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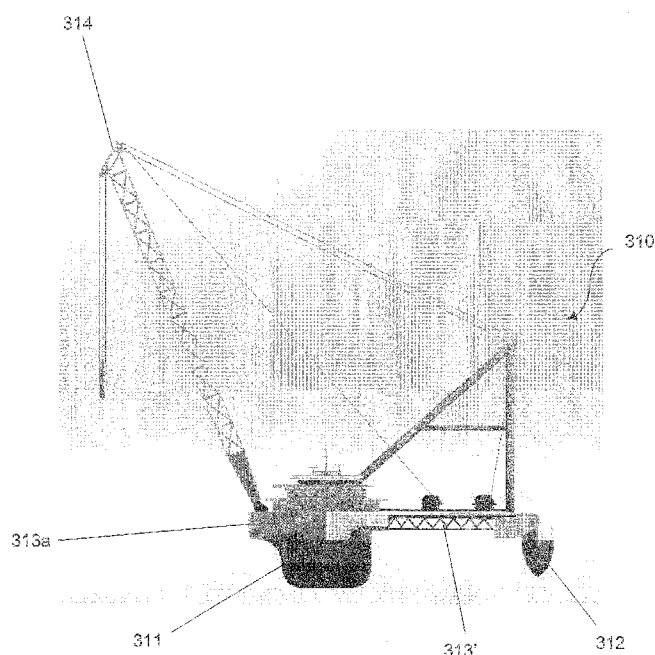


Figure 10

(57) Abstract: The present invention relates to a semi-submersible vessel having a transit state and an operative state, the vessel comprising: a first hull having a first topside; a second hull having a second topside; a platform adapted to connect the first and second hulls; and at least one lifting device, wherein the first and second hulls are asymmetrical hulls, and the height of the vessel at the first hull is different relative to the height of the vessel at the second hull, and wherein the first and second hulls are adapted to be ballasted into a water body in the operative state. The present invention also relates to a method of lifting a load at an offshore site of a water body utilizing a semi-submersible vessel of the present invention.



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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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SEMI-SUBMERSIBLE VESSEL

Field of Invention

The present invention relates to a semi-submersible vessel, in particular, a semi-submersible for lifting loads at offshore sites and a method thereof.

5 Background Art

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general
10 knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

Heavy lift operations (where an indivisible/ individual load typically weighs more than 100 tons and can be up to 10,000 tons) are frequently carried out at offshore sites during the fabrication and/or installation/decommissioning of major
15 offshore components and structures, such as production facilities, sub-assemblies, completed jackets/modules etc. In recent years, more and more heavy lifting crane operations in the offshore industry have been performed by floating vessels. Due to limited availability of floating vessels with high lifting capacity, topside structures are often split into several modules instead of an
20 integrated deck-structure, which are installed using several lifts with low capacity crane vessels. This is a time consuming process and results in high operation cost. However, if floating vessels with high lifting capacity are available, heavier structures can be fabricated and installed in single lift operation instead of several lift operations and subsequent fabrication. This can substantially reduce the
25 installation or decommissioning cost.

Most of the existing high lifting capacity heavy lift vessels are either mono-hull or catamaran with symmetrical hulls. Limitations of such vessels known in the art include but are not limited to the following:

- Heavy lift vessels with mono-hull or semisubmersible crane vessels with
30 twin symmetrical hulls travel at lower speeds and have higher transit time. The large surface area of twin symmetrical hulls or large mono-

hull creates substantial resistance during motion and thereby reduces the vessel's speed during transit.

- It is known to fit heavy lift vessels with rotary cranes, either on the sides of mono-hull vessels or on the aft or forward portions of one or both hulls of vessels with twin symmetrical hulls. Rotary cranes are expensive systems.

- When cranes are positioned at the aft or forward end of vessels, the steep section of the hull at the end offers lesser buoyancy and hence lesser support during lift. As a result, continuous and complex ballasting operations are performed at the opposite end of the crane to counter the heavy lift. The mid-ship section also requires strengthening to perform lift at the ends of the hulls.

- It is known to install dynamic positioning thrusters at the bottomside of the hulls of a vessel to help in the precise positioning of the vessel during lifting operation. However, the thrusters fitted at the bottomside of the hull bottom add to the hull resistance during transit. Furthermore, these thrusters are difficult to access for repair and maintenance during transit or operation since they are always under water.

- For a twin hull semi-submersible vessel, the lifting of a load is performed with a portion of their columns immersed in water, where the deckbox is above and clear of the water surface. Therefore, the buoyancy offered by the vessel is very little due to small water plane area during a lift operation. As a result, continuous de-ballasting and ballasting operations are performed in various components of the vessel during the lift, where such operations are complicated processes which slow down the entire lift operation.

- The cranes installed on vessels known in the art use lifting gear systems that are complex and typically involve time-consuming preparations before the load can be lifted.

WO 2009/084950 A1 discloses a semi-submersible vessel known in the art, where the vessel has symmetrical hulls. WO 2009/084950 A1 is concerned with reinforcement means to strengthen the structure of semi-submersible vessels.

WO 2004/002814 A1 discloses a vessel having a symmetrical hull structure where the hulls are linked by portal crane structures and the lifting of a load is effected between the hulls and by the portal crane structures. Special care has to be taken on the control of the de-ballasting of the tanks during the lift operation
5 where the hulls have to be de-ballasted simultaneously such that no listing or trimming occurs during the lifting operation.

US 6,932,326 B1 discloses a method for lifting and transporting a heavy load using a heavy lift vessel with at least two heavy lift cranes adapted to operate simultaneously. The vessel is a mono-hull vessel and said prior art does not teach
10 how the cranes can be placed and operated on a twin-hull vessel.

US 4,281,615 discloses a semi-submersible column stabilized service vessel for tending offshore production and drilling operations. This vessel has twin symmetrical hulls and when in operation, the water level is at a portion of the columns, i.e. the deck is above and clear of the water level, which can make the
15 vessel unstable during lift operations. US 8,752,496 B2 discloses a semi-submersible vessel having a lower hull with a structure supporting a deck, where in operation, the deck may be positioned at the water level, resting on the water surface. However this vessel has at best twin symmetrical hulls which can reduce the vessel's speed during transit. Further this vessel utilizes rotary cranes located
20 at the forward and/or aft portions of the vessel, which may require complex ballasting and/or de-ballasting during operation.

CN 102328733 A discloses a semi-submersible heavy lift vessel, commercially known as the Gretha and operated by OSS-International, comprises a twin hull asymmetrical structure, where the hulls are ballasted during heavy lift
25 operations. However the Gretha utilizes expensive rotary cranes positioned substantially at the forward and aft portions of the hulls. Further, the asymmetrical hulls and columns of the Gretha vessel are of the same height which hinders and reduces its speed during the travel of the Gretha between locations. While CN 102328733 A discloses that the columns which connect the asymmetrical hulls to
30 the platform may have different cross-sectional areas, the same height of the asymmetrical hulls and columns is disclosed as an advantageous design of the Gretha vessel. Furthermore, the deck of the Gretha does not rest on the water surface during operation. Additionally, the dynamic positioning thrusters are

located at the bottomside of the hulls which makes access for repair and maintenance difficult during transit or operation. The position of the thrusters also limits the Gretha to deep waters and reduces the lifespan of the thrusters since they are always subject to wear and tear in water.

5 Therefore, there exists a need for a better solution to ameliorate the aforementioned problems.

Summary of the Invention

10 The present invention seeks to address and/or ameliorate the problems in the prior art by providing a semi-submersible vessel and method thereof, for heavy lift operations which do not require complex ballasting and/or de-ballasting processes during operation, is capable of travelling at speeds higher than vessels known in the art with lower transit time, and a dynamic positioning system that requires less maintenance.

15 According to an aspect of the present invention, there is a semi-submersible vessel having a transit state and an operative state, the vessel comprising: a first hull having a first topside; a second hull having a second topside; a platform adapted to connect the first and second hulls; and at least one lifting device, wherein the first and second hulls are asymmetrical hulls, and the height of the vessel at the first hull is different relative to the height of the vessel
20 at the second hull, and wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

 Preferably, the height of vessel at the second hull is less than the height of the vessel at the first hull. Even more preferably, the first hull is larger than the second hull.

25 Preferably, the vessel further comprises at least one positioning propelling means arranged below the platform, wherein the at least one positioning propelling means is adapted to be positioned out of water in the transit state and the at least one positioning propelling means is adapted to be submerged in water and operable to position and manoeuvre the vessel, in the operative state.

30 Preferably, the vessel further comprises at least one column connecting the first hull to the platform and the second hull to the platform, wherein the at least one positioning propelling means is located on the at least one column. More

preferably, the positioning propelling means is located on a periphery of the first hull and/or the second hull. Preferably, the at least one propelling means is removable.

5 Preferably, the platform comprises a bottom side adapted to rest on the water body in the operative state.

Preferably, the platform is a deck adapted to connect the first and second hulls via the first and second topsides.

Preferably, the vessel further comprises at least one main propelling means arranged about an aft portion of the first hull.

10 Preferably, the at least one lifting device is arranged about and above a middle portion of the first topside and/or the second topside

Preferably, the vessel further comprises a track, wherein the at least one lifting device is movable along the track. More preferably, the track is arranged substantially along a middle portion of the first topside of the first hull.

15 Preferably, the vessel comprising two or more lifting devices. More preferably, the at least one lifting device is an A-frame crane.

According to an aspect of the present invention, there is a method of lifting a load at an offshore site from a water body, the method comprising the steps of:
a) providing at least one semi-submersible vessel comprising: a first hull having a first topside, and a second hull having a second topside, wherein the first and second hulls are asymmetrical hulls and wherein the height of the vessel at the first hull is different relative to the height of the vessel at the second hull; a platform adapted to connect the first and second hulls; and at least one lifting device; b)
20 ballasting the vessel into the water body; c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load; d) attaching the load to the at least one lifting device; and e) operating the at least one lifting device to lift the load.
25

Preferably, step b) comprises ballasting the first and second hulls into the water body such that a bottom side of the platform rests on the water body.

30 Preferably, the method further comprises the step of de-ballasting and/or further ballasting the first and/or second hull to lift the load. More preferably, the method further comprises the step of transferring ballast between the first and second hulls to lift the load.

Preferably, the method further comprises the step of moving the at least one lifting device along a track on the vessel.

According to an aspect of the present invention, there is a semi-submersible vessel having a transit state and an operative state, the vessel comprising: a first hull having a first topside; a second hull having a second topside, the second hull operable to orientate between a first orientation and a second orientation; a platform adapted to connect the first and second hulls; and at least one lifting device, wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

10 Preferably, the second hull is operated to orientate in the second orientation in the operative state.

Preferably, the first orientation is a vertical orientation and the second orientation is a horizontal orientation.

15 Preferably, the second hull is substantially planar to the platform in the horizontal orientation.

Preferably, the vessel further comprises a hinge, wherein the second hull is adapted to be connected to the platform via the hinge. More preferably, the second hull is operable to rotate about the hinge between the first orientation and the second orientation.

20 According to an aspect of the present invention, there is a method of lifting a load at an offshore site from a water body, the method comprising the steps of: a) providing at least one semi-submersible vessel comprising: a first hull having a first topside, and a second hull having a second topside, the second hull operable to orientate between a first orientation and a second orientation; a platform adapted to connect the first and second hulls; and at least one lifting device; b) ballasting the first and second hulls into the water body; c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load; d) attaching the load to the at least one lifting device; and e) operating the at least one lifting device to lift the load.

25 30 Preferably, the method further comprises the step of operating the second hull to orientate it in the second orientation prior to step c). More preferably, the step of operating the second hull comprises partially ballasting the second hull.

Preferably, the first orientation is a vertical orientation and the second orientation is a horizontal orientation.

According to an aspect of the present invention, there is a semi-submersible vessel having a transit state and an operative state, the vessel comprising: a first hull having a first topside; a second hull having a second topside; a non-buoyant platform adapted to connect the first and second hulls; and at least one lifting device, wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

Preferably, the platform is a truss structure adapted to connect the first and second hulls via the first and second topsides.

According to an aspect of the present invention, there is a method of lifting a load at an offshore site from a water body, the method comprising the steps of: a) providing at least one semi-submersible vessel comprising: a first hull having a first topside, and a second hull having a second topside; a non-buoyant platform adapted to connect the first and second hulls; and at least one lifting device; b) ballasting the vessel into the water body; c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load; d) attaching the load to the at least one lifting device; and e) operating the at least one lifting device to lift the load.

Other aspects of the invention will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, which are for illustrative purposes only and are therefore not drawn to scale, in which:

Figure 1 provides a perspective view of an embodiment of a vessel of the present invention.

Figure 2 provides another perspective view of an embodiment of a vessel of the present invention.

Figure 3 provides a profile view of an embodiment of a vessel of the present invention.

Figure 4 provides a body plan view of an embodiment of a vessel of the present invention.

Figures 5a and 5b provide a plan view of an embodiment of a vessel of the present invention.

5 Figures 6a and 6b provide a plan view of an embodiment of a vessel of the present invention.

Figures 7a and 7b provide plan and body plan views of an embodiment of a vessel of the present invention in a transit state and an operative state.

10 Figure 8 provides a body plan view of two vessels of the present invention lifting a load.

Figure 9a provides a view of the stern of an embodiment of a vessel of the present invention, where the second hull is in a first orientation (vertical orientation).

15 Figure 9b provides a view of the bow of an embodiment of a vessel of the present invention, where the second hull is in a second orientation (horizontal orientation).

Figure 10 provides a view of an embodiment of a vessel of the present invention with a non-buoyant platform.

20 **Description of Embodiments of the Invention**

Particular embodiments of the present invention will now be described with reference to the accompany drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Other definitions for selected terms used herein
25 may be found within the detailed description of the invention and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one or ordinary skill in the art to which this invention belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

30 Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising, will be

understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers. Additionally, the “longitudinal” direction is defined as the direction that is substantially parallel to the length of the elongated structure 10.

The terms “top” and “bottom” used throughout the specification will have ordinary meaning in the art and will be understood by a skilled person to refer to how far an article is placed with respect to a ground level, for example, an article is located at the bottom if it is closer to a ground level compared to an article located at the top. For the avoidance of doubt, Figures 7a and 7b illustrate that cranes 114 are located on top of the vessel 110 while main propeller 116 is located at the bottom of vessel 110, when vessel 110 is offshore, whether in a transit or operative state. A transit state of the vessel 110 is shown in Figure 7a and refers to the state of the vessel 110 when it is not ballasted into an operative state as shown in Figure 7b. The transit state accordingly includes the state when the vessel 110 is stationary and not in an operative state, or when it is travelling to an intended location.

In accordance with an embodiment of the invention as shown in Figures 1 and 2, there is a semi-submersible vessel 10 for offshore lifting operations. Preferably, the vessel 10 is suitable for offshore heavy lifting operations of more than 100 tons. It will be appreciated that the vessel 10 can also be used for light lifting operations (i.e. loads weighing less than 100 tons), e.g. lifting machinery away from an offshore structure. Offshore lifting operations include but are not limited to decommissioning and removing components of offshore structures, i.e. lifting such components from a water body and/or waterbed, and installation and setting up of offshore structures, i.e. lifting components and manoeuvring them in a particular arrangement to set up such offshore structures. A water body includes, but is not limited to, oceans, seas (open or landlocked), lakes and rivers, and a waterbed includes but is not limited to the natural ground surface at the bottom of such water bodies such as a sea-bed. Vessel 10 has a first hull (body) 11 having

a first topside 11a and a first bottomside 11b, a second hull (body) 12 having a second topside 12a and a second bottomside 12b, and a platform 13 connecting the first hull 11 and second hull 12. The platform 13 also comprises a topside and a bottomside. The first hull 11 and second hull 12 are located at a pre-determined distance from one another. The first and second hull 11, 12 comprises ballast compartments (not shown) for adjusting the position of the vessel 10 relative to a water level of the water body. In Figures 1 and 2, the platform 13 connects via its bottomside, the first hull 11 and second hull 12 via the first topside 11a and second topside 12a respectively. Therefore in this embodiment, platform 13 can also be referred to a deck 13. Depending on the application, the platform 13 need not connect the hulls 11, 12 via their topsides 11a, 12a, and can connect the hulls 11, 12 via their amidship portions, i.e. the topsides 11a, 12a of hulls 11, 12 are located above platform 13. The first hull 11 and second hull 12 are asymmetrical hulls, where the first hull 11 and second hull 12 comprise different dimensions with respect to one another. In some embodiments, the first hull 11 is larger relative to the second hull 12. The smaller hull 12 functions as an outrigger in the transit state of the vessel 10 to provide stability to the first hull 11 and as a counterweight (when ballasted) in the operative state of the vessel 10.

Vessel 10 has cranes 14, i.e. lifting device for lifting a load, a dynamic positioning (DP) system comprising positioning propelling means 15 (e.g. positioning propellers) to assist in the manoeuvring and positioning of the vessel 10 during operation, and a main propelling means 16 (e.g. main propeller) for driving the vessel 10 in an intended direction of travel when in the transit state. Cranes 14 are arranged on the deck 13 and on first hull 11. Preferably, the cranes 14 are arranged substantially about and above a middle portion of the first topside 11a of first hull 11. It will be understood that the cranes 14 are considered arranged above the first topside 11a of the first hull 11 when the platform 13 connects the first hull 11 and second hull 12 via their topsides 11a, 12a, such that the platform 13 is in between the topside 11a and the cranes 14. Accordingly, if the platform 13 connects the first and second hulls 11, 12 via their amidship portions, i.e. the platform 13 is not between the topside 11a and the cranes 14, the term "above" will refer to the cranes 14 being located on the topside 11a of the first hull 11. This arrangement improves and increases the lifting capability of the vessel 10 because

during operation, significant upward buoyancy forces act on the first hull 11 which counter any opposing and downward forces exerted by the weight of components on platform 13 and of any load being lifted by the cranes 14. The second hull 12 acts as a counterweight during operation, to assist the upward buoyancy forces acting on the first hull 11. The forces that allow the second hull 12 to act as a counterweight comprise the weight of the second hull 12 and any ballast in its ballast compartments. The large first hull 11 also improves stability of the vessel 10. The arrangement of the cranes 14 in the present invention is preferable over traditional arrangement of cranes on vessels because cranes are usually positioned at the forward or aft portions of vessels, where there are weak buoyancy forces at the site where the cranes are located and/or weak counterweight forces at the opposite portions of where the cranes are located, to counter any loads being lifted by the cranes. Accordingly, known vessels require complex ballasting and de-ballasting during operation so as to be capable of lifting loads. Such complex ballasting and de-blasting typically requires precise coordination or the vessel may list and tilt during operation, which can pose a danger to the vessel and its personnel.

The main propeller 16 is arranged at a rearward or aft portion of first hull 11 to propel the vessel 10 in an intended direction of travel. Depending on the application, there may be more than one main propeller 16. This improves reliability by providing redundancy. Preferably, the second hull 12 does not comprise any machinery, e.g. engines and propelling means. This reduces maintenance of the second hull 12 thereby reducing costs. Positioning propellers 15 are arranged below the bottom-side of platform 13, and will be discussed in further detail below.

Figures 3 and 4 provide another embodiment of the vessel of the present invention. Vessel 110 comprises a first hull 111, a second hull 112, a platform 113, cranes 114, positioning propellers 115, main propeller 116, azimuthal propeller 117 and columns 118. The first hull 111 has a first topside 111a and a first bottomside 111b, and the second hull 112 has a second topside 112a and a second bottomside 112b. The first and second hull 111, 112 and the platform 113 can comprise ballast compartments (not shown) for adjusting the position of the vessel 110 relative to a water level of a water body. The platform 113 connects

the first and second hulls 111, 112 which are located a predetermined distance from one another. The platform 113 is a buoyant deck structure that is capable of providing stability and operational ease (e.g. access between the first hull 111 and second hull 112) during a lifting operation. The platform 113 is supported by
5 columns 118 which are connected to the first and second topsides 111a, 112a of the first and second hulls 111, 112. Depending on the application, the height of the columns 118 may range from a few meters to several meters, for example the height of the columns 118 may range from 30 to 35 meters.

The first hull 111 and second hull 112 are asymmetrical hulls, where at least
10 one dimension (which includes but is not limited to height, length, surface area and volume) of the first hull 111 is different from that of the second hull 112. Preferably, the size of the first hull 111 is larger than the second hull 112. The smaller hull 112 functions as an outrigger in the transit state of the vessel 110 to provide stability to the first hull 111 and as a counterweight in the operative state
15 of the vessel 110. Preferably, the height of the vessel 110 at the first hull 111 is different from and relative to the height of the vessel at the second hull 112. More preferably, the height B of the vessel 110 at the second hull 112 is less than the height A of the vessel 110 at the first hull 111. It will be understood that the height of the vessel 110 refers to the distance from the topmost portion of the
20 vessel 110 (i.e. without any equipment, e.g. cranes 114) to its bottommost portion. With reference to Figure 4, the height of the vessel 110 is the topside of platform 113 to the first bottomside 111b or to the second bottomside 112b. The height of the vessel 110 at the first hull 111 or the second hull 112 can comprise and will depend on the depth/height of the platform 113, the height of the columns 118 and
25 the height of the hulls 111, 112. Depending on the application, the vessel 110 may exclude columns 118 and the height of the vessel 110 at the first and second hulls 111, 112 will comprise the depth/height of the platform 113 and the height of the hulls 111, 112. The difference in height of the vessel 110 at the first hull 111 and 112 contributes to the advantages of the present invention. Due to the shorter
30 height B of the vessel 110 at the second hull 112, there will be little and minimal contact of the second hull 112 with the water body, i.e. reduced draft of the vessel 110, thereby reducing and minimizing drag and frictional resistance when the vessel 110 is travelling in the transit state. The vessel 110 will therefore travel at

higher speeds with improved performance compared to prior art semi-submersible vessels such that travel time can be reduced to improve efficiency and productivity of the vessel 110.

5 The second hull 112 preferably comprise minimal or no machinery and equipment. The second hull 112 however can comprise ballast compartments (not shown) for ballasting the vessel 110 into the water body. The first hull 111 being the larger hull preferably comprises majority or all of the equipment and machinery of the vessel 110. As better shown in Figure 5b, the vessel 110 can comprise two
10 main propellers 116 which are located at the aft portion of the first hull 111. This arrangement improves the performance of the vessel 110 and reduces maintenance of the smaller second hull 112. Further, reliability of the vessel 110 may be improved by providing redundancy, since in the event of failure of one main propeller 116, it is still possible to operate the other operational main propeller 116 to pilot/drive the vessel 110 to an intended location, for example for
15 repair.

The azimuthal propeller 117 functions partly as a mooring anchor and is involved in the station keeping of the vessel 110. The azimuthal propeller 117 can be driven by a separate and independent engine, and will help the vessel 110 moor or weathervane at a location, thereby saving the complex process of
20 dropping a mooring anchor to station the vessel 110. The azimuthal propeller 117 is retractable and may be stored within the first hull 111 when the vessel 110 is in the operative state or when the vessel 110 is in the transit state travelling to an intended location. This reduces the drag experienced by the vessel 110 when it is travelling.

25 The cranes 114 are arranged on a topside of platform 113 and positioned above the first hull 111. Preferably, the cranes 114 are arranged substantially about and above a middle portion of the first topside 111a of first hull 111. It will be understood that the cranes 114 are considered arranged above the first topside 111a of the first hull 111 when the platform 113 connects the first hull 111 and
30 second hull 112 via their topsides 111a, 112a, such that the platform 113 is in between the topside 111a and the cranes 114. Accordingly, if the platform 113 connects the first and second hulls 111, 112 via their amidship portions, i.e. the platform 13 is not between the topside 11a and the cranes 114, the term "above"

will refer to the cranes 114 being located on the topside 111a of the first hull 111. This arrangement is preferable over traditional arrangement of cranes on vessels because cranes are usually positioned at the forward or aft portions of known vessels, where there are weak buoyancy forces at the site where the cranes are located and/or weak counterweight forces at the opposite portions of where the cranes are located, to counter any loads being lifted by the cranes. Accordingly, known vessels require complex ballasting and de-ballasting during operation so as to be capable of lifting loads. Such complex ballasting and de- ballasting typically requires precise coordination or the vessel may list and tilt during operation, which can pose a danger to the vessel and its personnel. In the present invention however, the cranes 114 are arranged above the first hull 111 which is a larger hull compared to the second hull 112, such that significant buoyancy forces acting on the first hull 111 by the water body during operation provide stabilizing and substantial upward forces that counteract any downward forces resulting from the weight of components on the vessel 110 and any load being lifted by the cranes 114.

A substantial portion of a crane 114 is preferably arranged substantially about and above a middle portion of the first topside 111a of first hull 111. Each crane 114 is an A-frame crane comprising a first mast 114a and a second mast 114b, both of which are pivotal at one end about a pivot 114d and linked by a cable 114c (which includes but is not limited to ropes and chains) at another end. Crane 114 is preferably an A-frame crane as such cranes are more economical compared to rotary cranes of the same capacity. Moreover, the capacity for the addition of more cranes (as explained below) is not possible for rotary cranes since the space is earmarked at the design stage for the possible boom rotation, which cannot be altered at a later stage. However, it will be appreciated that depending on application and requirements, the crane 114 may also be a rotary crane. The first mast 114a extends out and over the side of the vessel 110 at the first hull 111. The cable 114c connects the first mast 114a and second mast 114b via suitable pulley systems (not shown). One end of the cable 114c is connected to a winch 114e or any suitable device which is capable of drawing in and/or winding the cable 114c to lift a load via the other end of the cable 114c. The winch 114e may be automatically or manually operated. As shown in Figure 4, a substantial portion

of crane 114, i.e. first mast 114a, second mast 114b and pivot 114d, is arranged substantially about and above a middle portion of the first topside 111a of first hull 111, while the winch 114e is positioned on platform 113 between the first hull 111 and second hull 112. In this arrangement, majority of the weight of the crane 114 acts on the first hull 111, down towards a water body. The weight of the crane 114 is counteracted by upward buoyancy forces acting on the first hull 111 that is in contact with the water body. This arrangement improves and increases the lifting capability of the vessel 110 because during operation, significant upward buoyancy forces act on the first hull 111 which counter any opposing and downward forces exerted by the weight of components on platform 113 and of any load being lifted by the cranes 114. The second hull 112 acts as a counterweight during operation, to assist the upward buoyancy forces acting on the first hull 111. The forces that allow the second hull 112 to act as a counterweight comprise the weight of the second hull 112 and any ballast in its ballast compartments. The large first hull 111 also improves stability of the vessel 110 since a larger surface area increases the displacement of water and in turn increases the buoyancy forces acting on said first hull 111.

The vessel 110 preferably comprises at least two cranes 114 arranged substantially about and above a middle portion of the first topside 111a of first hull 111, as shown in Figures 5a and 5b. Two or more cranes 114 advantageously spread out the weight of a load being lifted and evens out the pressure and force exerted on the first hull 111, during a lifting operation of the vessel 110. The cranes 114 are located and movable along a track (rail) 119 located on the first hull 111 or above the first hull 111 on platform 113, as shown in Figures 6a and 6b. Preferably, the pivot 114d engages and is movable along the track 119. The movement of the pivot 114d along the track 119 will also move the first mast 114a, second mast 114b and the cable 114c. The cranes 114 are preferably locked in position during a lifting operation of the vessel 110. The track 119 is preferably located along an edge of the first hull 111 or the platform 113, near the water body, so that the cranes 114 can substantially extend out and over the side of the vessel 110 during a lifting operation to minimize damage of the vessel 110. The track 119 is arranged and extends substantially along a middle portion of the first hull 111 and has a length that is substantially parallel to a longitudinal axis of the first hull

111. Preferably, the ends of the track 119 do not extend to the forward and aft portions of the first hull 111 because the cranes 114 will unlikely be positioned there during an operative state since there are weak buoyancy forces at such portions to assist in the lifting of loads. However, in the event that there are more than two cranes 114 as shown in Figure 6b, a crane 114 may be positioned close to the forward and/or aft portions of the first hull 111. The number of cranes 114 and their positions along the track 119 will depend on the application and load requirement. The lifting capacity of the vessel 110 will increase with the number of cranes 114. The winch 114e may also be located on, is engaged to and is movable along a track (not shown) located on the platform 113 between the first and second hulls 111, 112. This allows the winch 114e to move in relation to the movement of the first mast 114a, second mast 114b cable 114c and pivot 114d.

The DP system comprises at least two positioning propellers 115. Preferably the DP system comprises a plurality of positioning propellers 115. The number of positioning propellers 115 will depend on the application of the vessel 110 and the requirements involved. The positioning propellers 115 may be controlled for example, manually, remotely via a user-operated computer system or automatically via sensors (mounted on suitable locations on the vessel 110) and computer systems. The positioning propellers 115 are preferably operated and driven by different engines from the main propeller 116 and azimuthal propeller 117. When the vessel 110 is in operation, the positioning propellers 115 function to manoeuvre the vessel 110 and position it at its intended location. The positioning propellers 115 are arranged below and preferably near the platform 113, and may be located near an upper portion of and about the columns 118 of the first hull 111 or about the periphery of the first hull 111, for example in the absence of columns 118. The positioning propellers 115 are preferably located immediately below the platform 113, for example the positioning propellers 115 may be attached to the bottomside of the platform 113 (as shown in Figures 7a and 7b) via suitable attachment means. The positioning propellers 115 are located out of the water body in the transit state of the vessel 110 and are submerged in the water body the operative state of the vessel 110. Depending on the application and requirements, the positioning propellers 115 may also be arranged below and preferably near the platform 113, and may be located near an upper portion of and

about the columns 118 of the second hull 112 or about the periphery of the second hull 112. Positioning propellers are usually located at the bottom of the hulls in prior art vessels. Therefore prior art vessels are not able to conduct lifting operations in shallow waters because the location of these positioning propellers increases the vessel's draft. Therefore the arrangement of the positioning propellers 115 in the present invention allows for the vessel 110 to conduct lifting operations in shallow water with draft limitations since the positioning propellers 115 are located about the periphery of the vessel 110. Further, the positioning propellers 115 do not require retraction or removal when the vessel 110 enters shallow waters or is in dry-dock. The positioning propellers 115 being located out of the water in the transit state has several advantages, which include but are not limited to reduced wear and tear since the positioning propellers 115 are dry and not used in the transit state thereby prolonging the life of the positioning propellers 115, improved ease of maintain, repair and replacement of the positioning propellers 115 when the vessel 110 is offshore since the positioning propellers 115 are easily accessible in the transit state, reduced sailing friction of the vessel 110 as the positioning propellers 115 do not contribute to drag, and improved ease of dry-docking inspections/repairs for the vessel 110. In the operative state, the vessel 110 is ballasted into the water body via the first and second hulls 111, 112, thereby submerging the positioning propellers 115. Depending on application, the positioning propellers 115 may be extendable and retractable into and out of the water body.

In another embodiment of the present invention as shown in Figures 9a and 9b, the semi-submersible vessel 210 comprises a first hull (body) 211, a second hull (body) 212 and a platform 213 connecting the first hull 211 and second hull 212. The first hull 211 and second hull 212 are asymmetrical hulls, where the first hull 211 and second hull 212 comprise different dimensions with respect to one another. The first hull 211 is larger relative to the second hull 212. The height of the second hull 212 is less than the height of the first hull 211. The smaller hull 212 functions as an outrigger in the transit state of the vessel 210 to provide stability to the first hull 211 and as a counterweight (when ballasted) in the operative state of the vessel 210.

Vessel 210 has cranes 214, i.e. lifting device for lifting a load. Cranes 214 are arranged on the deck 213 and above first hull 211. Preferably, the cranes 214 are arranged substantially about and above a middle portion of the first topside of first hull 211. More preferably, the cranes 214 are arranged on an offshoot 213a which is an extension of the platform 213 and first hull 211. The offshoot 213a contributes to buoyancy during a lifting operation when the vessel 210 is ballasted such that platform 213 contacts a water surface. The offshoot 213a increases the surface area of the platform 213 in contact with the water surface during a lifting operation thereby increasing buoyancy.

The second hull 212 is operable to orientate between a first orientation and a second orientation, with respect to the platform 213. The orientation of the second hull 212 is with respect to the side of the platform 213 in which the platform 213 and second hull 212 are connected. Preferably, the first orientation is a substantially vertical orientation as shown in Figure 9a and the second orientation is a substantially horizontal orientation as shown in Figure 9b. The second hull 212 is considered substantially vertical when a central axis C is in the same or substantially the same direction as gravity, or perpendicular or substantially perpendicular to a water surface. The second hull 212 is substantially horizontal when the central axis C is perpendicular or substantially perpendicular to the direction of gravity, or parallel or substantially parallel to a water surface. It will be appreciated that the second hull 212 may be oriented to an orientation that is between the substantially vertical and substantially horizontal orientations, for example, where the second hull 212 is inclined relative to the platform 213, i.e. central axis C is at an incline relative to the direction of gravity. Such inclined orientation can also be considered a second orientation of the second hull 212.

The platform 213 and/or the second hull 212 is fitted with suitable actuating mechanisms, such as hydraulic and electrical systems, to allow the second hull 212 to switch/flip between the first and second orientations. The second hull 212 can be connected to the platform 213 by a suitable hinge (not shown), where the second hull 212 is operable to rotate about the hinge between the first and second orientations. The rotation axis is preferably an axis that runs along the side of the platform 213 where the platform 213 and second hull 212 connects. Said axis is a longitudinal axis that is substantially parallel to the length of the second hull 212.

The second hull 212 flips/switches between orientations at different stages of operation/transit.

During transit, the second hull 212 is in a substantially vertical orientation as shown in Figure 9a. During the transit period, the total weight of the vessel 210 is supported by the first hull 211 and the vertically oriented smaller second hull 212. The substantially vertical orientation of the smaller second hull 212 provides lower resistance in waves when the vessel 210 is in transit. During a lifting operation, the second hull 212 is operated and flipped to a substantially horizontal orientation as shown in Figure 9b. The second hull 212 is preferably locked by a suitable locking mechanism in the substantially horizontal orientation during a lifting operation. This increases the counter moment with reference to the first hull 211 as a pivot, to balance the pulling force resulting from the lifted load by a crane 214. When the second hull is filled with ballast (e.g. water) and operated to flip to the substantially horizontal orientation, the distance of the ballasted portion of second hull 212 to the first hull 211 as the pivot, is increased. This in turn increases the moment about the first hull 211 by the second hull 212, in the direction of gravity. Depending on the application, the second hull 212 can be oriented to an inclined orientation as a second orientation. An inclined orientation during a lifting operation may be suitable for lifting loads that are not substantially heavy, e.g. loads slightly heavier than 100 tons. Orienting the second hull 212 to an inclined orientation may consume less resources, e.g. fuel and time compared to a substantially horizontal orientation. However while an inclined orientation of the second hull 212 increases the counter moment, such increase is not as much as when the second hull 212 is in the substantially horizontal orientation.

In another embodiment of the present invention as shown in Figure 10, the semi-submersible vessel 310 comprises a first hull (body) 311, a second hull (body) 312 and a platform 313' connecting the first hull 311 and second hull 312. The first hull 311 and second hull 312 are asymmetrical hulls, where the first hull 311 and second hull 312 comprise different dimensions with respect to one another. The first hull 311 is larger relative to the second hull 312. The height of the second hull 312 is less than the height of the first hull 311. The smaller hull 312 functions as an outrigger in the transit state of the vessel 310 to provide

stability to the first hull 311 and as a counterweight (when ballasted) in the operative state of the vessel 310.

Vessel 310 has cranes 314, i.e. lifting device for lifting a load. Cranes 314 are arranged on the platform 313' and above first hull 311. Preferably, the cranes 314 are arranged substantially about and above a middle portion of the first topside of first hull 311. More preferably, the cranes 314 are arranged on an offshoot 313a of the platform 313'. The offshoot 313a contributes to buoyancy during a lifting operation when the vessel 310 is ballasted such that platform 313 contacts a water surface. The offshoot 313a increases the surface area of the platform 313 in contact with the water surface during a lifting operation thereby increasing buoyancy. The platform 313' or part thereof, is a non-buoyant or substantially non-buoyant structure. Preferably, the portion of the platform 313' between the first hull 311 and the second hull 312 is a non-buoyant or substantially non-buoyant structure. Preferably, said portion is a non-buoyant truss structure.

The platform 313' is considered non-buoyant if it is not able to keep afloat in a water body, and will tend to sink in the water body. A non-buoyant platform structure instead of a continuous closed buoyant deck box is more appropriate during a lifting operation in providing stability and operational ease. During lifting operations, a balance has to be achieved between a lifted load and the applied counter ballast load about the centre of floatation (CoF), which is a centroid of an area of a water plane at which the vessel 310 floats. A lower counter ballast is needed for a longer distance (restoring arm) of the counter ballast from the CoF, for example, the distance between the ballast in the second hull 312 and the centroid of an area of a water plane at which the vessel 310 floats. By creating a non-buoyant structure in the platform 313' between the first hull 311 and the second hull 312, the CoF is prevented from shifting significantly towards the counter ballast at the second hull 312 when the vessel 310 is in the operative state, even if the platform 313' is in contact with the water body. In particular, during a lifting operation when the platform 313' floats on a water surface, majority of the water plane area is formed by the first hull 311 and a middle portion of the platform 313', while minority of the water plane area is formed by the second hull 313. If the platform 313' is buoyant, the centroid of water plane area will be located between the first hull 311 and the second hull 312, and a heavier counter ballast

and/or a longer restoring arm will be required to achieve a lifting operation. However, if the platform is substantially non-buoyant, the centroid of the water plane area will be located closer to or at the first hull 311 since the non-buoyant platform 313' will not contribute to the formation of the water plane area and majority of the water plane area is formed by the first hull 311 and minority of the water plane area is formed by the second hull 312. As the centroid shifts towards the first hull 311, the CoF shifts farther away from second hull 312. This prevents a significant reduction in the restoring arm by a shift in the CoF, and allows the conduct of a heavy lift operation with a relatively smaller counter ballast.

It will be appreciated that the features in the different embodiments described about, may be used in combination, for example, a semi-submersible having a second hull that is operable to orientate between a first and second orientation, and a non-buoyant platform.

In Operation

Figure 7a provides plan and body plan views of the vessel 110 in its transit state while Figure 7b provides plan and body plan views of the vessel 110 in its operative state. Referring to Figure 7a, the vessel 110 when in the transit state, floats on a lower portion of the first and second hulls 111, 112, on the surface of a water body 120. In this state, the bottomside of platform 113 is located a distance above and away from the surface of the water body 120, above the water level 121. The positioning propellers 115 are also located a distance above and away from the surface of the water body 120, above the water level 121. When in this transit state, the positioning propellers 115 are dry and easily accessible for repair, maintenance and replacement. The positioning propellers 115 also experience less wear and tear, and do not contribute to drag when the vessel 110 is travelling. In the transit state, the second hull 112 functions as an outrigger to provide stability to the vessel 110, especially during travel. As there is little surface area of the second hull 112 in contact with the water body, the vessel 110 is capable of travelling at high speeds.

When the vessel 110 has reached an intended offshore location to perform a lifting operation, the ballast compartments (not shown) of the first hull 111, second hull 112 and/or the platform 113 will be filled with suitable ballast, which

includes but is not limited to water and cement. The filling of the ballast compartments will weigh down the vessel 110 into the water body 120, to submerge the first hull 111 and second hull 112 into the water body 120, under the water level 121. The ballasting of the vessel 110 will also cause the positioning
5 propellers 115 and columns 118 to be submerged into the water body 120, under the water level 121. As part of the operative state, the platform 113 contacts the water body 120 or is positioned close to the water level 121. Preferably, the platform 113 rests on and floats on the water body 120 during a lifting operation, as shown in Figure 7b. The floating of the platform 113 on the surface of the water
10 body 120 is advantageous because the platform 113 provides a large floatation surface area and buoyancy that confers improved stability to the vessel 110 in the operative state.

In the operative state, the positioning propellers 115 are operated to perform precise positioning of the vessel 110, which includes moving the vessel
15 110 precisely to an intended offshore location, for example positioning the vessel 110 alongside a load 130 where the first hull 111 is adjacent to the load 130, and/or to stabilize the position of the vessel 110 at the intended offshore location. The positioning propellers 115 may function in the presence or absence of a load. The positioning propellers 115 may be independently operated or operated as a group
20 of propellers. If required, the main propeller 116 and the azimuthal propeller 117 may be activated to assist in the precise positioning of the vessel 110.

In a lifting operation as shown in the body plan view of Figure 7b, one end of cable 114c is attached to the load 130. The load 130 is lifted out from the water body 120 by the drawing in of the cable 114c via its other end by the winch 114e.
25 The first mast 114a and second mast 114b can also assist in the lifting of the load 130 by pivoting about the pivot 114d. As an alternative or in addition to, the ballast compartments in the first hull 111 may be de-ballasted to increase the buoyancy forces acting on the first hull 111 such that the first hull 111 will buoy upwards to lift the load 130 out of and above the water body 120. Further, the second hull 112
30 may be further ballasted to act as a counterweight to lift the load 130 out of and above the water body 120. Therefore it will be appreciated that the operation of the cranes 114, the ballasting/de-ballasting of the first and/or second hulls 111, 112 or a combination thereof, will cause the lifting of the load 130 out of and above

the water body 120. In various embodiments, to counter a moment resulting from a force exerted by lifted load near the first hull 111 during a lifting operation, ballast in the first hull 111 is expeditiously transferred to the second hull 112. The redistribution of ballast helps to improve stability of the vessel 110. Accordingly, ballast in the first hull 111 and second hull 112 may be transferred to one another during a lifting operation, by mechanisms and systems known in the art. It will be appreciated that as the platform 113 floats on the water body 120 in the operative state, the first and second hulls 111, 112 need not be ballasted/de-ballasted because the large surface area of the platform provides sufficient stability and buoyancy to the vessel 110 even when lifting the load 130, i.e. the load 130 may be lifted by simply drawing in the cable 114c. This is advantageous because the vessel 110 need not be fitted with complex equipment to coordinate and synchronize the ballasting and de-ballasting of the first and/or second hulls 111, 112, and/or transfer of ballast between the first and second hulls 111, 112. When the load 130 is lifted out of the water body 120, the positioning propellers 115 can be operated to move the vessel 110 and the load 130 away from the lift site and onto another vessel. Lowering of the load 130 comprises operating the cranes 114 to release the cable 114c, ballasting the first hull 111, de-ballasting the second hull 112, or a combination thereof.

The load 130 may be of any weight, in that if the weight of the load 130 exceeds the lifting capacity of vessel 110, more than one vessel 110 may be utilized to lift the load 130 as provided in Figure 8. Preferably, one vessel 110 is capable of lifting a load 130 weighing more than 100 tons and more preferably up to 10,000 tons. Depending on the application, one vessel 110 is capable of lifting a load 130 weighing more than 10,000 tons. Therefore when there are two vessels 110 as shown in Figure 8, the total lifting capacity of the lifting operation can double, for example, the load 130 may weigh 20,000 tons or more. When there are more than one vessel 110 involved in a lifting operation, the vessels 110 may be fitted with suitable equipment, which includes but is not limited to equipment for communication between the vessels 110, and sensors on the vessels 110 to ensure a safety distance between the vessels 110 and/or the load 130.

When the lifting operation is completed, the first hull 111, second hull 112 and/or the platform 113 will be de-ballasted to increase the buoyancy of the vessel

110. During the transition of the vessel 110 from the operative state to the transit state, the platform 113 moves away from and above the water body 120 to locate at a distance from the water level 121. This distance will depend on the amount of de-ballasting carried out or the amount of ballast left in the ballast compartments.

5 The positioning propellers 115 will also move out of the water body 120. When in the transit state, the positioning propellers 115 are located out of the water body 120 and the platform 113 is preferably not in contact with the water body, with only the lower portions of the first and second hulls 111, 112 being in contact with the water body 120. The vessel 110 can then be operated, piloted and driven to the
10 next location.

In another embodiment of the present invention as shown in Figures 9a and 9b, where Figure 9a shows an embodiment of the vessel 210 in a transit state with the second hull 212 in a substantially vertical orientation while Figure 9b shows an embodiment of the vessel 210 in an operative state with the second hull 212 in a
15 substantially horizontal orientation. When vessel 210 has reached an intended offshore location to perform a lifting operation, the second hull 212 is oriented via suitable actuation mechanisms from the substantially vertical orientation (Figure 9a) to the substantially horizontal orientation (Figure 9b), and the ballast compartments (not shown) of the first hull 211, second hull 212 and/or the platform
20 213 will be filled with suitable ballast, which includes but is not limited to water and cement. The filling of the ballast compartments will weigh down the vessel 210 into a water body.

The first and second hulls 211, 212 may be ballasted before the second hull 212 is oriented to the substantially horizontal orientation, to place the vessel
25 210 in an operative state. In various embodiments, the second hull 212 is oriented to the substantially horizontal orientation before the first and second hulls 211, 212 are ballasted to place the vessel 210 in an operative state.

In various embodiments, the second hull 212 is partially ballasted before and/or during the process of orienting the second hull 212 from the substantially
30 vertical orientation to the substantially horizontal orientation, so that the orientation process is a controlled process. Partially ballasting the second hull 212 before and/or during the orientation process reduces the buoyant force acting on the second hull 212 by the water body, thereby improving the control of the orientation

process and flipping of the second hull 212. Preferably, the second hull 212 is not fully ballasted before and/or during the orientation process because this would create a substantial downward force that requires a substantial counter force to flip and orientate the second hull 212 from the substantially vertical orientation to the substantially horizontal orientation. It would be appreciated that the first hull 211 may be partially ballasted as well during this orientation process to provide stability to the vessel 210. After the second hull 212 has been oriented to the substantially horizontal orientation, ballasting of the first and second hulls 211, 212 can continue.

Similar to the embodiment in Figures 7a and 7b, the ballasting of the vessel 110 will also cause the positioning propellers to be submerged into the water body, under the water level. As part of the operative state, the platform 213 contacts the water body or is positioned close to the water level. Preferably, the platform 213 rests on and/or floats on the water body during a lifting operation.

During a lifting operation, as an alternative or in addition to the lifting of a load by the cranes 214, the ballast compartments in the first hull 211 may be de-ballasted to increase the buoyancy forces acting on the first hull 211 such that the first hull 211 will buoy upwards to lift the load out of and above the water body. Further, the second hull 212 may be further ballasted to act as a counterweight to lift the load out of and above the water body. Furthermore, orientation of the second hull 212 may occur during the lifting operation, particularly when the second hull 212 is in an inclined orientation during the start of the lifting operation. For example, the second hull 212 in an inclined orientation can be operated during the lifting operation to orientate in a substantially horizontal orientation to increase the counter moment about the first hull 211. In various embodiments, to counter a moment resulting from a force exerted by lifted load near the first hull 211 during a lifting operation, ballast in the first hull 211 is expeditiously transferred to the second hull 212. This transfer may occur when the second hull 212 is in a substantially horizontal orientation. The redistribution/repositioning of ballast helps to improve stability of the vessel 210. Accordingly, ballast in the first hull 211 and second hull 212 may be transferred to one another during a lifting operation, by mechanisms and systems known in the art. Therefore it will be appreciated that the operation of the cranes 214, the ballasting/de-ballasting of the first and/or

second hulls 211, 212, transfer of ballast between the first and second hulls 211, 212, the orientation of the second hull 212 or a combination thereof, will cause the lifting of the load out of and above the water body.

5 To switch to the transit state, the first hull 211, second hull 212 and/or the platform 213 will be de-ballasted to increase the buoyancy of the vessel 210. During the transition of the vessel 210 from the operative state to the transit state, the platform 213 moves away from and above the water body to locate at a distance from the water level. This distance will depend on the amount of de-ballasting carried out or the amount of ballast left in the ballast compartments.

10 With the first and second hulls 211, 212 sufficiently de-ballasted, the second hull 212 is oriented from the substantially horizontal orientation to the substantially vertical orientation. The vessel 210 can then be operated and driven to the next location.

The first and second hulls 211, 212 may be de-ballasted before the second

15 hull 212 is oriented to the substantially vertical orientation, to place the vessel 210 in an transit state. In various embodiments, the second hull 212 is oriented to the substantially vertical orientation before the first and second hulls 211, 212 are de-ballasted to place the vessel 210 in a transit state.

In various embodiments when switching to the transit state, the second hull

20 212 is partially de-ballasted before and/or during the orientation process to increase the buoyant force acting on the second hull 212 by the water body, thereby improving the control of the orientation process and flipping of the second hull 212. Preferably, the second hull 212 is not fully de-ballasted before and/or during this orientation process because this would create a substantial upward

25 force that requires a substantial counter force to flip and orientate the second hull 212 from the substantially horizontal orientation to the substantially vertical orientation. It would be appreciated that the first hull 211 may be partially de-ballasted as well during this orientation process to provide stability to the vessel 210. After the second hull 212 has been oriented to the substantially vertical

30 orientation, de-ballasting of the first and second hulls 211, 212 can continue.

Turning to another embodiment of the present invention as shown in Figure 10, the vessel 310 is capable of operating in the same manner as the vessel 110 of the embodiment in Figures 7a and 7b. However, the platform 313' or part

thereof, of vessel 310 is a non-buoyant or substantially non-buoyant structure. Preferably, the portion of the platform 313' between the first hull 311 and the second hull 312 is a non-buoyant or substantially non-buoyant structure. Preferably, said portion is a non-buoyant truss structure.

5 When the vessel 310 has reached an intended offshore location to perform a lifting operation, the ballast compartments (not shown) of the first hull 311 and second hull 312 will be filled with suitable ballast, which includes but is not limited to water and cement. In various embodiments, the platform 313' comprises ballast
10 compartments that are operable to be filled with suitable ballast to switch the vessel 310 to an operative state. The filling of the ballast compartments will weigh down the vessel 310 into a water body, to submerge the first hull 311 and second hull 312 into the water body. As part of the operative state, the platform 313' contacts the water body or is positioned close to the water level.

 During a lifting operation, a balance has to be achieved between a lifted
15 load and the applied counter ballast load about the centre of floatation (CoF), which is a centroid of an area of a water plane at which the vessel 310 floats. A lower counter ballast is needed for a longer distance (restoring arm) of the counter ballast from the CoF, for example the distance between the ballast in the second hull 312 and a centroid of an area of a water plane at which the vessel 310 floats.
20 By creating a non-buoyant structure in the platform 313' between the first hull 311 and the second hull 312, the CoF is prevented from shifting significantly towards the counter ballast at the second hull 312 when the vessel 310 is in the operative state, even if the platform 313' is in contact with the water body. In particular, during a lifting operation when the platform 313' floats on a water surface, majority
25 of the water plane area is formed by the first hull 311 and a middle portion of the platform 313', while minority of the water plane area is formed by the second hull 313. If the platform 313' is buoyant, the centroid of water plane area will be located somewhere in the middle portion of the platform 313', between the first hull 311 and the second hull 312, and a heavier counter ballast and/or a longer restoring
30 arm will be required to achieve a lifting operation. However, if the platform is substantially non-buoyant, the centroid of the water plane area will be located closer to or at the first hull 311 since the non-buoyant platform 313' will not contribute to the formation of the water plane area and majority of the water plane

area is formed by the first hull 311 and minority of the water plane area is formed by the second hull 312. As the centroid shifts towards the first hull 311, the CoF shifts farther away from second hull 312. This prevents a significant reduction in the restoring arm by a shift in the CoF, and allows the conduct of a heavy lift operation with a relatively smaller counter ballast. During a lifting operation, as an alternative or in addition to the lifting of a load by the cranes 314, the ballast compartments in the first hull 311 may be de-ballasted to increase the buoyancy forces acting on the first hull 311 such that the first hull 311 will buoy upwards to lift the load out of and above the water body. Further, the second hull 312 may be further ballasted to act as a counterweight to lift the load out of and above the water body. Furthermore, extension of the platform 313' may occur during the lifting operation, to increase the restoring arm and the counter moment exerted by the ballast at the second hull 312. Therefore it will be appreciated that the operation of the cranes 314, the ballasting/de-ballasting of the first and/or second hulls 311, 312, the extension/retraction of the platform 313' or a combination thereof, will cause the lifting of the load out of and above the water body.

To switch to the transit state, the first hull 311 and second hull 312 will be de-ballasted to increase the buoyancy of the vessel 310. During the transition of the vessel 310 from the operative state to the transit state, the platform 313' moves away from and above the water body to locate at a distance from the water level. This distance will depend on the amount of de-ballasting carried out or the amount of ballast left in the ballast compartments. The vessel 310 can then be operated, piloted and driven to the next location. It will be appreciated that the platform 313' can be retracted before the first and second hulls 311, 312 are de-ballasted to place the vessel in a transit state.

It will be appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the invention. In particular,

- The cross-sectional shape of the first and second hulls may be any suitable shape. Preferably the first and second hulls have substantially curved outer peripheral surfaces.

- The second hull can be located on the port or starboard side of the first hull.
- The vessel may comprise more than two main propellers.
- The vessel may comprise more than two azimuthal propellers.
- 5 • The main, positioning and azimuthal propellers may be any suitable propelling means which include but are not limited to blade propellers and thrusters.
- The platform may be ballasted or de-ballasted to assist in the lifting and lowering of the load.
- 10 • The cranes may be any suitable lifting devices and are not limited to A-frame and rotary cranes, and can include other types of cranes, gin pole, hoists, and lifts.
- The platform/deck may be fitted with systems and equipment for offshore activities, for example accommodation modules/equipment and helipads.
- 15 • The vessel can be towed by suitable means, e.g. a towing vessel to an intended location, whether or not the vessel of the present invention has no main propellers.
- The vessel can be fitted with suitable computer systems which
- 20 operate the various components of the vessel.

Claims

1. A semi-submersible vessel having a transit state and an operative state, the vessel comprising:

5 A first hull having a first topside;
 A second hull having a second topside;
 A platform adapted to connect the first and second hulls; and
 At least one lifting device,

10 wherein the first and second hulls are asymmetrical hulls, and the height of the vessel at the first hull is different relative to the height of the vessel at the second hull, and wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

- 15 2. The semi-submersible vessel of claim 1, wherein the height of vessel at the second hull is less than the height of the vessel at the first hull.

3. The semi-submersible vessel of claim 1 or 2, wherein the first hull is larger than the second hull.

- 20 4. The semi-submersible vessel of any one of the preceding claims, the vessel further comprising at least one positioning propelling means arranged below the platform, wherein the at least one positioning propelling means is adapted to be positioned out of water in the transit state and the at least one positioning propelling means is adapted to be submerged in water and
25 operable to position and manoeuvre the vessel, in the operative state.

5. The semi-submersible vessel of claim 4, the vessel further comprising at least one column connecting the first hull to the platform and the second hull to the platform, wherein the at least one positioning propelling means
30 is located on the at least one column.

6. The semi-submersible vessel of claim 4 or 5, wherein the positioning propelling means is located on a periphery of the first hull and/or the second hull.
- 5 7. The semi-submersible vessel of any one of claims 4 to 6, wherein the at least one propelling means is removable.
8. The semi-submersible vessel of any one of the preceding claims, wherein the platform comprises a bottom side adapted to rest on the water body in
10 the operative state.
9. The semi-submersible vessel of any one of the preceding claims, wherein the platform is a deck adapted to connect the first and second hulls via the first and second topsides.
- 15 10. The semi-submersible vessel of any one of the preceding claims, the vessel further comprising at least one main propelling means arranged about an aft portion of the first hull.
- 20 11. The semi-submersible vessel of any one of the preceding claims, wherein the at least one lifting device is arranged about and above a middle portion of the first topside and/or the second topside.
12. The semi-submersible vessel of claim 11, the vessel further comprising a
25 track, wherein the at least one lifting device is movable along the track.
13. The semi-submersible vessel of claim 12, wherein the track is arranged substantially along a middle portion of the first topside of the first hull.
- 30 14. The semi-submersible vessel of any one of claims 11 to 13, the vessel comprising two or more lifting devices.

15. The semi-submersible vessel of any one of claims 11 to 14, wherein the at least one lifting device is an A-frame crane.
- 5 16. A method of lifting a load at an offshore site from a water body, the method comprising the steps of:
- 10 a) providing at least one semi-submersible vessel comprising:
A first hull having a first topside, and a second hull having a second topside, wherein the first and second hulls are asymmetrical hulls and wherein the height of the vessel at the first hull is different relative to the height of the vessel at the second hull;
A platform adapted to connect the first and second hulls; and
At least one lifting device,
- 15 b) ballasting the vessel into the water body;
- c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load;
- d) attaching the load to the at least one lifting device; and
- e) operating the at least one lifting device to lift the load.
- 20 17. The method of claim 16, wherein step b) comprises ballasting the first and second hulls into the water body such that a bottom side of the platform rests on the water body.
- 25 18. The method of claim 16 or 17, the method further comprising the step of de-ballasting and/or further ballasting the first and/or second hull to lift the load.
- 30 19. The method of claim 18, the method further comprising the step of transferring ballast between the first and second hulls to lift the load.
20. The method of any one of claims 16 to 19, the method further comprising the step of moving the at least one lifting device along a track on the vessel.

21. A semi-submersible vessel having a transit state and an operative state, the vessel comprising:

A first hull having a first topside;

A second hull having a second topside, the second hull operable to orientate between a first orientation and a second orientation;

A platform adapted to connect the first and second hulls; and

At least one lifting device,

wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

22. The semi-submersible vessel of claim 21, wherein the second hull is operated to orientate in the second orientation in the operative state.

23. The semi-submersible vessel of claim 21 or 22, wherein the first orientation is a vertical orientation and the second orientation is a horizontal orientation.

24. The semi-submersible vessel of claim 23, wherein the second hull is substantially planar to the platform in the horizontal orientation.

25. The semi-submersible vessel of any one of claims 21 to 24, the vessel further comprises a hinge, wherein the second hull is adapted to be connected to the platform via the hinge.

26. The semi-submersible vessel of claim 25, wherein the second hull is operable to rotate about the hinge between the first orientation and the second orientation.

27. A method of lifting a load at an offshore site from a water body, the method comprising the steps of:

a) providing at least one semi-submersible vessel comprising:

A first hull having a first topside, and a second hull having a second topside, the second hull operable to orientate between a first orientation and a second orientation;

A platform adapted to connect the first and second hulls; and

5

At least one lifting device,

- b) ballasting the first and second hulls into the water body;
- c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load;
- d) attaching the load to the at least one lifting device; and
- 10 e) operating the at least one lifting device to lift the load.

28. The method of claim 27, the method further comprising the step of operating the second hull to orientate it in the second orientation prior to step c).

15

29. The method of claim 28, wherein the step of operating the second hull comprises partially ballasting the second hull.

30. The method of any one of claims 27 to 29, wherein the first orientation is a vertical orientation and the second orientation is a horizontal orientation.

20

31. A semi-submersible vessel having a transit state and an operative state, the vessel comprising:

A first hull having a first topside;

A second hull having a second topside;

5 A non-buoyant platform adapted to connect the first and second hulls; and

At least one lifting device,

wherein the first and second hulls are adapted to be ballasted into a water body in the operative state.

10

32. The semi-submersible vessel of claim 31, wherein the platform is a truss structure adapted to connect the first and second hulls via the first and second topsides.

- 15 33. A method of lifting a load at an offshore site from a water body, the method comprising the steps of:

a) providing at least one semi-submersible vessel comprising:

A first hull having a first topside, and a second hull having a second topside;

20 A non-buoyant platform adapted to connect the first and second hulls; and

At least one lifting device,

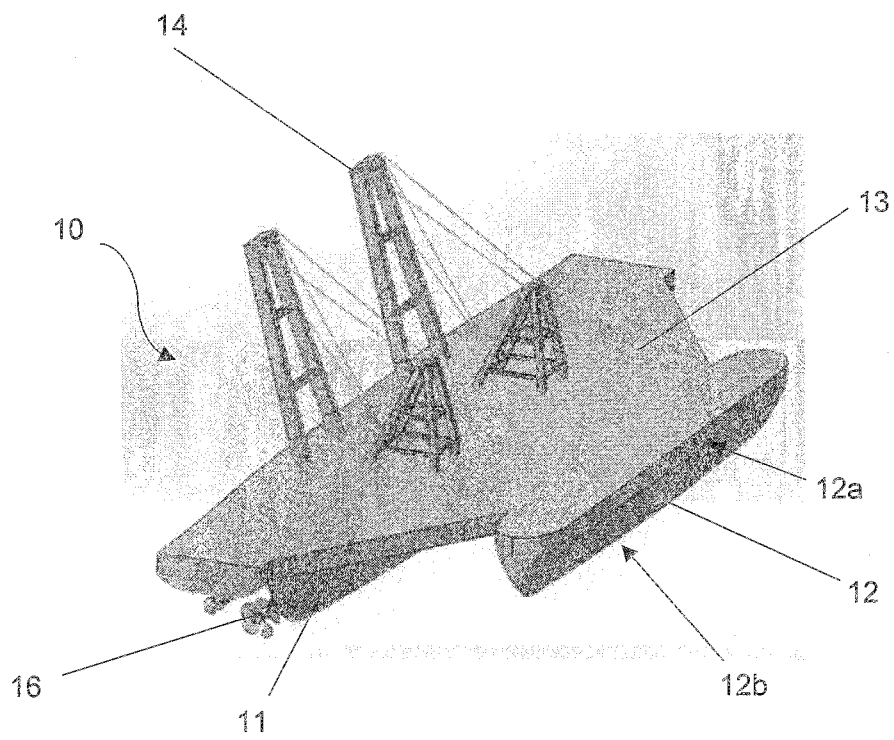
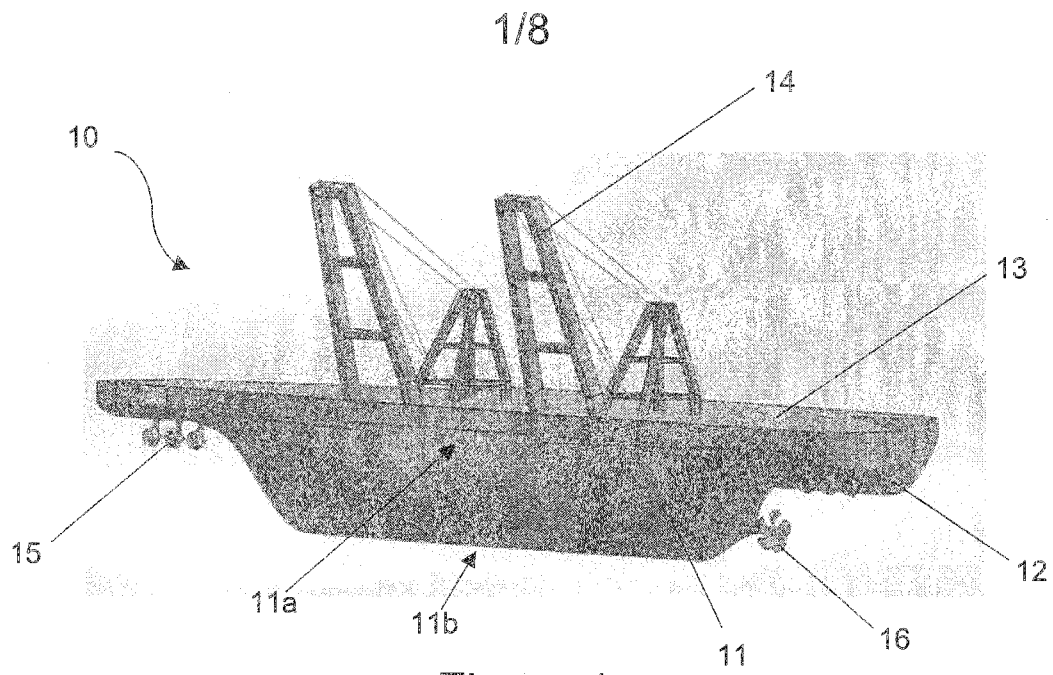
b) ballasting the vessel into the water body;

c) positioning the at least one vessel alongside the load, wherein the first hull is adjacent to the load;

25

d) attaching the load to the at least one lifting device; and

e) operating the at least one lifting device to lift the load.



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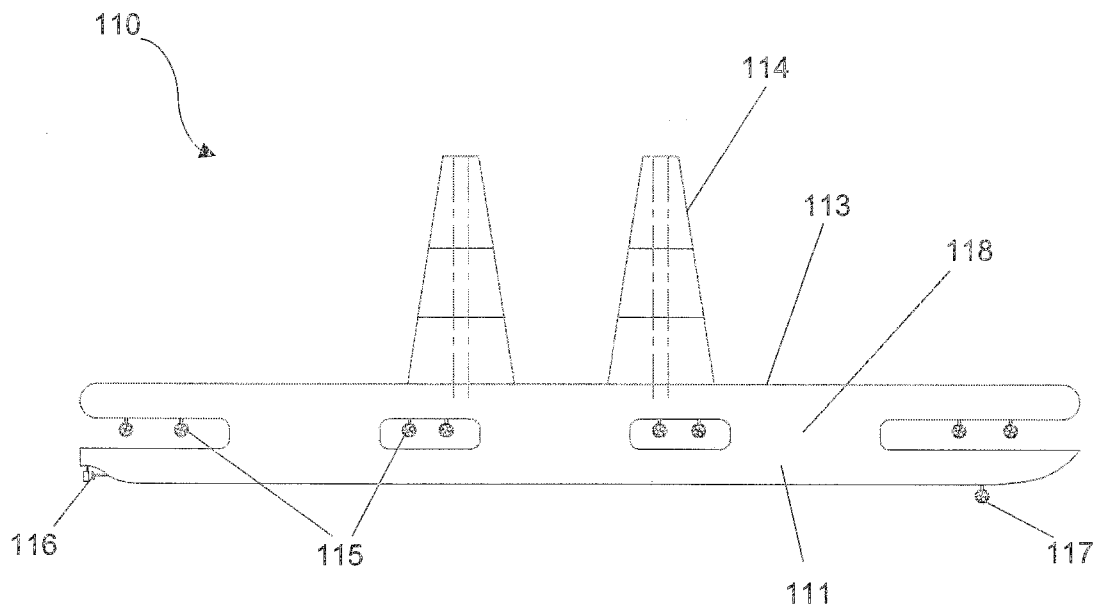


Figure 3

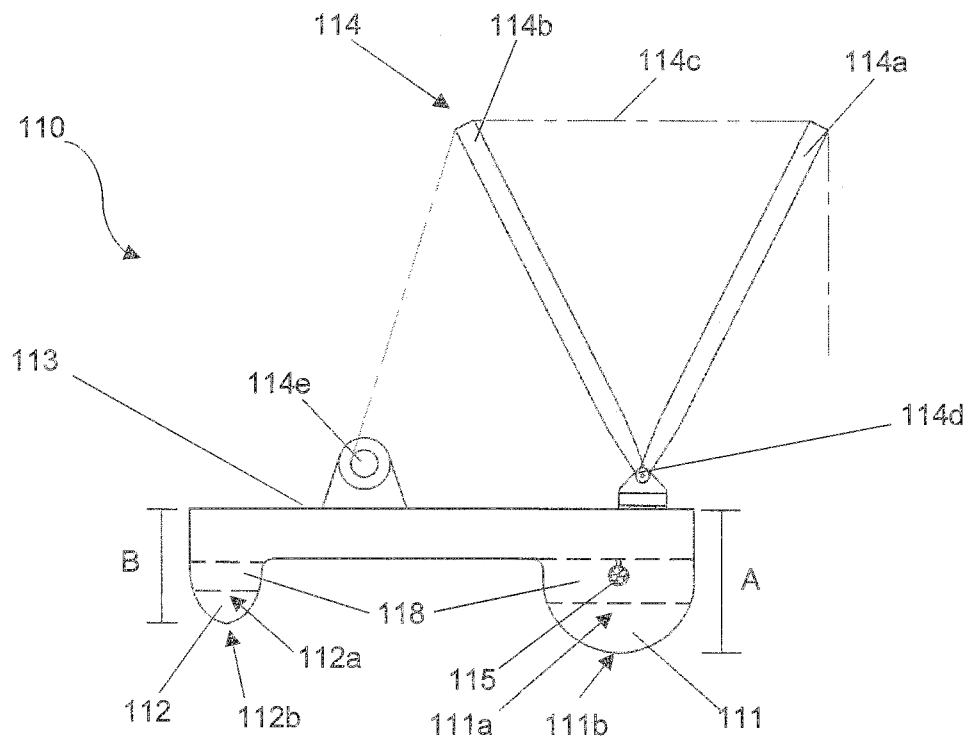


Figure 4

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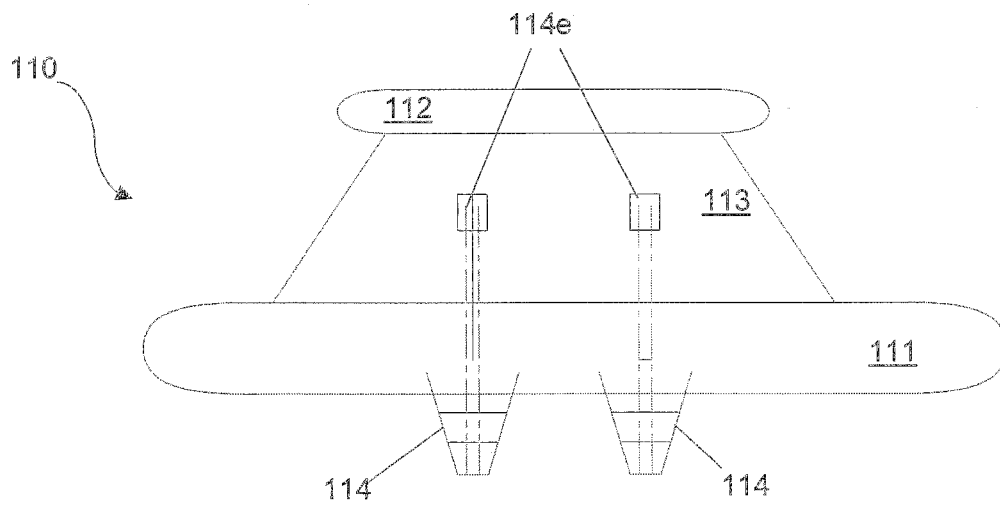


Figure 5a

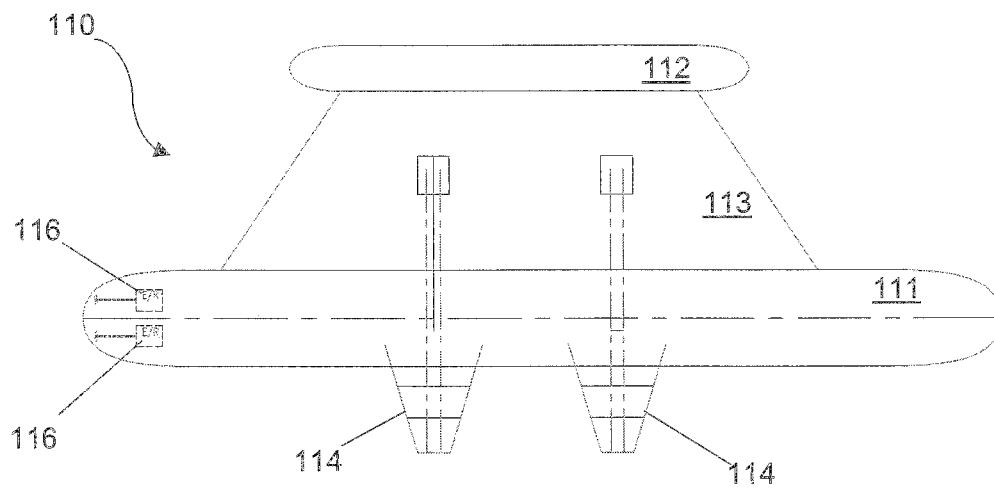


Figure 5b

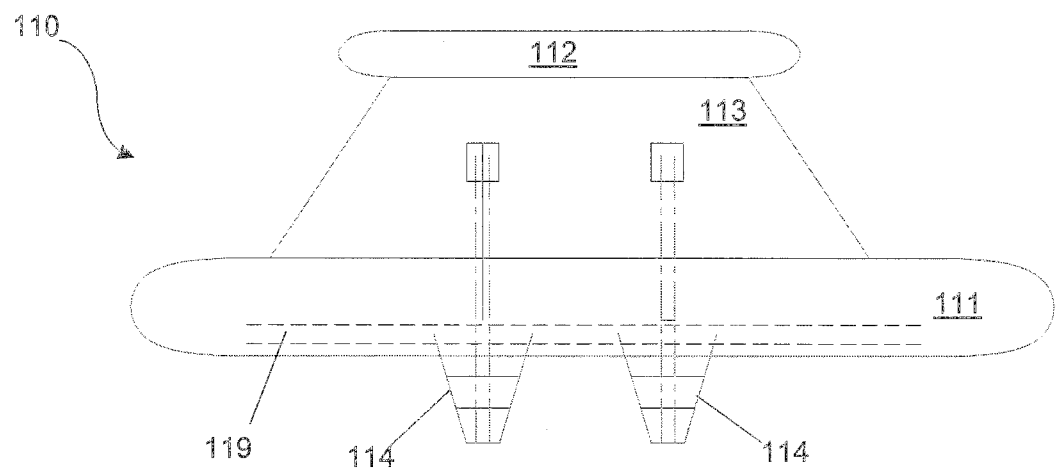


Figure 6a

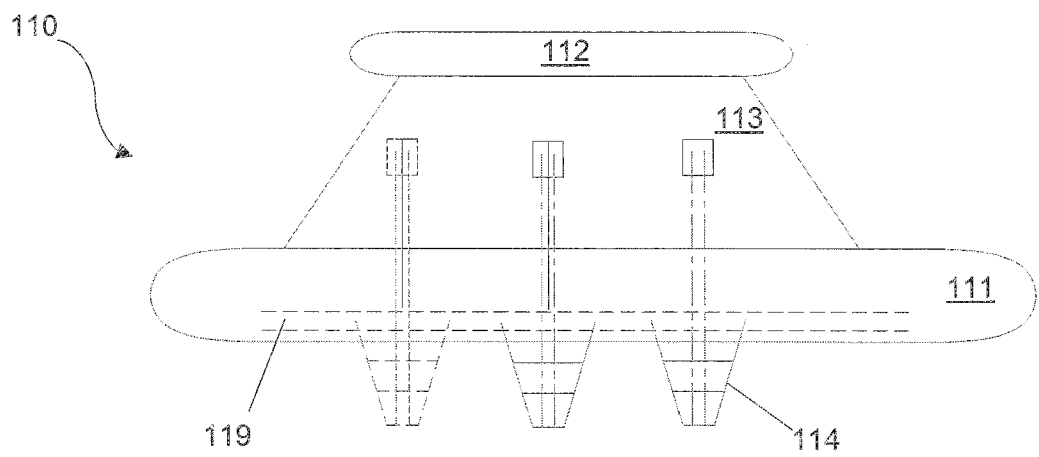


Figure 6b

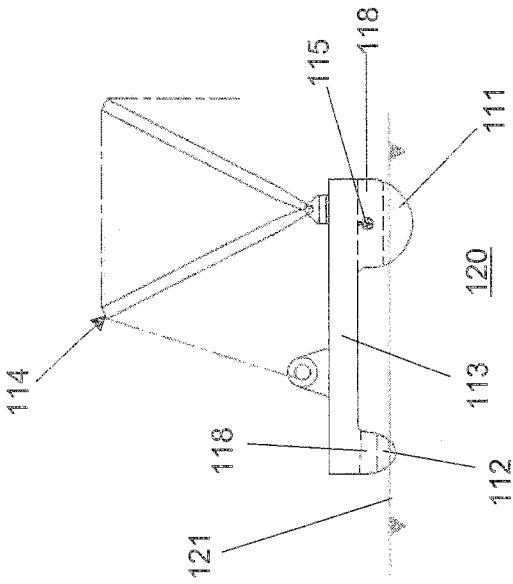


Figure 7a

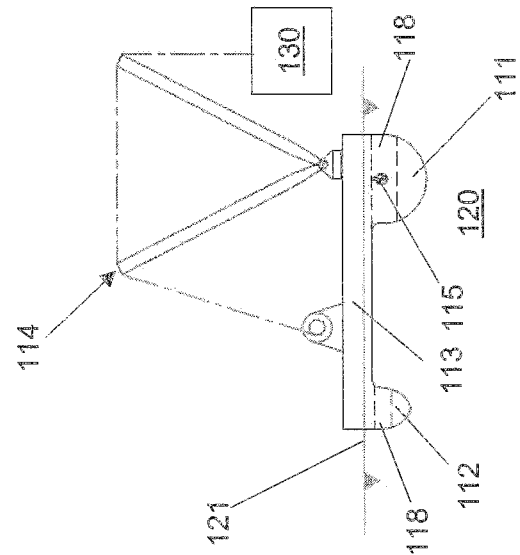
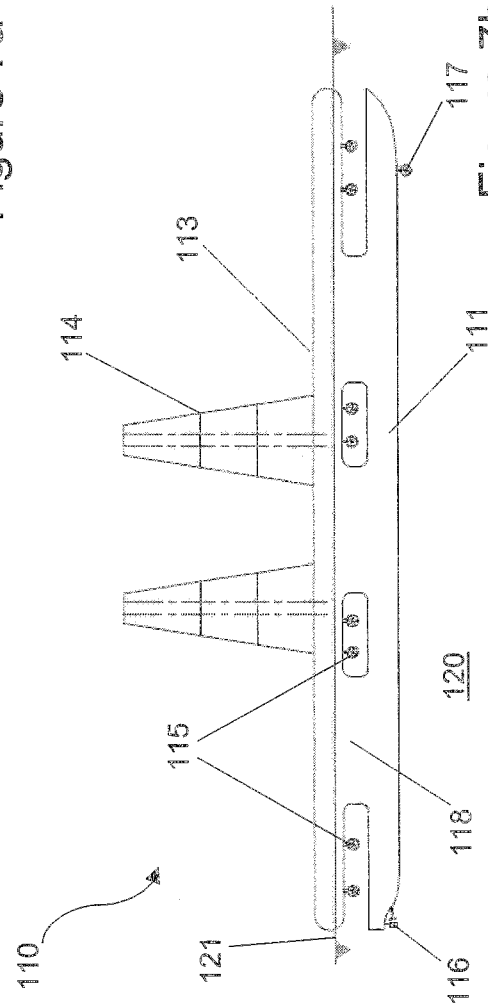
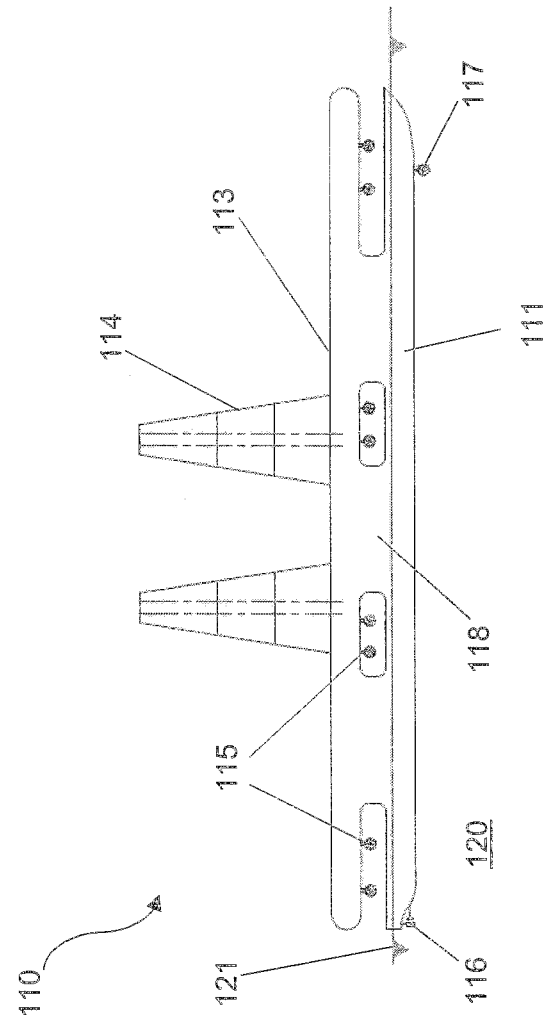


Figure 7b



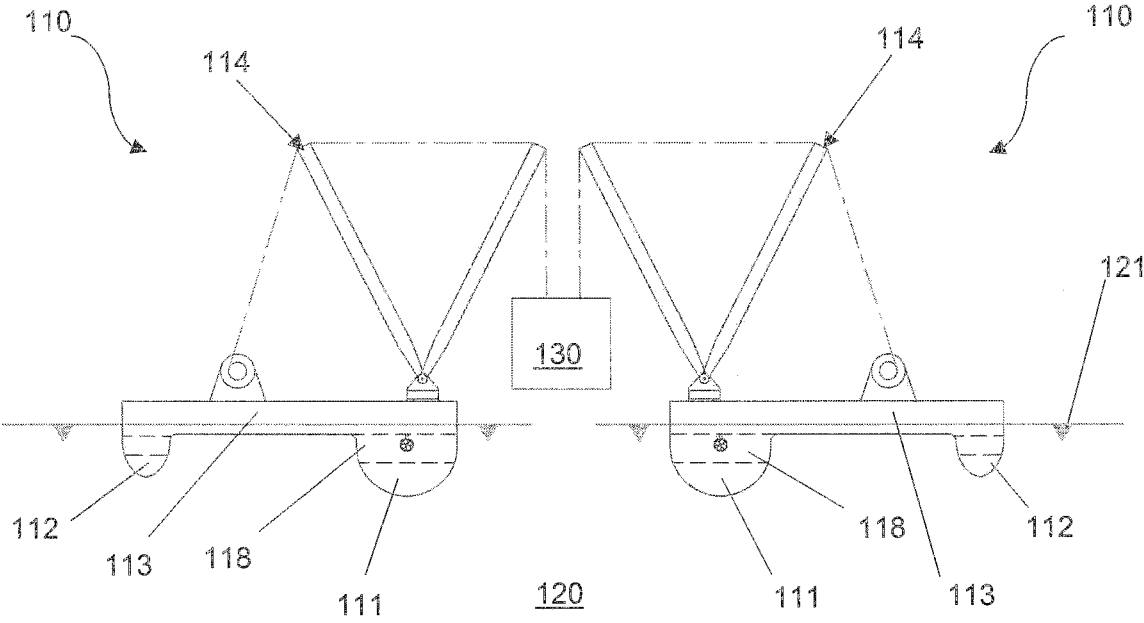


Figure 8

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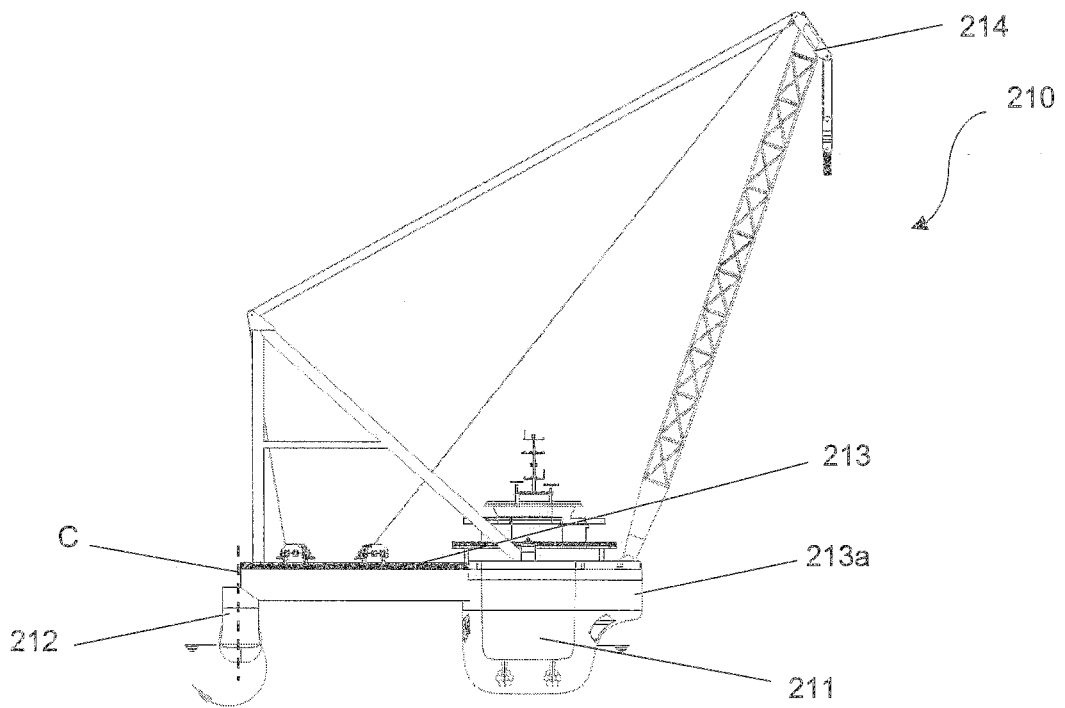


Figure 9a

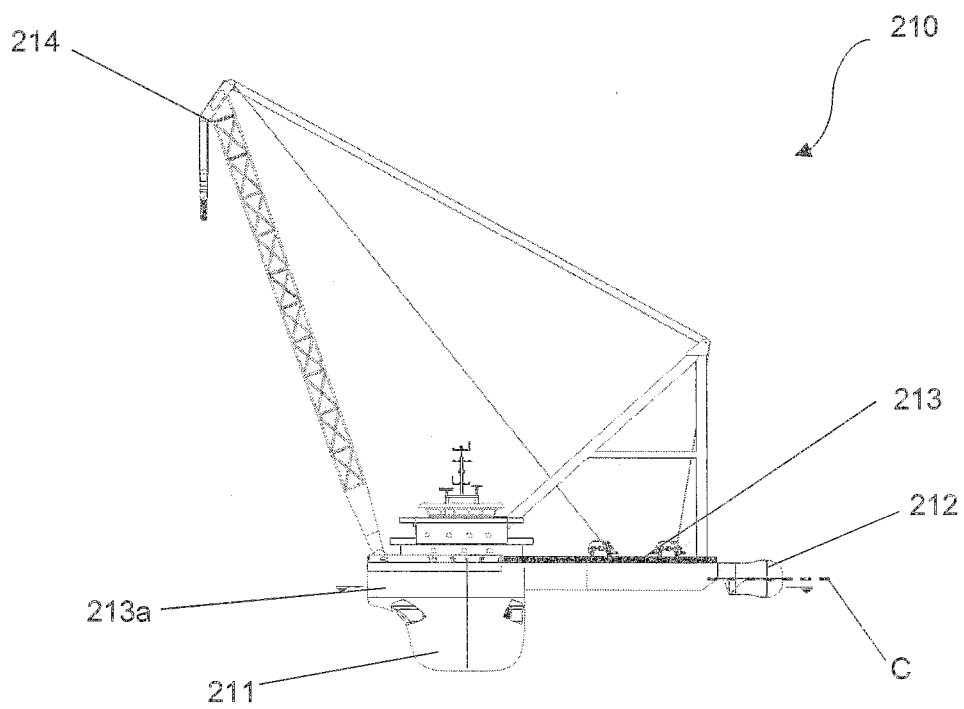


Figure 9b

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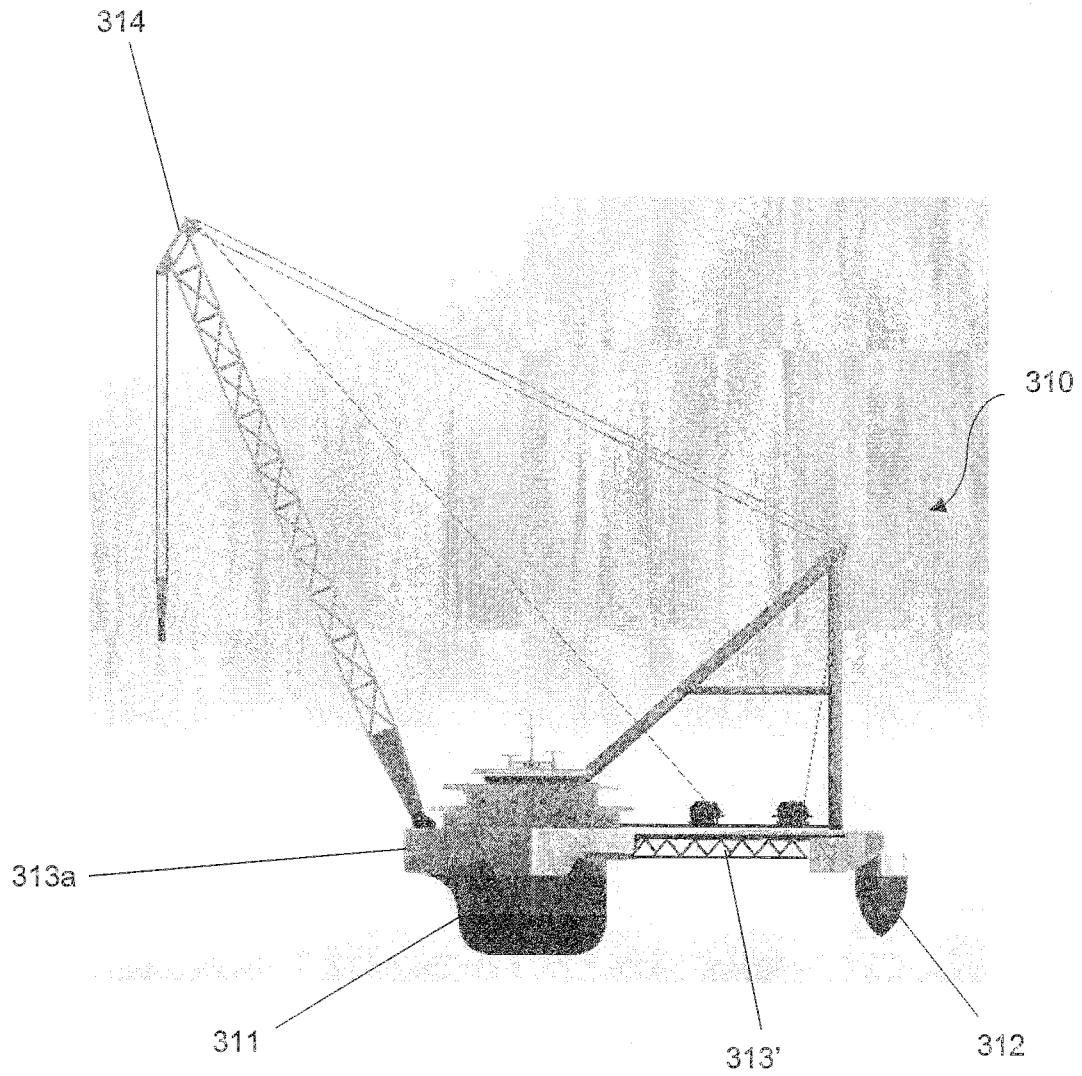


Figure 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2017/050124

A. CLASSIFICATION OF SUBJECT MATTER

B63B 35/44 (2006.01) B63B 1/10 (2006.01)

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

FAMPAT: semi-submersible vessel, ship, two hulls, float, asymmetrical, propeller, crane, and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102328733 A (YANTAI CIMC RAFFLES OFFSHORE ENGINEERING LIMITED ET AL.) 25 January 2012	1-20
Y	Paragraph [0005], [0031-0033], [0038], Figures 1, 4 of the original non-English language document (a machine translation is enclosed only for your reference)	1-20
Y	EP 2706006 A1 (CONSTRUCTIONS MECANIKES DE NORMANDIE) 12 March 2014	1-20
	Paragraph [0003], [0005], [0013], [0019], Figures 2, 3 of the machine translation	
A	US 7985108 B1 (BEKKER J. R. M. ET AL.) 26 July 2011	
	whole document, particularly column 2, line 9-52, figures. 1A, 1B and 2	
A	US 2010/0224114 A1 (COPPENS T.) 9 September 2010	
	whole document, particularly paragraph [0153], figure 4	
A	WO 2009/084950 A1 (HEEREMA MARINE CONTRACTORS NEDERLAND B.V.) 9 July 2009	
	whole document	

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

*Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

22/06/2017

(day/month/year)

Date of mailing of the international search report

24/06/2017

(day/month/year)

Name and mailing address of the ISA/SG



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2017/050124

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please refer to Supplemental Box (Continuation of Box No. III).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-20

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2017/050124

Supplemental Box (Continuation of Box No. III)

This International Searching Authority found multiple inventions in this international application, as follows:

Invention 1: Claims 1-20 relate to a semi-submersible vessel having a transit state and an operative state, the vessel comprising a first hull having a first topside, a second hull having a second topside, a platform adapted to connect the first and second hulls and at least one lifting device, wherein the first and second hulls are adapted to be ballasted into a water body in the operative state. Said claims further define that the first and second hulls are asymmetrical hulls, and the height of the vessel at the first hull is different relative to the height of the vessel at the second hull;

Invention 2: claims 21-30 relate to a semi-submersible vessel having a transit state and an operative state, the vessel comprising a first hull having a first topside, a second hull having a second topside, a platform adapted to connect the first and second hulls and at least one lifting device, wherein the first and second hulls are adapted to be ballasted into a water body in the operative state. Said claims further define that the second hull is operable to orientate between a first orientation and a second orientation;

Invention 3: claims 31-33 relate to a semi-submersible vessel having a transit state and an operative state, the vessel comprising a first hull having a first topside, a second hull having a second topside, a platform adapted to connect the first and second hulls and at least one lifting device, wherein the first and second hulls are adapted to be ballasted into a water body in the operative state. Said claims further define that the platform is non-buoyant.

Please refer to **Box No. IV** of Written Opinion of The International Searching Authority (Form PCT/ISA/237) for detailed explanation.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2017/050124

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 102328733 A	25/01/2012	CN 102328733 (B)	02/04/2014
EP 2706006 A1	12/03/2014	EP 2706006 (B1) FR 2995278 (A1)	22/04/2015 14/03/2014
US 7985108 B1	26/07/2011	NONE	NONE
US 2010/0224114 A1	09/09/2010	AU 2006338668 (B2) BR PI0621365 (A2) CA 2642117 (C) CN 101389526 (A) GB 2449033 (A) NO 20084044 (A) RU 2008138542 (A) WO 2007/097610 (A1) WO 2007/097611 (A1)	30/08/2007 06/12/2011 30/08/2007 18/03/2009 05/11/2008 25/11/2008 10/04/2010 30/08/2007 30/08/2007
WO 2009/084950 A1	09/07/2009	NONE	NONE