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(54) Title: TURRET MOORING

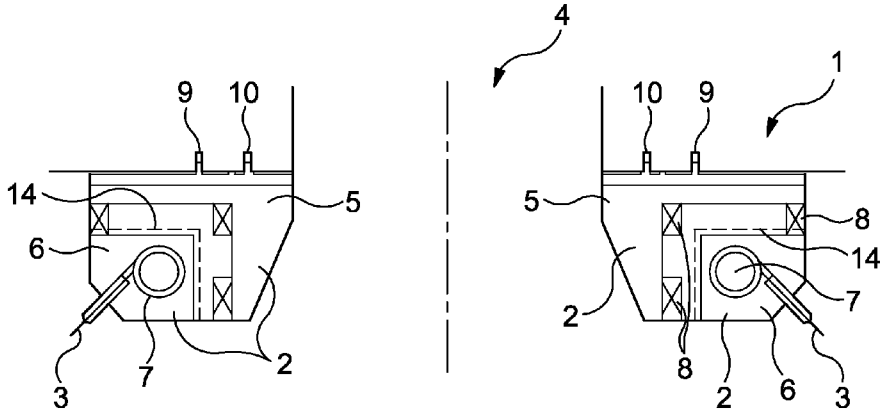


Fig. 1

(57) Abstract: A connection between a turret mooring buoy (2) and a floating vessel (1) for restricting the relative motion between the buoy and the vessel in a horizontal plane comprising: at least one protrusion on one of the buoy and the vessel, at least one opening on the other one of the buoy and the vessel, wherein the protrusions are arranged to be placed inside the openings when the buoy and vessel are connected to each other.

WO 2014/173456 A1

Turret Mooring

TECHNICAL FIELD

The invention relates to the field of drilling operations and to drilling operations from moored mobile offshore drilling vessels.

BACKGROUND

Drilling operations in water with medium to shallow depths, around 100 to 500meters, may be carried out from moored drilling vessels. During a drilling operation, the drilling vessel preferably stays in the same position with respect to the sea bed to avoid tension or bending of a drill string extending from the vessel to the sea bed. In deeper waters, above 500 meters, a drilling vessel may be kept in substantially the same position with respect to the sea bed using dynamic positioning with use of the vessel's propulsion units. In benign medium to shallow waters the drilling vessel may be kept in the same position by mooring lines extending from the vessel to the sea bed, which method is also referred to as spread mooring. Turret mooring may also be used whereby a portion of the vessel is attached to the seabed by mooring lines. The connection between the vessel and the mooring lines may be direct or indirect via a buoy.

In ice infested waters where ice forces act on vessels, it is not possible to operate column stabilized semi-submersibles at an acceptable risk level because it may be unable to withstand the forces acting upon it owing to ice loading. When using turret mooring, it is desirable to be able to disconnect the vessel in order to move the position of the vessel with respect to the seabed if external forces on the vessel exceed design limitations of the mooring system.

SUMMARY

It is an object to provide a connection between a turret mooring buoy and a vessel which is able to withstand large forces in a plane parallel to the water surface.

According to a first aspect, there is provided a connection between a turret mooring buoy and a floating vessel for restricting the relative motion between the buoy and the

vessel in a horizontal plane comprising: at least one protrusion on one of the buoy and the vessel, at least one opening on the other one of the buoy and the vessel, wherein the protrusions are arranged to be placed inside the openings when the buoy and vessel are connected to each other.

Said protrusions and said openings may extend in a substantially vertical direction for disconnecting the buoy and floating vessel in a substantially vertical direction. Said protrusions and said openings may have corresponding geometrical shapes, such as shapes with a substantially rectangular cross section.

Said protrusions and said openings may be symmetrically distributed around a moon pool area of the vessel and the buoy. The protrusions and the openings may have a substantially circular shape around a moon pool area of the vessel and the buoy.

The protrusions may be provided on the buoy and may have the shape of a plurality of rings provided around a moon pool area of the vessel and the buoy and wherein said openings may be formed within the hull of the vessel for receiving the plurality of rings. Said opening may be the moon pool area of the vessel.

A space may be provided between said openings and said protrusions when the vessel and the buoy are connected, the space being arranged to be sealed on reduction of a fluid pressure within the space for increasing a bond between the buoy and the vessel.

The buoy may comprise a first portion and a second portion, which portions are rotatably connected to each other. Said first portion may be arranged to be connected to mooring lines and said second portion may be arranged to be connected to the vessel.

According to a second aspect of the invention, there is provided a turret mooring buoy comprising a plurality of sections which can be separated from each other for emergency evacuation. The plurality of sections may connected by weak links.

According to a third aspect of the invention, there is provided a turret mooring buoy comprising a protrusion or an opening, wherein the protrusion or opening is arranged to form a connection with, respectively, a corresponding opening or protrusion on a

floating vessel. The protrusion or opening on the turret mooring buoy may have a geometrical shape which correspond to an interlocking geometrical shape of the opening or protrusion on the floating vessel. The protrusion or opening may extend in a circular shape around an upper surface of the buoy.

According to a fourth aspect of the invention, there is provided a floating vessel comprising a protrusion or opening, the protrusion or opening being arranged to form a connection with, respectively, a corresponding opening or protrusion on a buoy. Said protrusions or said openings may have corresponding interlocking geometrical shapes. The protrusion or opening may extend in a circular shape around a moon pool area of the vessel.

According to a fifth aspect of the invention, there is provided a method of connecting a turret mooring buoy with a floating vessel, the method comprising: locating the floating vessel substantially above the turret mooring buoy; raising the turret mooring buoy such that corresponding protrusions and openings on any of the vessel and buoy interlock. The method may further comprise forming a seal between the vessel and the turret mooring buoy.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates schematically a vertical cross section through a turret mooring buoy connected to a vessel;

Figure 2 illustrates schematically a top view of a turret mooring buoy;

Figure 3 illustrates schematically a perspective view of a turret mooring buoy with mooring lines; and

Figure 4 is a flow diagram showing an exemplary method of connecting a turret mooring buoy and a vessel.

DETAILED DESCRIPTION

Drilling operations in water with medium to shallow depths may be carried out using drilling vessels. During a drilling operation, the drilling vessel preferably stays in the same position with respect to the sea bed to avoid tension or bending of a drill string extending from the vessel to the sea bed. The drilling vessel may be kept in the same position by mooring lines extending from the vessel to the sea bed, which is also referred to as spread mooring. Turret mooring may also be used whereby a buoy is attached to the seabed by mooring lines and whereby the buoy is divided into a geostationary part attached to the seabed by mooring lines and a rotary part connected to the vessel.

The buoy is a passive element whereby its position is controlled by attachment to mooring lines and/or to a vessel together with buoyancy forces working on the buoy. The buoyancy forces may be controlled by pumping air or sea water into or out of buoyancy compartments. A buoy may in use be semi-submerged or submerged in the sea. A buoy may have any shape, but for convenient attachment to the hull of a vessel, the shape of the top of the buoy may correspond to the shape of the hull. When the buoy is anchored to the sea bed by moorings lines, and is also attached to a vessel, it effectively acts as an anchor point between the vessel and the sea bed.

A drill string may extend from a drilling vessel to a fixed position at the sea bed such as a blow-out preventer (BOP). In shallow water, a relative motion of a drilling vessel with respect to the sea bed will more quickly give rise to a large deflection angle of the drill string with respect to a vertical orientation when compared to deeper waters in which the distance to the sea bed is larger. In order to protect the integrity of both the well head and the BOP, there are limits on how much deflection of the drill string is acceptable. A typical limit for the offset of the drill string relative to the vertical is around 1 degree. The motion of a drilling vessel relative to the well head may be restricted by dynamic positioning, whereby the vessel's propulsion unit is used to keep the vessel substantially stationary with respect to the well head, or by mooring lines which anchor the vessel to the sea bed.

The inventors have appreciated that a connection between the mooring lines and the vessel is required that is strong in the horizontal plane (the plane substantially parallel to the water surface). The connection between the vessel and the mooring lines may be indirect, for example via a submersed buoy which is attached to both the vessel and the mooring lines. A strong connection is particularly important in ice-infested waters,

where the ice may apply a large force onto the vessel in the plane of the water surface. Such a horizontal force applied by ice may cause the vessel to move away from its drilling position. The large ice forces need to be transferred from the vessel to the mooring lines. Currently, turret mooring buoys are connected to a vessel using a combination of upwards forces by the buoyancy of the buoy onto the hull of the vessel and a frictional restriction in the horizontal plane due to the choice of material (e.g. rubber) of the buoy at the interface of the buoy and the hull, but at periods of excessively high ice loading this may not provide sufficient strength.

Herein disclosed is a turret mooring system, wherein a turret mooring buoy is connectable to the sea bed by mooring lines. The turret mooring buoy comprises a first portion which is connectable to the mooring lines and a second portion which is rotatable with respect to the first portion in the horizontal plane. The second portion is connectable to a vessel. The rotatable connection between the first portion and the second portion enables the vessel to “weathervane”, i.e. turn about a vertical axis, without moving the first portion with respect to the sea bed. This vertical axis could, during a drilling operation, substantially coincide with a main axis of a drill string extending from the vessel towards the sea bed. The vessel and the mooring buoy both may have an opening through which a drilling riser may extend. This opening is also referred to as the “moon pool”.

The possibility to turn the vessel around a central axis while being moored to the seabed is particularly advantageous in ice infested waters because that will enable the vessel to turn its bow into the direction of an ice flow. An orientation whereby the bow of the vessel faces the ice flow reduces the force applied to the vessel when compared to an orientation whereby a side of the vessel faces the ice flow.

Herein disclosed is a connection between the second portion of the mooring buoy and the vessel which provides a strong connection between the hull of the vessel and the second portion of the buoy. The connection allows for a disconnection of the buoy in the vertical direction whereby the buoy may be lowered with respect to the vessel to disconnect the buoy.

The connection is provided between the turret mooring buoy and the vessel for restricting the relative motion between the buoy and the vessel in the horizontal plane.

The connection comprises at least one protrusion on one of the buoy and the vessel and at least one opening on the other one of the buoy and the vessel. The protrusions are arranged to be located inside the openings when the buoy and vessel are connected to each other. The protrusions and openings extend in a substantially vertical direction for disconnecting the buoy and floating vessel in the vertical direction and for restricting the relative movement between the buoy and the vessel in the horizontal plane.

The protrusions and openings may have corresponding geometrical shapes, for example, the protrusions may be generally block shaped. Alternatively, the protrusions may have a triangular cross-section in the vertical plane. This allows some play between the protrusions and corresponding openings when the protrusions and openings are brought together.

In order to evenly distribute the forces, the protrusions and openings may be symmetrically distributed around the moon pool area of the vessel and of the buoy. The protrusions and the openings may have a substantially circular shape around a moon pool area of the vessel and the buoy, although it will be appreciated that other shapes could be used, and may be required depending on constraints of the hull size or shape.

In one embodiment, the protrusions are provided on the buoy and may have the shape of a plurality of concentrically arranged rings provided around a moon pool area of the vessel and of the buoy and the openings are formed within the hull of the vessel for receiving the plurality of rings. It will be appreciated that the protrusions may alternatively be provided on the hull of the vessel and the corresponding openings provided on the buoy. It will be further appreciated that the hull may be provided with both protrusions and openings, which are arranged to interlock with corresponding openings and protrusions provided on the buoy.

The opening may also be the moon pool area of the vessel.

A space may be provided between said openings and said protrusions when the vessel and the buoy are connected. The space may be arranged to be sealed and the

pressure within the space is arranged to be reduced with respect to the environment of the buoy for increasing the bond between the buoy and the vessel.

The buoy comprises a first portion and a second portion, which portions are rotatably connected to each other. The first portion is arranged to be connected to mooring lines and the second portion is arranged to be connected to the vessel.

The turret mooring buoy may comprise a plurality of sections which can be separated from each other for emergency evacuation. The plurality of sections may be connected by weak links and/or interlocking devices.

Further herein disclosed is a method of connecting a turret mooring buoy with a floating vessel, comprising placing one or more protrusions which are provided on one of said buoy or said vessel into one or more openings which are provided on the other one of said buoy or said vessel.

An embodiment is illustrated in Figure 1. Figure 1 shows a vertical cross section through a drilling vessel hull (1), a buoy (2) and mooring lines (3). A moon pool (4) is provided in the hull of the vessel and the opening of the moon pool extends through the buoy. In the vertical cross section through the centre of the moon pool, the hull and the buoy is shown on either side of the moon pool. The buoy is provided with a second portion (5), which is rigidly connected to the hull of the vessel and is rotatable relative to a first portion (6). The first portion is the geo-stationary part (6) of the buoy and is connected to mooring lines by mooring line winches or tensioners (7). A plurality of mooring line tensioners may be located in separated compartments inside the turret buoy. The first and second portions are rotatably connected to each other by rotary bearings (8). The second portion (5) of the buoy has two concentric rings (9, 10) which extend into corresponding circular openings in the hull of the ship. The centre of the rings coincides with the centre of the moon pool (4). A void may be provided between the rings on the buoy and the walls of the openings in the hull, which has watertight seals for creating an area with low pressure such that the buoy is pressed against the hull by suction.

The method of connecting the buoy to the hull includes positioning the vessel above the buoy. The buoy would preferably already be connected to the mooring lines before

the vessel is positioned above the buoy. After positioning the vessel above the buoy, the buoy is raised until the buoy makes contact with the hull of the ship. The positioning of the buoy itself may be controlled by the mooring line winches or tensioners, optionally in combination with controlling the buoyancy of the buoy by pumping water or air into or out of the buoyancy compartments. The protrusions and openings on the buoy and the hull are aligned such that an interlock is created by the structural connection when the buoy makes contact with the hull.

After connection of the buoy to the hull, the water may be pumped out of the voids to create suction between the buoy and the hull. The flat area surrounding the rings which is in contact with the hull may also be placed under suction. This suction creates a force in addition to an upwards pressure of the buoy onto the hull because of buoyancy forces inside the buoy. Ballast compartments may be provided inside the buoy for controlling the buoyancy forces. The rings 9, 10 enable an accurate positioning of the buoy relative to the hull of the vessel. The rings also provide a strong connection between the buoy and the hull, and in particular restrict movement between the buoy and the hull in the plane of the surface of the water. This design is also preferable over a design with a turret which is internal to the hull because an internal turret requires a lot of space in the hull and a complex re-design if an existing vessel needs to be retrofitted with the internal turret.

Figure 2 shows a top view of an embodiment. The buoy of Figure 2 has four sets of four mooring lines (11), which would provide a strong connection to the sea bed in case of challenging weather conditions. Any other number of mooring lines would also be possible, for example three sets of three mooring lines distributed equally around the centre of the turret. The moon pool (4) is shown in the centre of the buoy.

Figure 3 shows a perspective view of the buoy with mooring lines extending from the buoy downwards towards the sea bed.

Figure 4 illustrates the method of connecting a turret mooring buoy to a vessel. The following numbering corresponds to that of Figure 4:

S1. The vessel is positioned over the buoy such that the protrusions and corresponding openings substantially line up.

S2. Once the vessel is in place, the buoy is raised.

S3. The corresponding openings and protrusions interlock.

S4. The interface between the buoy and the vessel may be sealed to strengthen the connection between the buoy and the vessel.

There may be emergency situations whereby the vessel needs to be disconnected quickly from the mooring lines and whereby the turret buoy must separate from the drilling riser. The entire buoy may be disconnected from the vessel. Such a disconnection requires that the drilling riser is pulled up and no other obstructions are in the moon pool. This disconnection is preferable since the mooring lines can still be attached to the buoy and allow for a faster reconnection if needed. However, during an emergency disconnection the drilling riser will most likely be an obstacle to take into consideration. Emergency disconnection can be done by disconnecting each individual anchor line using remotely operated anchor release units. Alternatively, as disclosed herein, emergency release from the riser can be done by splitting up the buoy into different sections along predetermined split edges. The split edges may be held together by weak links which break when a predetermined threshold force is exceeded. Alternatively, the buoy may be split up by releasing a connection between different sections which is actively controlled from an operator on the vessel or automatically in response to sensed data. By keeping the mooring lines connected to the different sections, the mooring lines can be released in a controlled manner.

The buoy illustrated in Figure 2 has a generally square outer boundary when seen from the top. Four split edges (13) are provided which extend from each one of the four corners of the square towards the centre of the buoy. The dotted lines (13) in Figure 2 indicate where splitting can take place in case of an emergency. The buoy may split along lines which are different from the lines shown in Fig. 2: the lines may have a different shape, there may be more lines or fewer lines, or the lines may be provided on a different position on the buoy. Dotted lines (14) in Fig.1 indicate in the vertical plane where the buoy can separate in an emergency. After splitting, each of the four sections of the geostationary portion remain connected to each one of the respective sets of mooring lines, but each of the four sections are disconnected from the central part of

the buoy. The central portion (5) in Fig. 1 remains connected to the hull of the ship via the rings (9, 10). Alternatively, the entire buoy, including central portion with the rings (9, 10), can be arranged to separate from the hull of the ship in an emergency.

In addition to ballast compartments within the buoy for controlling the buoyancy forces, further buoyancy elements may be provided in each of the different sections which split apart. These furthers elements may be remotely controlled to avoid the mooring lines and the buoy sections falling to the sea bed in an uncontrolled manner.

In some embodiments, a drilling riser may be cut at the top after being disconnected at a blow out preventer in an emergency and the riser may then be dropped down through the moon pool opening in the turret buoy. The buoy may then be disconnected from the vessel without the buoy splitting. The buoy will remain afloat in the water and will be available for reconnection.

A mooring system may be pre-laid at the seabed before use. The turret mooring buoy can be connected to the mooring lines floating in the water and the vessel may then be connected to the buoy by “fishing” up the buoy and pulling it towards the shop’s hull for connection to the hull.

It will be appreciated by a person of skill in the art that various modifications may be made to the above described embodiments without departing from the scope of the present disclosure. For example, the protrusions are described as forming a circular ring around a top surface of the buoy, but it will be appreciated that other shapes may be used. Furthermore, any suitable cross section for the protrusions may be used.

CLAIMS:

1. A connection between a turret mooring buoy and a floating vessel for restricting the relative motion between the buoy and the vessel in a horizontal plane comprising:

at least one protrusion on one of the buoy and the vessel,

at least one opening on the other one of the buoy and the vessel,

wherein the protrusions are arranged to be placed inside the openings when the buoy and vessel are connected to each other.

2. The connection according to claim 1, wherein said protrusions and said openings extend in a substantially vertical direction for disconnecting the buoy and floating vessel in a substantially vertical direction.

3. The connection according to claim 1 or 2, wherein said protrusions and said openings have corresponding geometrical shapes.

4. The connection according to any one of claims 1 to 3, wherein said protrusions have a substantially rectangular cross section.

5. The connection according to any one of claims 1 to 4, wherein said protrusions and said openings are symmetrically distributed around a moon pool area of the vessel and the buoy.

6. The connection according to any one of claims 1 to 5, wherein the protrusions and the openings have a substantially circular shape around a moon pool area of the vessel and the buoy.

7. The connection according to any one of claims 1 to 6, wherein the protrusions are provided on the buoy and have the shape of a plurality of rings provided around a moon pool area of the vessel and the buoy and wherein said openings are formed within the hull of the vessel for receiving the plurality of rings.

8. The connection according to any one of claims 1 to 7, wherein said opening is the moon pool area of the vessel.

9. The connection according to any one of claims 1 to 8, wherein a space is provided between said openings and said protrusions when the vessel and the buoy are connected, the space being arranged to be sealed on reduction of a fluid pressure within the space for increasing a bond between the buoy and the vessel.

10. The connection according to any one of claims 1 to 9, wherein the buoy comprises a first portion and a second portion, which portions are rotabably connected to each other.

11. The connection according to claim 10, wherein said first portion is arranged to be connected to mooring lines, the mooring lines being arranged to extend to the sea bed and being arranged to be anchored to the sea bed, and wherein said second portion is arranged to be connected to the vessel.

12. A turret mooring buoy comprising a plurality of sections which can be separated from each other for emergency evacuation.

13. The turret mooring buoy according to claim 12, wherein the plurality of sections are connected by weak links.

14. A turret mooring buoy comprising a protrusion or an opening, wherein the protrusion or opening is arranged to form a connection with, respectively, a corresponding opening or protrusion on a floating vessel.

15. The turret mooring buoy according to claim 14, wherein the protrusion or opening on the turret mooring buoy has a geometrical shape which correspond to an interlocking geometrical shape of the opening or protrusion on the floating vessel.

16. The turret mooring buoy according to claim 14 or 15, wherein the protrusion or opening extends in a circular shape around an upper surface of the buoy.

17. A floating vessel comprising a protrusion or opening, the protrusion or opening being arranged to form a connection with, respectively, a corresponding opening or protrusion on a buoy.

18. The floating vessel according to claim 17, wherein said protrusions or said openings have corresponding interlocking geometrical shapes.

19. The floating vessel according to claim 17 or 18, wherein the protrusion or opening extends in a circular shape around a moon pool area of the vessel.

20. A method of connecting a turret mooring buoy with a floating vessel, the method comprising:

locating the floating vessel substantially above the turret mooring buoy;

raising the turret mooring buoy such that corresponding protrusions and openings on any of the vessel and buoy interlock.

21. The method of claim 20, further comprising forming a seal between the vessel and the turret mooring buoy.

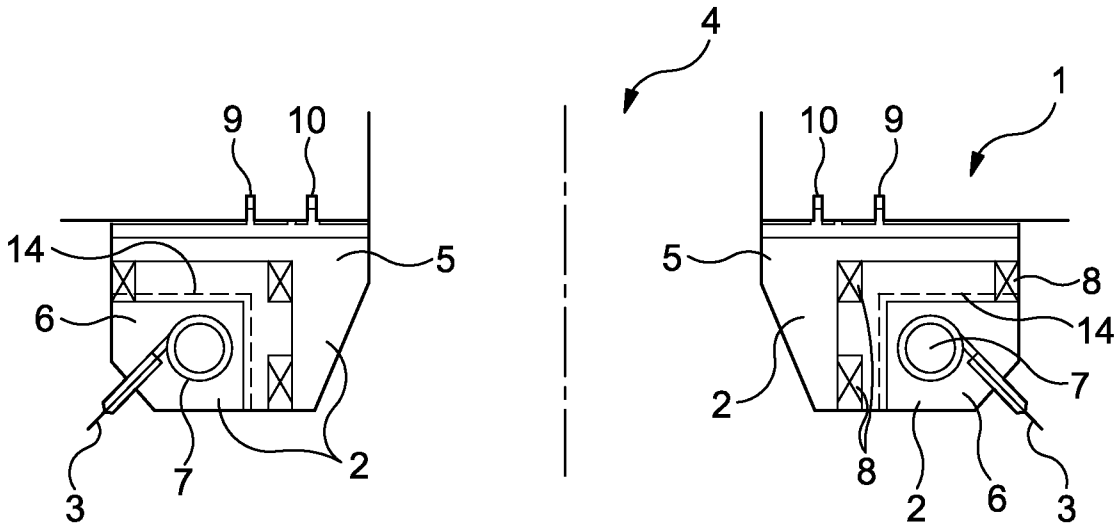


Fig. 1

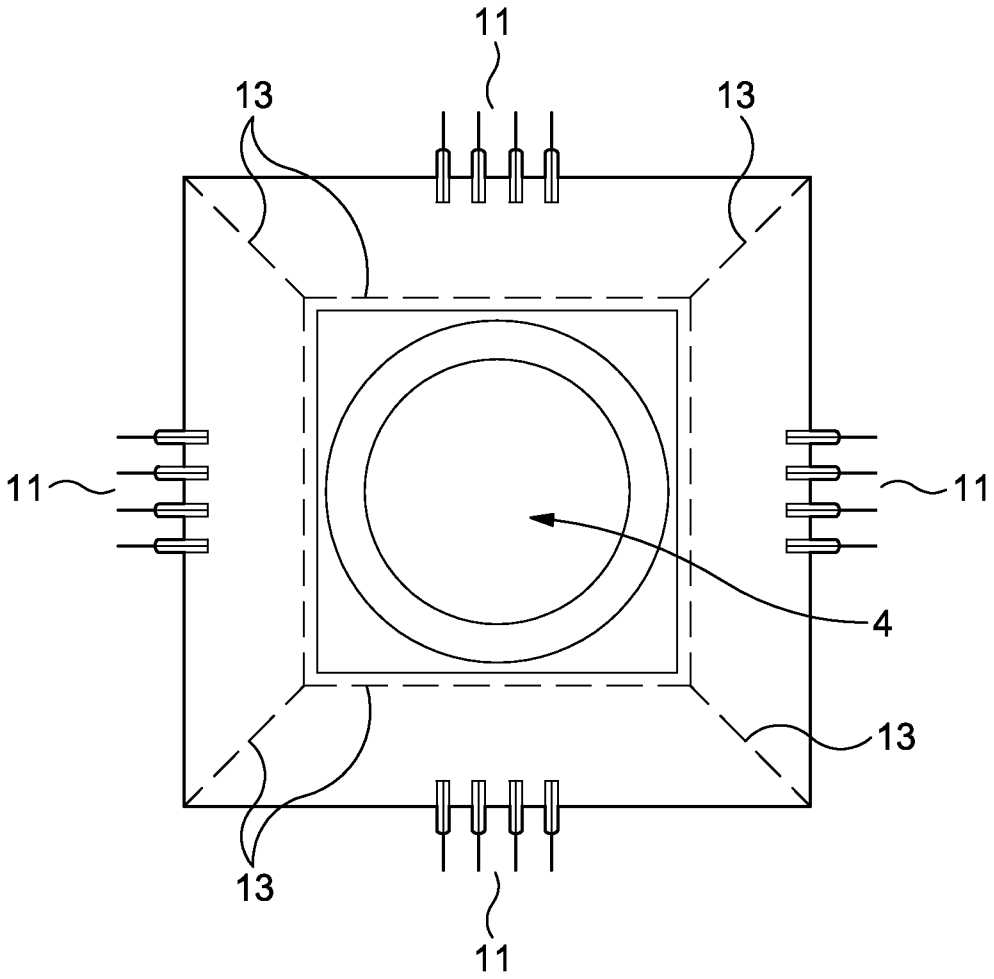


Fig. 2

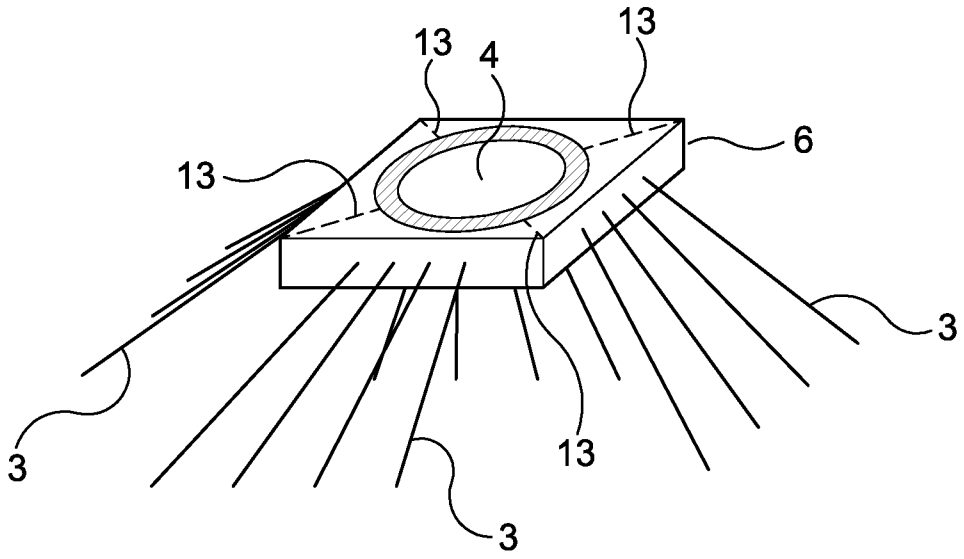

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Fig. 3

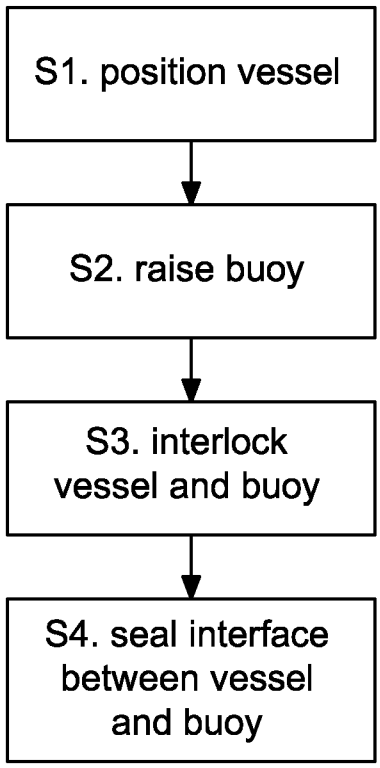

S1. position vessel
S2. raise buoy
S3. interlock vessel and buoy
S4. seal interface between vessel and buoy

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/058746

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B21/50 B63B22/02
ADD.

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)
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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8 342 777 B2 (BAYLOT MICHEL [FR] ET AL BAYLOT MICHEL [IT] ET AL) 1 January 2013 (2013-01-01) column 8, line 48 - column 13, line 67; figures 4-8	1-21
X	US 6 845 727 B2 (EIDE JORGEN [NO] ET AL EIDE JOERGEN [NO] ET AL) 25 January 2005 (2005-01-25) column 3, line 25 - column 6, line 28; figures 2, 6, 7	1-21
X	US 2011/130057 A1 (DENISE JEAN-PAUL [FR] ET AL) 2 June 2011 (2011-06-02) paragraphs [0106] - [0176]; figures 6-12	1-6, 10-21

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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"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

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Date of the actual completion of the international search	Date of mailing of the international search report
14 January 2014	21/01/2014

Name and mailing address of the ISA/	Authorized officer
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1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/058746

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 717 762 B2 (BOATMAN L TERRY [US] ET AL) 18 May 2010 (2010-05-18) column 1, line 22 - column 3, line 22; figures 1-4 column 6, line 14 - column 10, line 58; figures 5-10, 15, 16 -----	1-6, 14-21
X	US 7 510 452 B2 (VAN TOL HUIBERT [NL] ET AL) 31 March 2009 (2009-03-31) figures 1, 2, 8 -----	1-6, 14-21
X	US 8 418 639 B2 (HOOPER ALAN [SG] ET AL) 16 April 2013 (2013-04-16) figures 1,2 -----	1-6, 14-21

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/058746

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8342777 B2	01-01-2013	AT 535439 T	15-12-2011
		CA 2714637 A1	08-10-2009
		EP 2252500 A1	24-11-2010
		FR 2928898 A1	25-09-2009
		KR 20100124734 A	29-11-2010
		RU 2010131829 A	27-04-2012
		US 2011110724 A1	12-05-2011
		WO 2009122099 A1	08-10-2009
US 6845727 B2	25-01-2005	AU 777798 B2	28-10-2004
		BR 0016623 A	03-09-2002
		CA 2395361 A1	05-07-2001
		CN 1413156 A	23-04-2003
		GB 2372236 A	21-08-2002
		MY 134847 A	31-12-2007
		NO 996449 A	25-06-2001
		US 2003138299 A1	24-07-2003
		WO 0147768 A1	05-07-2001
US 2011130057 A1	02-06-2011	CA 2731070 A1	11-03-2010
		EP 2318267 A1	11-05-2011
		FR 2935679 A1	12-03-2010
		KR 20110070847 A	24-06-2011
		RU 2011101937 A	10-10-2012
		US 2011130057 A1	02-06-2011
		WO 2010026334 A1	11-03-2010
US 7717762 B2	18-05-2010	US 2007264889 A1	15-11-2007
		WO 2007127531 A2	08-11-2007
US 7510452 B2	31-03-2009	AT 389580 T	15-04-2008
		AU 2006334427 A1	12-07-2007
		BR PI0620883 A2	29-11-2011
		CA 2571227 A1	10-04-2007
		CN 101336190 A	31-12-2008
		DK 1803641 T3	07-07-2008
		EP 1803641 A1	04-07-2007
		ES 2303716 T3	16-08-2008
		PT 1803641 E	07-05-2008
		US 2007155259 A1	05-07-2007
		WO 2007077126 A1	12-07-2007
US 8418639 B2	16-04-2013	AU 2007358652 A1	12-03-2009
		EP 2222542 A1	01-09-2010
		GB 2465101 A	12-05-2010
		US 2011162571 A1	07-07-2011
		WO 2009031971 A1	12-03-2009