or a shallow water area.

The vessel is preferably moved to an installation site located within a shallow water area, in particular an intertidal zone as the vessel is able to provide a stable work platform that is not influenced by changes in the sea level from low tide to high tide, or vice versa.

5

An object of the invention is achieved by a vessel providing a stable working platform, comprising:

- a hull comprising at least a flat bottom which is configured to rest on a seabed,
- a deck provided in the hull which defines an outer working platform,
- 10 - one or more buoyancy chambers are arranged inside the hull, wherein
- the vessel further comprises means for at least partially filling the buoyancy chambers with water, and wherein the flat bottom of the vessel is configured to rest on the seabed when lowered into contact with the seabed so that the vessel provide a stable working platform.

15

This provides a vessel capable of providing a stable working platform which is not influenced by the tidal changes or requires a jack-up system to raise the platform. This allows for a faster operation turn around and lower manufacturing costs compared to conventional jack-up barges or ships since no jack-up system or tension leg system is required. This configuration is suited for use in shallow water areas, in particular intertidal zones. The shallow water area is defined by having a water depth, e.g. a height of the sea level, equal or less than 50 metres. The intertidal zone is defined as an area covered by water during high tide and uncovered at low tide (also referred to as the area between high tide and low tide).

25

The vessel is provided with one or more buoyancy chambers arranged inside the hull, wherein these buoyancy chambers are connected to means for passively or actively filling the buoyancy chambers with water, as described above. These means are used to alter the buoyancy of the vessel so that it remains on the seabed during a service or installation process. This provides a stable working platform as well as it keeps the vessel in a correct position without having to adjust the position due to environmental impacts. Some conventional installation vessels use ballast tanks to lower the vessel relative to the sea level, however they still require a mooring system or a dynamic positioning system to keep the vessel in a correct position.

30

In one embodiment, the means are one or more doors and/or hatches arranged in the hull, the doors or hatches are connected to one or more buoyancy chambers arranged inside the hull and one or more openings in the hull, wherein the hatches or doors are configured to move between an open position and a closed position.

5

The vessel comprises one or more hatches arranged in at least one side surface of the hull, preferably in both side surfaces. The hatches are located in the lower half of the hull, e.g. below the waterline in an unloaded situation or in a predetermined loaded situation. An actuator or another opening mechanism is used to open and close the hatches, wherein the opening mechanism is controlled by a control unit. The buoyancy chambers may be ballast tanks or compartments. This allows water to freely flow into and out of the buoyancy chambers. Furthermore, water is able to flow through the vessel via the openings of the hatches, thereby preventing the vessel from moving, e.g. tilting, due to the flow of water and incoming waves.

10

15

The vessel additionally or alternatively comprises one or more doors arranged in at least the bow or stern of the vessel, preferably in both the bow and in the stern. The doors may be hinged doors configured to pivot around a pivot axis or sliding doors configured to slide along a guiding element, e.g. a groove or track. The buoyancy chamber may be an open deck or well deck extending along the longitudinal length of the vessel or a part thereof. This also allows water to freely flow into and out of the buoyancy chamber via the openings of the doors. This deck may further act as a conventional deck or working platform when not submerged.

20

25

In another embodiment, the means are one or more ballast tanks arranged inside the hull, the ballast tanks are connected to at least one pumping system for regulating the amount of water in the ballast tanks.

30

The vessel comprises a predetermined number of ballast tanks which act as the buoyancy chambers. The buoyancy chambers are each connected to a pumping system configured to pump water in or out of the buoyancy chambers. The pumping system may be a separate pumping system with a separate inlet and a separate outlet. The pumping system may instead be integrated into the vessel and comprise one or more openings provided in the outer surface of the hull which act as inlets or outlets depending on the

pumping direction. These openings may be located in the hull below the waterline in the unloaded or the predetermined loaded situation. The other end of the pumping system is arranged relative to the buoyancy chambers. This allows water to be actively pumped into or out of the buoyancy chambers to alter the buoyancy of the vessel. Furthermore, the pumping system enables the vessel to be lowered or raised at any time, e.g. during the high tide or after completing the installation or servicing process.

The control unit is configured to control the operation of the pumping system, e.g. the direction of flow. The control unit may further be configured to monitor the sea level and control the operation of the pumping system based on the measured sea level, as described above. One or more measuring unit configured to measure the sea level are connected to the control unit which regulate the amount of the water in the buoyancy chambers based on the measured sea level. This allows the vessel to remain on the seabed while reducing the pressure applied to the seabed.

The pumping system may also be used to empty any water trapped in the buoyancy chambers when the hatches and/or doors are closed. The control unit is configured to activate the pumping system when it has determined that all the hatches and/or doors are closed. This allows the vessel to achieve positive buoyancy so that it is raised from the seabed, or simply increase the stability of the vessel during transport. A measuring unit or visual markings located inside the vessel may be used to measure the amount of water inside the vessel. This measuring may be used to active the pumping system.

In one embodiment, the deck is configured to hold one or more lifting units, e.g. a crane unit, and optionally one or more wind turbine parts, e.g. a rotor or a wind turbine tower.

The deck may be an upper deck or a raised deck located above the lower or open deck. The deck is configured to hold the lifting units, such as a crane unit, a jack-up unit or other suitable lifting units, used during the service or installation process. The deck may comprise means for securing the lifting units to the deck, such as mounting brackets, fastening hooks or eyes or other suitable fastening means. The lifting unit may be an onshore lifting unit, e.g. a mobile crane unit, loaded onto the deck at the loading site or an on-board lifting unit, e.g. a crane unit installed on the deck. The

deck may further comprise one or more cavities or compartments for storing service equipment, spare parts or other items. Alternatively, one or more of the cavities may be configured to receive and hold the lifting unit. The deck may be configured to receive and hold different types and/or different sizes of lifting units, thus allowing the vessel to be outfitted with a lifting unit adapted for a particular purpose. The vessel may exemplarily be provided with a small crane unit for servicing the wind turbine or a large crane unit for erecting the wind turbine.

The deck may further comprise one or more storage spaces for one or more wind turbine parts, such as a wind turbine blade, a rotor hub, a nacelle, a wind turbine tower or other parts of the wind turbine structure. Alternatively, these wind turbine parts may be arranged on a second deck located relative to the upper or raised deck. Furthermore, the wind turbine parts may instead be arranged on a separate transport vessel which is positioned relative to the vessel. This allows the vessel to complete the installation process without having to halt the process during high tide.

### **Description of the Drawing**

The invention is described by example only and with reference to the drawings, wherein:

- 20 Fig. 1 shows a first exemplary embodiment of a vessel according to the invention positioned relative to an offshore wind turbine;
- Fig. 2 shows the vessel of fig. 1 seen from the bow;
- Fig. 3 shows the vessel of fig. 1 resting on the seabed during high tide;
- Fig. 4 shows the vessel of fig. 3 seen from the bow;
- 25 Fig. 5 shows the vessel of fig. 1 resting on the seabed during low tide;
- Fig. 6 shows the vessel of fig. 5 seen from the bow;
- Fig. 7 shows a second exemplary embodiment of the vessel positioned relative to the offshore wind turbine; and
- Fig. 8 shows the vessel of fig. 7 resting on the seabed.

30

In the following text, the figures will be described one by one and the different parts and positions seen in the figures will be numbered with the same numbers in the dif-

ferent figures. Not all parts and positions indicated in a specific figure will necessarily be discussed together with that figure.

### Reference list

- 1 Wind turbine
- 5 2 Offshore foundation
- 3 Wind turbine tower
- 4 Nacelle
- 5 Rotor hub
- 6 Wind turbine blades
- 10 7 Vessel
- 8 Hull
- 9 Bottom
- 10 Sides of hull
- 11 Stern
- 15 12 Bow
- 13 Seabed
- 14 Doors
- 15 Pumping system
- 16 Opening direction of doors
- 20 17 Upper deck
- 18 Lifting unit, crane
- 19 Lower deck
- 20 Sea level
- 21 Bulwark
- 25 22 Gunwale
- 23 Ballast tanks
- 24 Hatches

### Detailed Description of the Invention

Fig. 1 shows an exemplary embodiment of a wind turbine 1 installed on an offshore  
30 foundation 2 at an installation site. The wind turbine 1 comprises a wind turbine tower  
3 provided on the offshore foundation 2 and a nacelle 4 arranged on top of the wind  
turbine tower 3. A rotor having a rotor hub 5 and at least two wind turbine blades 6,  
here three is shown, is rotatably mounted to the nacelle 4.

A vessel 7 is configured to provide a stable working platform relative to the wind turbine 1 during a service process or optionally an installation process. The vessel 7 comprises a hull 8 having a bottom 9 connected to sides 10, a stern 11, and a bow 12. The bottom 9 is shaped as a flat bottom configured to rest on a seabed 13. A door 14, e.g. a hinged door, is arranged in the stern 11 and configured to provide access to a lower deck (shown in fig 4) located in the hull 8. Another door 14, e.g. a hinged door, is further arranged in the bow 12 and configured to further provide access to the lower deck. An opening mechanism is connected to the door 14 and configured to move, e.g. pivot, the door 14 between an open position (shown in fig. 3) and a closed position (shown in fig. 1).

At least one pumping system 15 comprising an inlet and an outlet is loaded onto the vessel 7. The pumping system 15 may instead be an on-board pumping system installed in the vessel 7. The pumping system 15 is arranged relative to the lower deck for pumping water out of the vessel 7 or into the vessel 7. A second pumping system is optionally arranged on the vessel 7 as shown in fig. 1.

The vessel 7 is initially moved out to the installation site, e.g. from a loading site, and positioned relative to the wind turbine 1 or the offshore foundation thereof, e.g. using an external vessel.

Fig. 2 shows the wind turbine 1 and the vessel 7 seen from the bow 12. The vessel 7 is positioned at a predetermined distance from the offshore foundation 2 or the wind turbine 1, e.g. the wind turbine blades 6. The doors 14 are placed in a closed position during transport to the installation site.

After placing the vessel 7 in a correct position, preferably during high tide, the vessel 7 is lowered onto the seabed 13 by moving the doors 14 to their open position (indicated by arrow 16) as shown in figs. 3-4. This enables the lower deck to passively be filled, e.g. flooded, with water in order to alter the buoyancy of the vessel 7.

The vessel 7 may also be lowered onto the seabed 13 by activating the pumping system 15, e.g. turning on the pump and opening the respective valves. This enables the

lower deck to be actively filled with water in order to alter the buoyancy of the vessel 7.

5 The vessel 7 further comprises an upper deck 17 defining the working platform as shown in fig. 4. A lifting unit 18, e.g. an onshore crane, and other service equipment are loaded onto the upper deck 17 at the loading site before the vessel 7 is moved to the installation site. The upper deck 17 comprises holding means (not shown) for se-  
10 curing the lifting unit 18 to the upper deck 17. Storage means, e.g. cabinets or cavities, may be arranged in the hull 8, e.g. the upper deck 17, for safe storage of the service equipment and/or the spare parts of the wind turbine 1. The lifting unit 18 is used dur-  
ing the service process to lift items between the wind turbine 1 and the vessel 7.

The lower deck 19, e.g. a well deck, is located below the upper deck 17 and is config-  
15 ured to be submerged under water during the service process. This deck 19 acts as a buoyancy chamber for the vessel 7 which is used to raise and lower the vessel 7 rela-  
tive to the sea level 20. The lower deck 19 also acts as a second working platform when not submerged.

The vessel 7 comprises at least one bulwark 21 arranged relative to the upper deck 17  
20 for limiting water from entering the upper deck 17. A gunwale 22 is provided on top of the bulwark 21. The gunwale 22 defines a distance to the sea level 20, e.g. the mean sea level or the sea level at high tide. During the service process, this distance is re-  
duced since the vessel 7 is resting on the seabed 13. The vessel 7 is configured to op-  
25 erate in intertidal zones or in shallow waters where the water depth is less than the height of the vessel 7, e.g. the height of the sides 10.

Fig. 5-6 show the vessel 7 resting on the seabed 13 during a low tide. Yet another way  
to lower the vessel 7 onto the seabed 13 is to simply follow the falling sea level 20  
during the tidal change from high tide to low tide. Once the vessel 7 is resting on the  
30 seabed 13 as shown in fig. 5, the doors 14 are opened to allow water to enter the ves-  
sel 7 during the service process.

During the service process, water is able to passively flow through the vessel 7, e.g.  
submerging the lower deck 19, following the rising sea level 20 during the tidal

change from low tide to high tide. This allows the vessel 7 to remain on the seabed 13 during the servicing process, thereby eliminating the need for halting the service process during high tide.

- 5 After completing the service process, the doors 14 are closed to prevent water from entering the vessel 7 as shown in fig. 6. The vessel 7 is then raised from the seabed 13 by simply following the rising sea level 20 from low tide to high tide.

10 The vessel 7 may also be raised during the high tide by closing the doors 14 and then using the pumping system 15 to pump any trapped water out of the vessel 7, e.g. away from the lower deck 19. The pumping system 15 is activated by the optional control unit after it has determined that all the doors 14 have been closed. This enables the vessel 7 to alter this buoyancy so that it is raised from the seabed 13.

- 15 After the vessel 7 is raised from the seabed 13, the vessel 7 is able to be moved to another location, e.g. another installation site or back to the loading site/harbour.

20 Figs. 7-8 show a second exemplary embodiment of the vessel 7 where a predetermined number of ballast tanks 23 is arranged in the hull 8. The ballast tanks 23 act as buoyancy chambers that enables the vessel 7' to be raised or lowered relative to the sea level 20. The ballast tanks 23 are distributed along the hull 8 as shown in fig. 7.

25 After the vessel 7' is positioned relative to the wind turbine 1 as shown in fig. 7, the pumping system 15' is activated to pump water into the ballast tanks 23. Each ballast tank 23 is connected to an individual pumping system 15'. This allows the buoyancy chambers to be actively filled with water in order to lower the vessel 7 onto the seabed 13.

30 The vessel 7 comprises one or more optional hatches 24 arranged in the sides 10 of the vessel 7. The hatches 24 are configured to be moved from a closed position to an open position. The hatches 24 are preferably located in the lower part of the hull 8, e.g. below the water line in a loaded situation. An opening mechanism (not shown) is connected to each of the hatches 24 for moving the hatches between the open and closed positions. This allows the buoyancy chambers to be passively filled with water by

allowing the water to freely flow into and out of the buoyancy chambers following the sea level 20.

5 Once the vessel 7 is resting on the seabed 13 as shown in fig. 8, the service process is initiated, thereby providing a stable working platform during the tidal changes. After the service process is completed, the vessel 7 is raised from the seabed 13 as shown in fig. 7 by closing the hatches 24 during low tide, thereby preventing further water to enter the vessel 7. The vessel 7 is then raised following the tidal change from low tide to high tide.

10

The vessel 7 may also be raised by activating the pumping system 15' to pump water out of the ballast tanks 23. The pumping system 15' is activated when the hatches 24 are closed and/or when the service process is completed. This enables the vessel 7 to be raised during high tide and moved to another location.

15

The present invention is not limited to the illustrated embodiment or the described embodiments herein, and may be modified or adapted without departing from the scope of the present invention as described in the patent claims below.

## CLAIMS

1. A method for providing a stable working platform, where the method comprises the steps of:
- 5       - moving a vessel (7) to an offshore wind turbine installation site,  
      - positioning the vessel (7) relative to the installation site, e.g. where at least a part of a wind turbine (1) is installed at the installation site,  
      - lowering the vessel (7) relative to a sea level (20) towards a seabed (13),
- characterised by**
- 10       - further lowering the vessel (7) into contact with the seabed (13) by at least partially filling one or more buoyancy chambers in the vessel (7) with water until the bottom (9) of the vessel (7) is resting on the seabed (13) so that the vessel (7) provides a stable working platform.
- 15       2. A method according to claim 1, **characterised in that** the method further comprises the step of lowering the vessel (7) onto the seabed (13) by activating a pumping system (15), wherein the pumping system (15) actively pumps water into one or more of the buoyancy chambers.
- 20       3. A method according to claim 1 or 2, **characterised in that** the method further comprises the step of lowering the vessel (7) onto the seabed (13) by opening one or more hatches (24) and/or doors (14) located in a hull (8) of the vessel (7), and passively filling one or more of the buoyancy chambers with water via the hatches (24) and/or doors (14).
- 25       4. A method according to any one of claims 1 to 3, **characterised in that** the method further comprises the step of moving one or more side elements arranged relative to an upper deck (17) of the vessel (7) between a retracted position and an extended position, wherein the side elements in the extended position increases the distance between the sea level (20) and a gunwale (22) of the vessel (7).
- 30       5. A method according to any one of claims 1 to 4, **characterised in that** the buoyancy chambers are passively filled and emptied during a tidal change via one or more

hatches (24) and/or doors (14) located in a hull of the vessel when the vessel is resting on the seabed.

5 6. A method according to any one of claims 1 to 5, **characterised in that** the method further comprises the step of providing one or more lifting units (18) on an upper deck (17) of the vessel (7), and at least servicing or replacing one or more wind turbine parts of a pre-installed wind turbine (1) by using the lifting unit (18).

10 7. A method according to any one of claims 1 to 6, **characterised in that** the method further comprises the step of providing one or more lifting units (18) on an upper deck (17) of the vessel (7), and at least erecting and installing one or more wind turbine parts on an offshore foundation (2) by using the lifting unit (18).

15 8. A method according to claim 6 or 7, **characterised in that** the lifting unit (18) and/or one or more wind turbine parts are loaded onto the vessel (7) at a loading site prior to moving the vessel (7) to the installation site.

20 9. A method according to any one of claims 6 to 8, **characterised in that** the vessel (7) is stabilised during operation of the lifting unit (18), e.g. by regulating the amount of water in at least one of the buoyancy chambers.

25 10. A method according to any one of claims 1 to 9, **characterised in that** the method further comprises the step of raising the vessel (7) by emptying the buoyancy chambers for water by using a pumping system (15) and/or by closing the hatches (24) and/or doors (14), and thereby achieving positive buoyancy of the vessel (7).

11. A method according to any one of claims 1 to 10, **characterised in that** the installation site is located within an intertidal zone or a shallow water area.

30 12. A vessel (7) for providing a stable working platform, comprising:  
- a hull (8) comprising at least a flat bottom (9) which is configured to rest on a seabed (13),  
- a deck (17, 19) provided in the hull which defines an outer working platform,  
**characterised in that**

- one or more buoyancy chambers are arranged inside the hull (8), and
- the vessel (7) further comprises means for at least partially filling the buoyancy chambers with water, and wherein the flat bottom (9) of the vessel (7) is configured to rest on the seabed (13) when lowered into contact with the seabed (13) so that the vessel (7) provides a stable working platform.

5

13. A vessel according to claim 12, **characterised in that** the means are one or more doors (14) and/or hatches (24) arranged in the hull (8), the doors (14) or hatches (24) are connected to one or more buoyancy chambers arranged inside the hull (8) and one or more openings in the hull (8), wherein the hatches (24) or doors (14) are configured to move between an open position and a closed position.

10

14. A vessel according to claim 12 or 13, **characterised in that** the means are one or more ballast tanks (23) arranged inside the hull (8), the ballast tanks (23) are connected to at least one pumping system (15) for regulating the amount of water in the ballast tanks (23).

15

15. A vessel according to any one of claims 12 to 14, **characterised in that** the deck (17) is configured to hold one or more lifting units (18), e.g. a crane unit, and optionally one or more wind turbine parts, e.g. a rotor or a wind turbine tower (3).

20

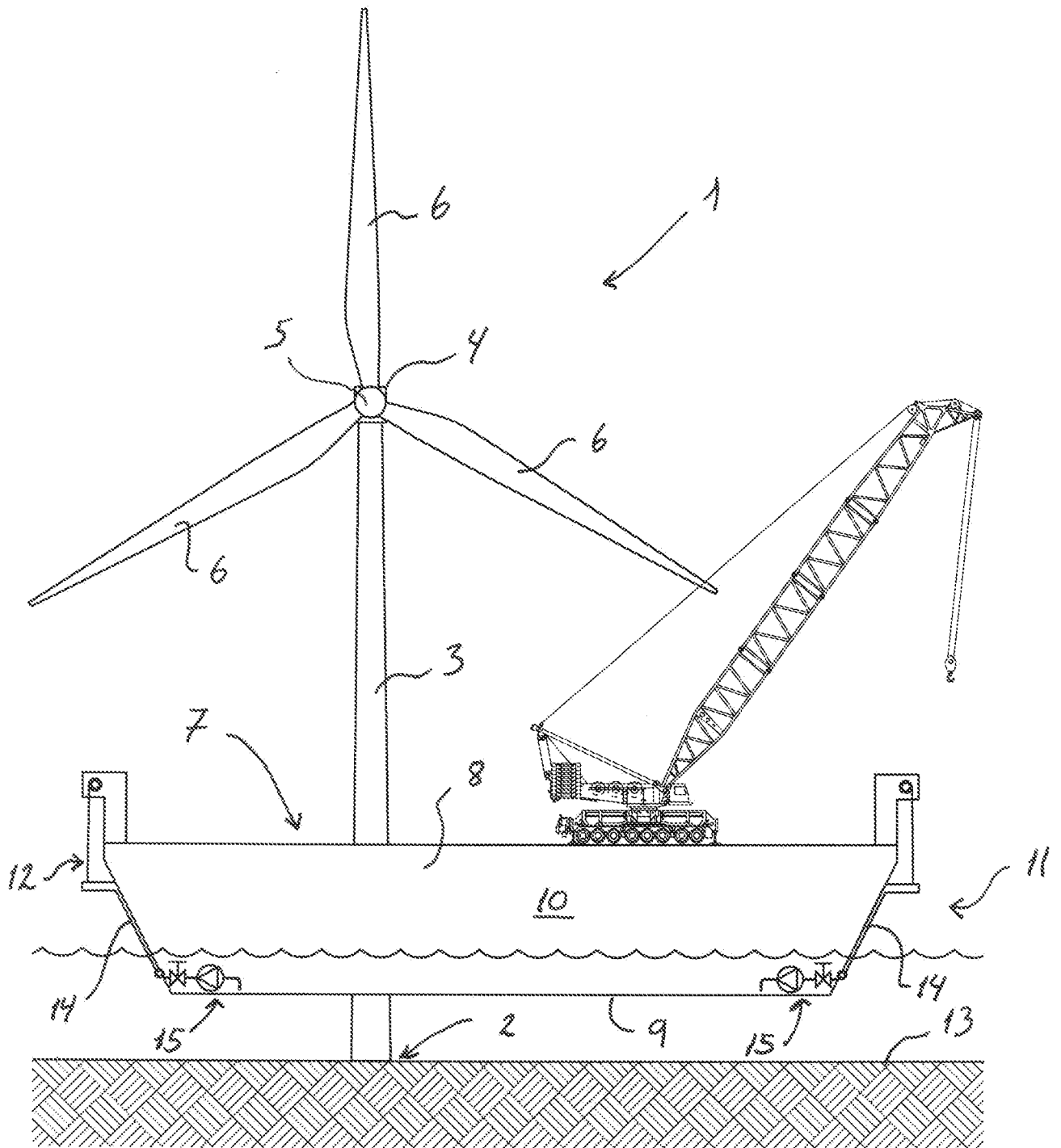


Fig. 1

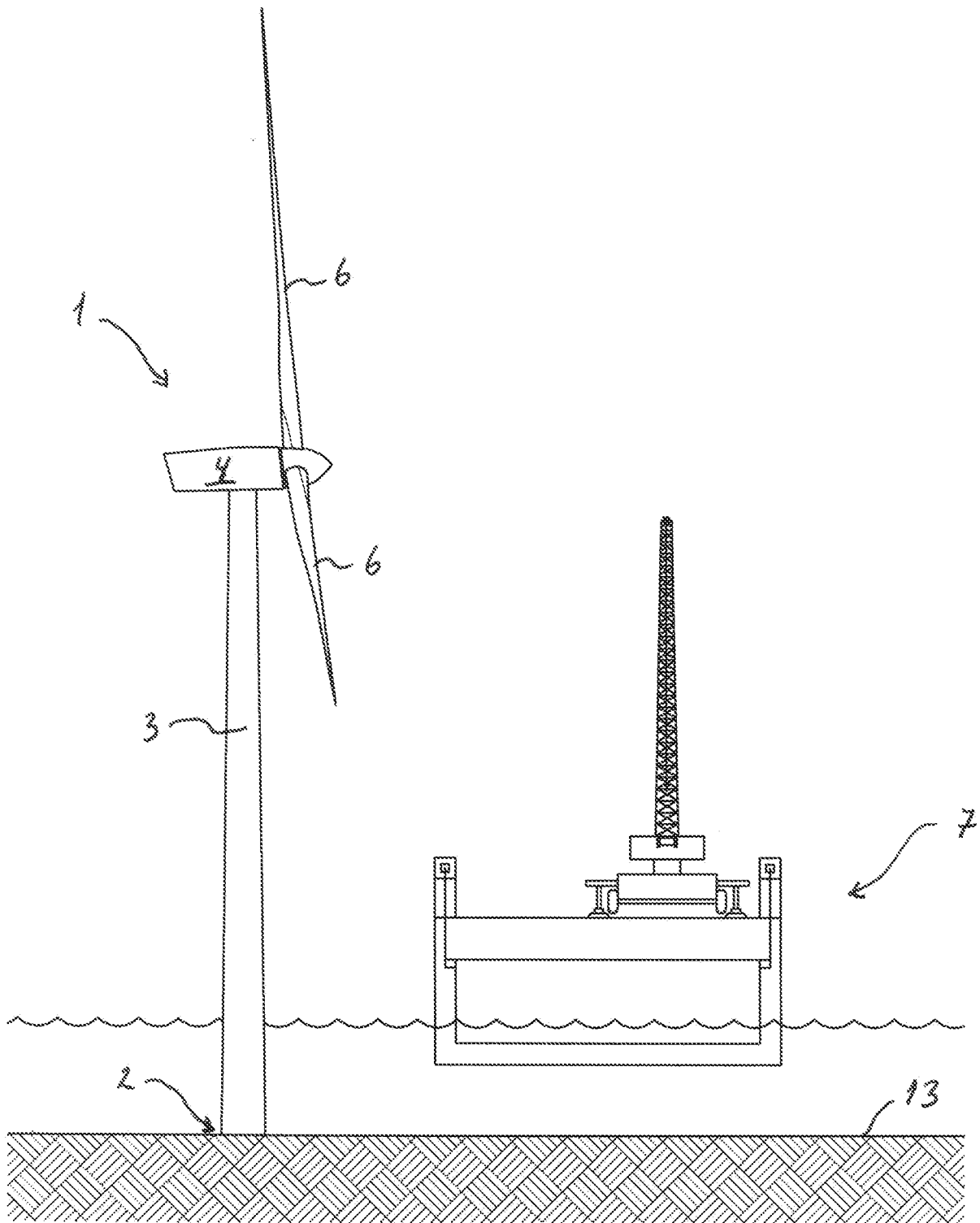


Fig. 2

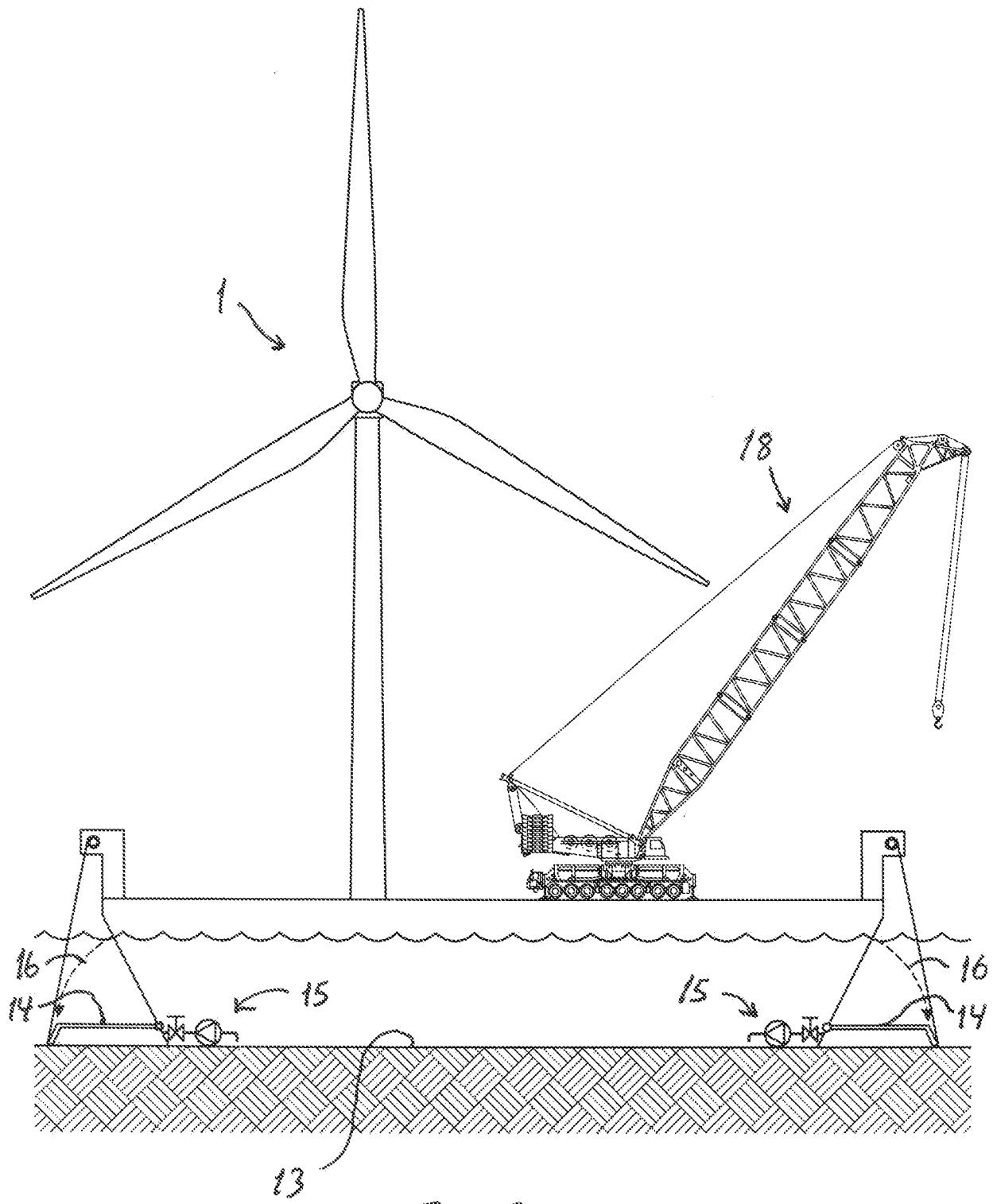


Fig 3

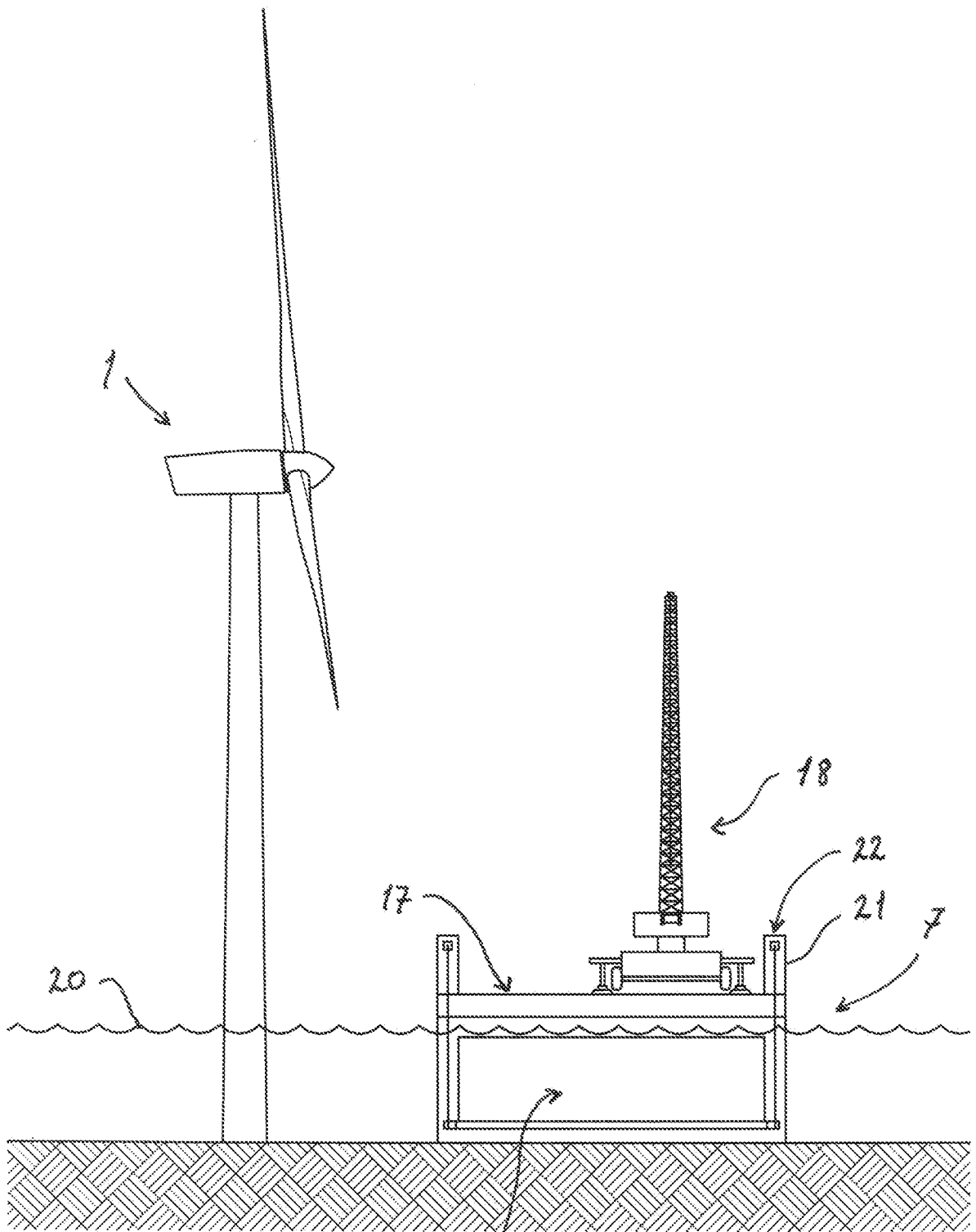


Fig. 4

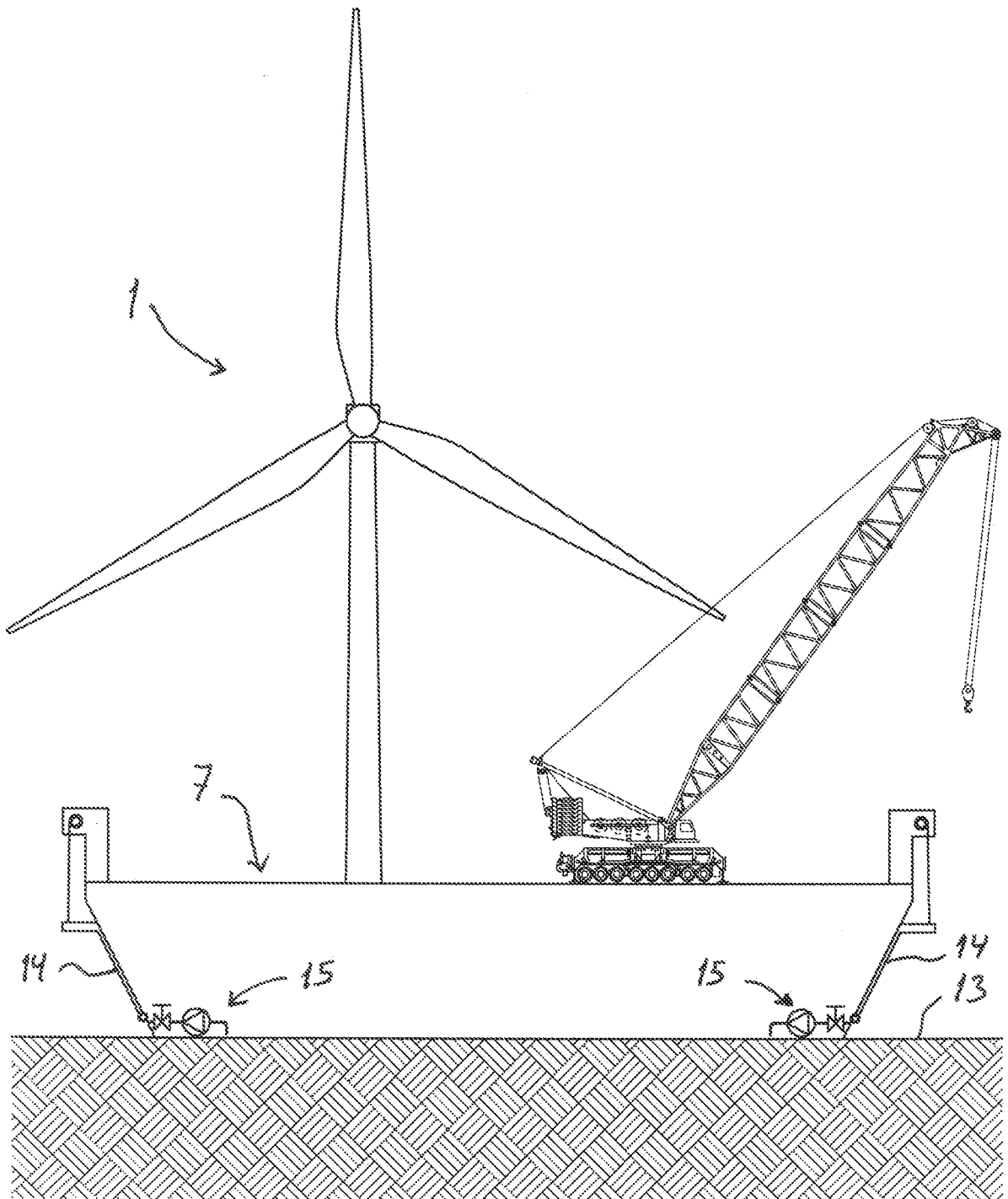


Fig. 5

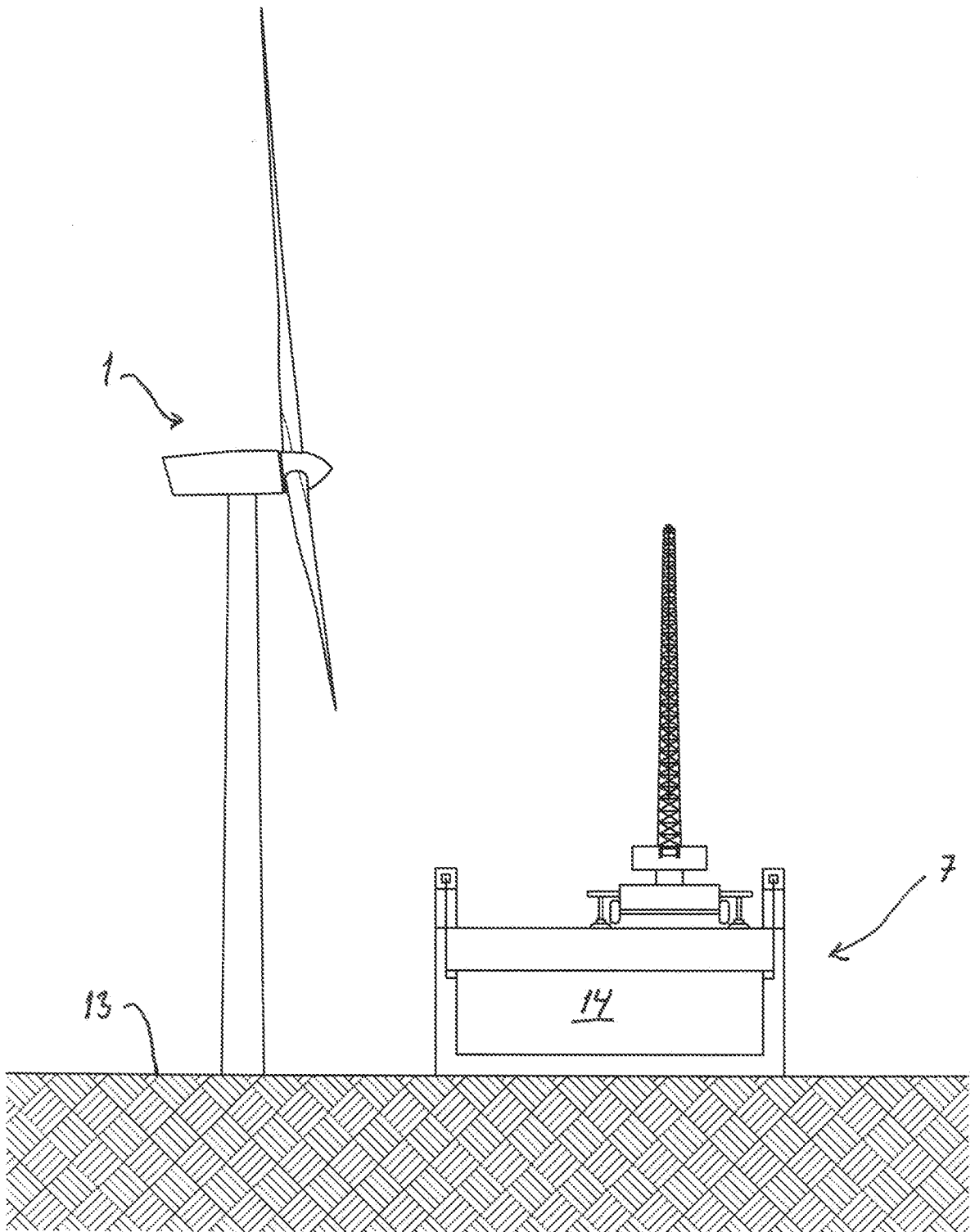


Fig. 6

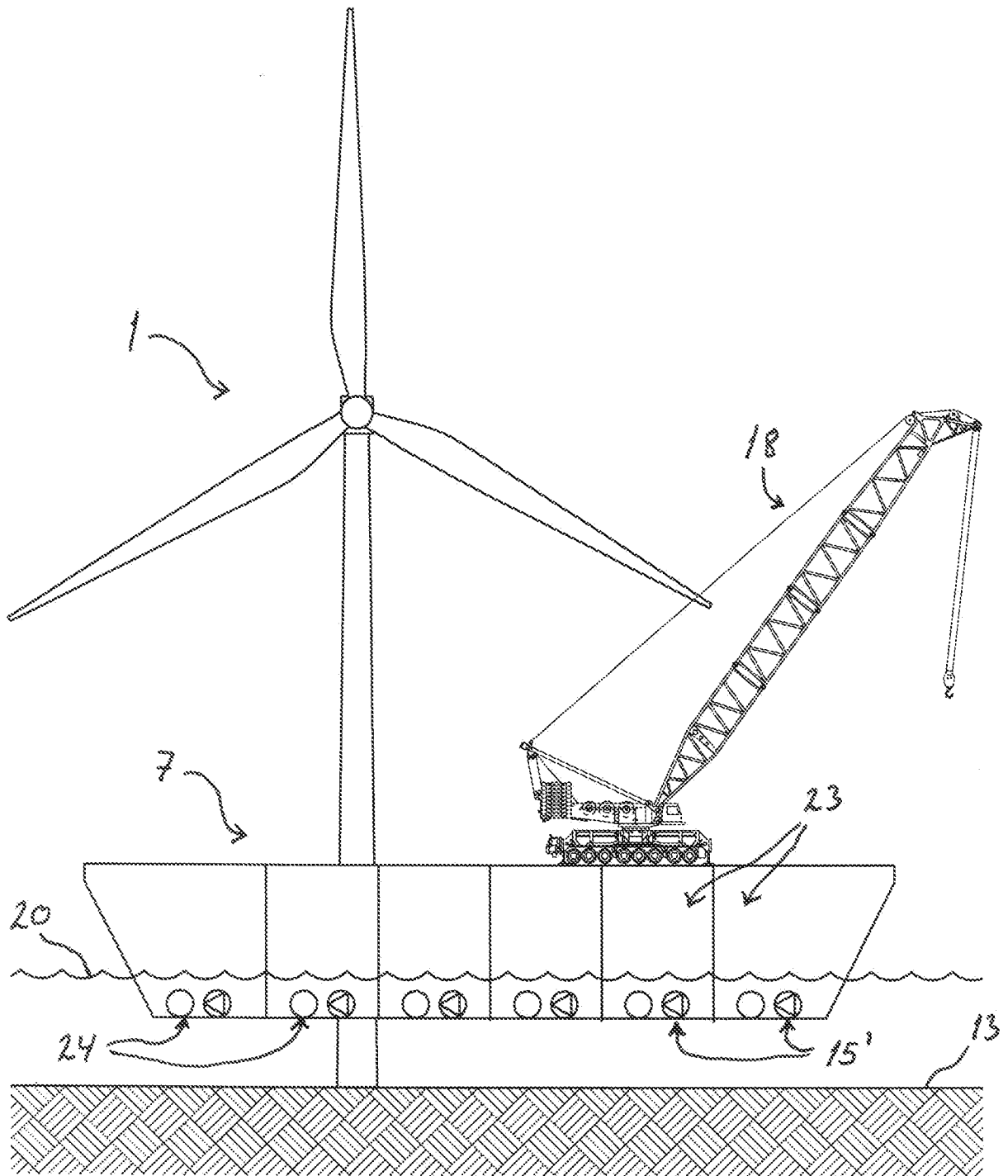


Fig. 7

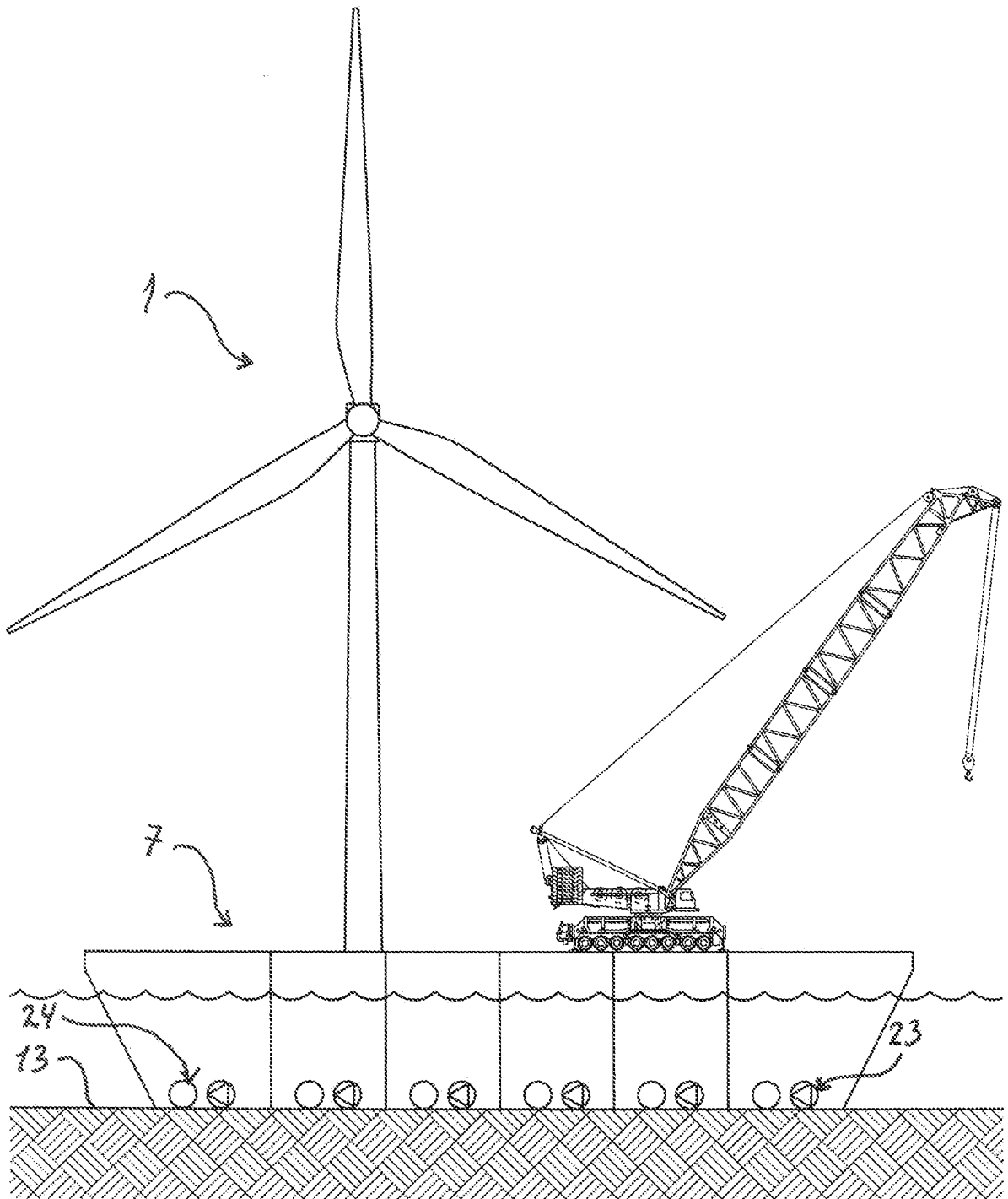


Fig. 8

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2016/050009

A. CLASSIFICATION OF SUBJECT MATTER B63B 35/00 (2006.01), F03D 1/00 (2006.01), F03D 13/25 (2016.01) According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED				
Minimum documentation searched (classification system followed by classification symbols) IPC&CPC&FICLA: B63B, F03D				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above.				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	WO 03/066427 A1 (FRED OLSEN RENEWABLES LTD) 14 August 2003. See abstract, figures 1 and 14-16, page 5, lines 3-5 and page 8, lines 18-25.	1-15		
A	WO 2012/066790 A1 (MITSUBISHI HEAVY IND LTD) 24 May 2012. The whole document.	1-15		
A	WO 2011/102738 A2 (AKER MARINE CONTRACTORS AS) 25 August 2011. The whole document.	1-15		
A	WO 2011/103988 A1 (ZUEBLIN AG) 01 September 2011. See abstract and figures 6 and 10-13.	1-15		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.				
* Special categories of cited documents: <table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“E” earlier application or patent but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; vertical-align: top;"> <p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&amp;” document member of the same patent family</p> </td> </tr> </table>			<p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“E” earlier application or patent but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p>	<p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&amp;” document member of the same patent family</p>
<p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“E” earlier application or patent but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p>	<p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&amp;” document member of the same patent family</p>			
Date of the actual completion of the international search	Date of mailing of the international search report			
30/03/2016	31/03/2016			
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. + 45 43 50 80 08	Authorized officer  Basel Hayatleh Telephone No. +45 43 50 83 66			

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2016/050009

Patent document cited in search report / Publication date	Patent family member(s) / Publication date
WO 03066427 A1 2003.08.14	AU 2002239178 A1 2003.09.02
WO 2012066790 A1 2012.05.24	JP 2012107585 A 2012.06.07
WO 2011102738 A2 2011.08.25	WO 2011102738 A3 2011.11.17 NO 331703B B1 2012.02.27 NO 20100323 A 2011.08.19
WO 2011103988 A1 2011.09.01	DE 102010009466 A1 2011.09.01 EP 2539219 A1 2013.01.02 EP 2539219 B1 2014.04.16 DK 2539219T T3 2014.07.07