(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 November 2020 (12.11.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/226503 A1

(51) International Patent Classification:
B63B 27/30 (2006.01) *E21B 17/01* (2006.01)

(21) International Application Number:
PCT/NO2020/050102

(22) International Filing Date:
22 April 2020 (22.04.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1906474.0 08 May 2019 (08.05.2019) GB

(71) Applicant: **EQUINOR ENERGY AS** [NO/NO]; Forusbeen 50, 4035 Stavanger (NO).

(72) Inventors: **EIDESEN, Bjørgulf Haukelidsæter**; Strandflåtveien 21, 4018 Stavanger (NO). **JOHNSEN, Cecilie Gotaas**; Tverrstien 1D, 7020 Trondheim (NO). **SAMUELSBERG, Arild**; Mjåsundvegen 17, 5518 Haugesund (NO).

(74) Agent: **NORONHA, Catherine**; 10 Salisbury Square, London, Greater London EC4Y 8JD (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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

(54) Title: OFFSHORE LOADING SYSTEM

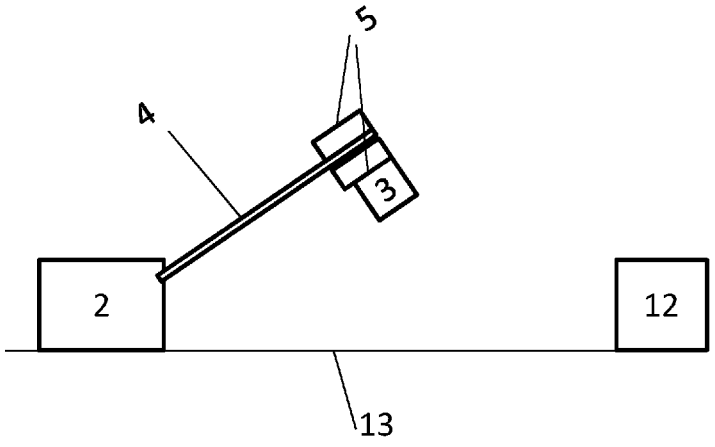


Fig. 2

(57) **Abstract:** An offshore loading system comprises a riser, an adjustable buoyancy element and a remotely operated vehicle. The riser is connectable to a storage tank, the adjustable buoyancy element is connected to the riser, and the remotely operated vehicle is arranged to control the adjustable buoyancy element to adjust the vertical position of at least one end of the riser.

WO 2020/226503 A1

Offshore loading system

The present invention relates to the field of offshore loading. More specifically, it relates to a system and method for loading hydrocarbons onto a transport vessel in an offshore location.

In the oil and gas industry, hydrocarbons extracted from wells in offshore locations are stored in a tank on the seabed and then transported via a riser from the tank to a transport vessel. In order to connect the riser to the transport vessel, a second vessel (which may be referred to as a stand-by vessel) is used to facilitate connection between the riser and the transport vessel. However, as can be appreciated, the need for a second vessel increases costs, and the expense of the second vessel can be particularly significant for marginal oil and gas fields.

According to the present invention, there is provided an offshore loading system, comprising: a riser; an adjustable buoyancy element; and a remotely operated vehicle; wherein the riser is connectable to a storage tank, the adjustable buoyancy element is connected to the riser, and the remotely operated vehicle is arranged to control the adjustable buoyancy element to adjust the vertical position of at least one end of the riser.

Thus, according to the invention, a riser, which may be connected to a storage tank, is provided with an adjustable buoyancy element. A remotely operated vehicle (ROV) can control the adjustable buoyancy element, e.g. by sending power and/or instructions to the adjustable buoyancy element to adjust its buoyancy, so that the vertical position of at least one end of the riser may be adjusted. In this way, the ROV and the adjustable buoyancy element may cause at least one end of the riser to rise upwards towards a sea surface, for example by increasing the buoyancy of the adjustable buoyancy element. Once brought into a location near the sea surface (e.g. just below the sea surface), the riser may be connected, e.g. via a hose, to a transport vessel. Fluids such as hydrocarbons stored in the storage tank can then flow up the riser and into the transport vessel for further transportation.

After the transfer of fluids from the storage tank to a transport vessel has been complete, the buoyancy of the adjustable buoyancy element may then be

adjusted (e.g. reduced) so that at least the end of the riser falls or is lowered back down towards the sea bed.

By using an ROV with an adjustable buoyancy element, as in the present invention, there is no need for a stand-by vessel and, as such, costs can be reduced compared to existing systems which require a stand-by vessel.

The adjustable buoyancy element is preferably connected to an end, or an end region, of the riser. For example, the adjustable buoyancy element may be connected to the riser no more than 1 m from an end. In this way, the vertical position of the end of the riser may be controlled or adjusted by adjusting the buoyancy of the adjustable buoyancy element.

The adjustable buoyancy element preferably comprises buoyancy adjusting means for adjusting the buoyancy of the adjustable buoyancy element, such that the vertical position of at least one end of the riser can be adjusted. For example, the buoyancy adjusting means may comprise a pump and a vacuum chamber. The pump is preferably arranged to pump (e.g. sea) water in and/or out of the vacuum chamber, thereby adjusting the buoyancy of the adjustable buoyancy element. In some embodiment, the pump may be arranged to pump sea water out of the vacuum chamber, e.g. when required. The vacuum chamber could comprise, for example, a (e.g. controllable) valve for allowing water to enter the vacuum chamber, e.g. when required.

In some embodiments, the adjustable buoyancy element may comprise more than one buoyancy adjusting means, e.g. as described above. This can help to provide redundancy in case one buoyancy adjusting means fails, for example.

The adjustable buoyancy element may comprise one or more thrusters or propulsion means (propellers) for adjusting the horizontal position of the adjustable buoyancy element. These may be used to bring the end of the riser into a desired horizontal position, e.g. beneath or close to a transport vessel.

The adjustable buoyancy element preferably comprises an interface for facilitating connection of the riser to a transport vessel. For example, an interface may be provided on the adjustable buoyancy element, e.g. over or around an open end of the riser, to which a hose, e.g. from a transport vessel, may be connected.

The (or another) ROV may be used to connect the hose to the adjustable buoyancy element. The ROV may first disconnect itself from the adjustable buoyancy element before facilitating connection of the hose to the adjustable buoyancy element. Other mechanisms such as a cord, cable or wire attached to

the hose could also alternatively be used to facilitate connection of the hose to the adjustable buoyancy element. In cases where the hose is already attached to the adjustable buoyancy element but requires attachment (at its other end) to the vessel, then references in the paragraph to the adjustable buoyancy element can be replaced with vessel, as appropriate.

The adjustable buoyancy element comprises a receiver and/or a transmitter for communication with the remotely operated vehicle.

The adjustable buoyancy element and/or ROV preferably comprises one or more sensors and/or transmitters for determining (e.g. by triangulation) the vertical and/or horizontal position of the adjustable buoyancy element. The adjustable buoyancy element may comprise one or more transmitters for transmitting a signal(s) indicative of its horizontal and/or vertical position or a signal(s) from which its horizontal and/or vertical position may be determined, e.g. to the ROV. This may allow the ROV to "find" the adjustable buoyancy element and then connect to it, e.g. as described below. The one or more sensors could be acoustic, radio or wireless (light-based) sensors, for example. Acoustic sensors can operate over a long range. Wireless (light-based) sensors may operate over a range of up to around 250 m.

The ROV preferably comprises a connector for electrical connection with a connector provided on the adjustable buoyancy element. Thus, the adjustable buoyancy element preferably comprises a connector for electrical connection with the connecter on the ROV. The connectors may facilitate communication between the ROV and the adjustable buoyancy element, and/or they may facilitate the provision of electrical power from the ROV to the adjustable buoyancy element. The remotely operated vehicle may provide electrical power to the adjustable buoyancy element, e.g. to power its buoyancy adjusting means (e.g the pump) and/or thrusters or propulsion means, if provided.

The ROV is preferably arranged to control the adjustable buoyancy element by sending a signal to the adjustable buoyancy element instructing it to adjust its buoyancy, e.g. by a specified amount, for a particular depth or vertical position.

For example, depending on a desired vertical position (e.g. a desired depth) of the riser, adjustable buoyancy element and/or ROV , the ROV may determine (e.g. compute or calculate or simply read from a memory) a required buoyancy of the adjustable buoyancy element in order to bring the riser, adjustable buoyancy element and/or ROV to the desired vertical position. Preferably, this method is

calibrated in advance (as hydrostatic pressure is constant for any given depth), such that a required buoyancy for a particular depth, or buoyancy as a function of depth, is known and stored, e.g. in a memory in the ROV. Thus, the ROV preferably comprises one or more processors for determining this buoyancy. A feedback control loop may be provided, e.g. in one or more processors in the ROV, to control the pump to get the riser, adjustable buoyancy element and/or ROV to the desired vertical position.

The ROV preferably comprises one or more sensors for detecting the vertical and/or horizontal position of the ROV. For example, the ROV may comprise underwater navigation system such as an acoustic navigation system, from which its vertical position and/or horizontal may be determined.

The remotely operated vehicle comprises one or more thrusters or propulsion means for controlling its position. The one or more thrusters or propulsion means may be arranged to adjust the vertical and/or horizontal position of the ROV, for example. They may also be used to adjust the horizontal (and possibly also vertical) position of the adjustable buoyancy element, e.g. when the ROV is connected to the adjustable buoyancy element,

The offshore loading system preferably further comprises a ROV station. The ROV station is preferably provided for charging (e.g. electrically charging) and/or facilitating communication with the ROV. The ROV station may have batteries or be connected, e.g. via a cable (such as from a shore- or platform-based power supply), to a power supply.

A signal from an onshore or sea level location may be sent, e.g. wirelessly, to the ROV station. The signal may comprise instructions to bring the end of the riser to a location close to the sea surface, for example. That signal, or an appropriate consequential signal may then be sent from the ROV station to the ROV, e.g. instructing the ROV to connect to the adjustable buoyancy element and instruct/control the adjustable buoyancy element to adjust its buoyancy so as to raise the end of the riser.

The ROV station may comprise means for charging and/or communicating with a plurality of ROVs. A separate ROV may be provided for each riser, for example. Alternatively, one ROV may be arranged to connect with and control a plurality of risers.

The ROV preferably comprises a receiver and/or a transmitter for communication with the ROV station and/or the adjustable buoyancy element.

The offshore loading system preferably further comprises a storage tank to which an end of the riser is connected.

The offshore loading system may further comprise a transport vessel to which an end of the riser can be connected, e.g. via a hose.

Preferably, the offshore loading system does not need or comprise an anchoring system. For example, it may be kept in a desired position by the thruster(s) or propulsion means of the ROV and/or adjustable buoyancy element. This also means that a subsea foundation for the system may not be required.

According to a further aspect, there is provided a method of using an offshore loading system as described above, the method comprising: connecting the ROV to the adjustable buoyancy element; and causing the ROV to instruct the adjustable buoyancy element to adjust its buoyancy so as to adjust the vertical position of at least one end of the riser.

A safety line may be provided connecting the adjustable buoyancy element to, e.g., a winch which may be located on the sea bed. In the event that the adjustable buoyancy element and/or ROV fails to work, the winch and safety line may be used to pull the (end of the) riser back down to the sea bed.

The method and the offshore loading system may comprise any of the optional or preferred features described herein.

The method preferably comprises the adjustable buoyancy element adjusting its buoyancy (e.g. increasing and/or decreasing its buoyancy) so as to adjust the vertical position of at least one end of the riser. The adjustable buoyancy element may adjust its buoyancy by pumping water in and/or out of a vacuum chamber in the adjustable buoyancy element, for example.

The method preferably comprises the remotely operated vehicle providing power to the adjustable buoyancy element, e.g. via an electrical connection.

The method preferably further comprises detecting a vertical position of the adjustable buoyancy element, the riser and/or the ROV, e.g. with one or more sensors provided in the adjustable buoyancy element, the riser and/or the ROV.

The method preferably further comprises adjusting the buoyancy of the adjustable buoyancy element according to the detected vertical position of the adjustable buoyancy element, the riser and/or the ROV.

The method preferably further comprises transporting fluids such as hydrocarbons from a tank to a transport vessel with the offshore loading system.

A further aspect of the invention relates to a method of installing an offshore loading system as described above. The method may comprise installing the adjustable buoyancy element on, e.g. an end or an end region of, a riser. The adjustable buoyancy element is preferably installed on the riser with a ROV. As such, the offshore loading system may be self-installing, i.e. it may be installed by ROV or robot, and no human physical presence is required. An ROV may transport the adjustable buoyancy element, e.g. from a supply vessel, to the riser and connect it to the end of the riser. The ROV may connect the adjustable buoyancy element to the riser with a subsea connection system, which may be ROV operated, for example.

In some embodiments, a connection means or connector, such as tubing (e.g. hard tubing), is provided on, or inside, the adjustable buoyancy element. The riser may be connected to that connection means or connector.

In some embodiments, the connection means or connector comprises a locking mechanism, e.g. the connection means or connector comprises a landing crib. A complementary locking mechanism may be provided on the riser and the two locking mechanisms may be arranged such that they can lock together, thereby connecting or attaching the adjustable buoyancy element to the riser.

Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Fig. 1 shows an embodiment of an offshore loading system located on a sea bed, i.e. when not in use;

Fig. 2 shows the offshore loading system during a raising or lowerng operation; and

Fig. 3 shows the offshore loading system connected to a transport vessel.

An offshore loading system 1 is provided for transporting hydrocarbons from a subsea tank 2 to a transport vessel 6. This system 1 and its operation is illustrated in Figs. 1 to 3.

As shown in the figures, the offshore loading system 1 comprises a flexible riser 4. An adjustable buoyancy element 5 is connected to one end 4b of the riser 4. The other end 4a of the riser 4 is connected to a storage tank 2, in which hydrocarbons extracted from a well are (or can be) stored. The tank 2 is located on the sea bed 13.

As shown in Fig. 3, the riser 4 can be connected to a transport vessel 6 so that hydrocarbons in the tank 2 can be transported up the riser 4 to the transport vessel 6 for transportation.

The adjustable buoyancy element 5 is a buoyancy element whose buoyancy can be adjusted. The adjustable buoyancy element 5 is provided around the end 4b of the riser 4. The adjustable buoyancy element 5 comprises a vacuum chamber and a pump which can pump water in and out of the vacuum chamber to adjust (increase or decrease) the buoyancy of the adjustable buoyancy element 5.

A remotely operated vehicle 3 (ROV), or drone, is also provided, as well as a ROV station 12. The ROV station 12 is located on the sea bed 13.

The ROV 3 is an electrically powered, remotely operated vehicle which can move around under water. It has one or more thrusters or propellers for controlling its motion and position. The ROV 3 contains sensors, e.g. in a navigation system, for detecting its horizontal and vertical position. The ROV may contain other kinds of sensors, e.g. motion sensors such as accelerometers and/or gyros. The ROV 3 also containers a transmitter and a receiver for transmitting and receiving signals.

The ROV 3 has an electrical connector for connection with a corresponding connector provided on the adjustable buoyancy element 5. When connected to the adjustable buoyancy element 5, the ROV 3 can control the adjustable buoyancy element 5 (i.e. instruct it to increase or decrease its buoyancy) and provide it with electrical power to drive the pump in the adjustable buoyancy element 5.

The ROV station 12 provides an electrical charging point for the ROV 3 (and, in some embodiments, other ROVs as well). It can also provide the ROV 3 with liquids and/or chemicals which may be required by the ROV 3. For example, the ROV station 12 may provide hydraulic fluid, fluids for washing and/or removing algae or other organic settlements from subsea equipment, etc.

In some embodiments (not shown), the ROV 3 is controlled via a cable such as a fibre optic cable provided between the ROV station 12 and the ROV 3.

In other embodiments, the ROV 3 is controlled wirelessly, for example via a mobile phone or data network such as the 4G network.

The ROV 3 is controlled, via the ROV station 12, from an on shore controller, for example via a fibre optical cable or a wireless/mobile (e.g. 4G/5G) communication network.

In some embodiments, a single ROV 3 is provided for a single (e.g. each) riser 4 (or its adjustable buoyancy element 5). In other embodiments, an ROV 3

may be used to operate (i.e. connect with the adjustable buoyancy element 5 of) more than one riser 4.

A pair of thrusters (or propulsion means) 9a, 9b are provided on opposite sides of the adjustable buoyancy element 5 for controlling the horizontal position of the end 4b of the riser 4. The thrusters 9a and 9b, like the pump, are powered with power supplied by the ROV 3 when it is connected to the adjustable buoyancy element 5. The ROV 3, when connected to the adjustable buoyancy element 5 can also help to control the horizontal position of the end 4b of the riser 4 with its own thruster(s).

A safety line 10 connects the adjustable buoyancy element 5 to a winch 11 which is provided on the sea bed 13. In the event that the adjustable buoyancy element 5 and/or ROV 3 fails to work, the winch 11 and safety line 10 can be used to pull the end 4b of the riser 4 back down to the sea bed 13.

The ROV 3 can communicate (e.g. wirelessly, for example over a mobile communication network) with the transport vessel 6, informing the transport vessel 6 of its position so that the transport vessel 6 can move to a suitable position for connection to the riser 4.

When not in use (as shown in Fig. 1), the offshore loading system 1 with its riser 4, adjustable buoyancy element 5 and ROV 3, is located on, or just above, the sea bed 13.

In a preferred embodiment, the riser 4 is located (i.e. held, e.g. by the adjustable buoyancy element 5) just above the sea bed 13. This can help to protect the riser 4 from being damaged by rocks, for example, on the sea bed 13.

When the system is not in use, the ROV 3 is stationary on the sea bed 13 or at ROV station 12 (e.g. being charged).

Upon receipt of an instruction, via the ROV station 12, to cause the riser 4 to rise to the surface, the ROV 3 travels to the riser 4 and connects to the adjustable buoyancy element 5. The ROV 3 navigates to the riser 4 using an acoustic subsea navigation system.

Once the ROV 3 has connected itself to the adjustable buoyancy element 5, the ROV 3 then provides power to the adjustable buoyancy element 5, and instructs or controls the adjustable buoyancy element 5 to increase its buoyancy, by pumping water out of the vacuum chamber, and cause the second end 4b of the riser 4, with the adjustable buoyancy element 5 and ROV 3 connected to it, to rise towards the sea surface.

As shown in Fig. 2, during such a raising operation of the riser 4, the riser 4 pivots or bends at its first end 4a, at the tank 2, as the second end 4b of the riser 4 rises up towards the sea surface and transport vessel 6.

The riser 4 is made to rise up, as shown in Fig. 2, by the adjustable buoyancy element 5, whose buoyancy is adjusted (increased) to make the second end 4b of the riser float upwards towards the surface of the sea. The buoyancy of the adjustable buoyancy element 5 is controlled such that the second end 4b of the riser 4 is brought to a position just below the surface of the sea. The vertical and horizontal positions of the adjustable buoyancy element 5 and/or second end 4b of the riser 4 are monitored and determined with a subsea navigation system and an external pressure sensor to measure depth.

As shown in Fig. 3, once the riser 4 has been brought such that its second end 4b is just below the sea surface, and this is beneath or close to the transport vessel 5, this second end 4b of the riser 4 is then connected to the transport vessel 6 via an interface 7 which is provided on the adjustable buoyancy element 5, and a hose 8 which connects the interface 7 to the transport vessel 6. The hose 8 connects the interface 7 to the transport vessel 6, or vice versa. In other words, the hose 8 may come with or descend from the transport vessel 6 and then be connected to the interface 7. Alternatively, the hose 8 may come with or be raised from the interface 7 on the adjustable buoyancy element 5 and then be connected to the transport vessel 6. In either case, the ROV 3 facilitates connecting the hose 8 to the transport vessel 6 or interface 7.

Hydrocarbons are then transported from the tank 2, up through the riser 4, through the interface 7 and hose 8, to a tank in the transport vessel 6.

The storage tank 2 has a passive pressuriser such that the pressure of the hydrocarbons in the tank 2 is equal to the hydrostatic pressure at the sea bed (usually around 20 bar). As the hydrocarbons travel up the riser 4, their pressure drops, typically to around 6 – 9 bar. This reduction in density results in uplift and the riser 4 and its contents have greater buoyancy near the top of the riser 4.

When hydrocarbons are being transported up the riser 4, the buoyancy of the adjustable buoyancy element 5 may need to be adjusted to compensate for any change in buoyancy of the riser and its contents. For example, if a drop in the height of the adjustable buoyancy element 5 is detected, for example by one or more sensors provided in the ROV 3 and/or in the adjustable buoyancy element, the buoyancy of the adjustable buoyancy element 5 is increased, by pumping water

out of the vacuum chamber, to raise the adjustable buoyancy element 5, until the adjustable buoyancy element 5 reaches its desired height (again). On the other hand, if an increase in the height of the adjustable buoyancy element 5 is detected, the buoyancy of the adjustable buoyancy element 5 is decreased, by allowing water to flow into the vacuum chamber (e.g. by opening a valve and/or closure mechanism) to lower the adjustable buoyancy element 5, until the adjustable buoyancy element 5 reaches its desired height (again).

Once transportation of hydrocarbons from the tank 2 to the transport vessel 6 is complete, the hose 8 is disconnected from the interface 7 (or vessel 6, if appropriate). This disconnection could be automatic and/or it could be performed by the ROV 3. The adjustable buoyancy element 5 is then made to reduce its buoyancy, by allowing water into the vacuum chamber, to lower the end 4b of the riser 4 back down to the sea bed 13 (or just above it).

In some embodiments, the riser 4, when connected to a vessel 6 as shown in Fig. 3, can be used to transport gas down to the subsea storage tank 2, or to a local production or processing facility such as a flowline on the seabed. For example, there can be a need for some internal fluid in the riser during periods when it is resting on the seabed.

Claims:

1. An offshore loading system, comprising:
a riser;
an adjustable buoyancy element; and
a remotely operated vehicle;
wherein the riser is connectable to a storage tank, the adjustable buoyancy element is connected to the riser, and the remotely operated vehicle is arranged to control the adjustable buoyancy element to adjust the vertical position of at least one end of the riser.

2. An offshore loading system as claimed in claim 1, wherein the adjustable buoyancy element is connected to an end of the riser.

3. An offshore loading system as claimed in claim 1 or 2, wherein the adjustable buoyancy element comprises buoyancy adjusting means for adjusting the buoyancy of the adjustable buoyancy element such that the vertical position of at least one end of the riser can be adjusted.

4. An offshore loading system as claimed in claim 3, wherein the buoyancy adjusting means comprises a pump and a vacuum chamber.

5. An offshore loading system as claimed in claim 4, wherein the pump is arranged to pump water in and/or out of the vacuum chamber and/or the vacuum chamber is arranged such that water can be let into the vacuum chamber, thereby adjusting the buoyancy of the adjustable buoyancy element.

6. An offshore loading system as claimed in any preceding claim, wherein the adjustable buoyancy element comprises one or more thrusters for adjusting the horizontal position of the adjustable buoyancy element.

7. An offshore loading system as claimed in any preceding claim, wherein the adjustable buoyancy element comprises an interface for facilitating connection of the riser to a transport vessel.

8. An offshore loading system as claimed in any preceding claim, wherein the adjustable buoyancy element comprises a receiver and/or a transmitter for communication with the remotely operated vehicle.

9. An offshore loading system as claimed in any preceding claim, wherein the adjustable buoyancy element comprises one or more sensors for detecting the vertical and/or horizontal position of the adjustable buoyancy element.

10. An offshore loading system as claimed in any preceding claim, wherein the remotely operated vehicle comprises a connector for electrical connection with a connector provided on the adjustable buoyancy element.

11. An offshore loading system as claimed in any preceding claim, wherein the remotely operated vehicle can provide electrical power to the adjustable buoyancy element.

12. An offshore loading system as claimed in any preceding claim, wherein the remotely operated vehicle can control the adjustable buoyancy element by sending a signal to the adjustable buoyancy element instructing it to adjust its buoyancy.

13. An offshore loading system as claimed in any preceding claim, wherein the remotely operated vehicle comprises one or more sensors for detecting the vertical and/or horizontal position of the remotely operated vehicle.

14. An offshore loading system as claimed in any preceding claim, wherein the remotely operated vehicle comprises one or more thrusters for controlling its position.

15. An offshore loading system as claimed in any preceding claim, further comprising a remotely operated vehicle station for charging and/or facilitating communication with the remotely operated vehicle.

16. An offshore loading system as claimed in claim 15, wherein the remotely operated vehicle comprises a receiver and/or a transmitter for communication with the remotely operated vehicle station and/or the adjustable buoyancy element.

17. An offshore loading system as claimed in any preceding claim, further comprising a storage tank to which an end of the riser is connected.

18. An offshore loading system as claimed in any preceding claim, further comprising a transport vessel to which an end of the riser can be connected.

19. A method of using an offshore loading system as claimed in any preceding claim, the method comprising:

connecting the remotely operated vehicle to the adjustable buoyancy element; and

causing the remotely operated vehicle to instruct the adjustable buoyancy element to adjust its buoyancy so as to adjust the vertical position of at least one end of the riser.

20. A method as claimed in claim 19, further comprising the adjustable buoyancy element adjusting its buoyancy so as to adjust the vertical position of at least one end of the riser.

21. A method as claimed in claim 20, wherein adjusting the buoyancy of the adjustable buoyancy element comprises pumping water in and/or out of the vacuum chamber in the adjustable buoyancy element.

22. A method as claimed in claim 19, 20 or 21, further comprising the remotely operated vehicle providing power to the adjustable buoyancy element.

23. A method as claimed in any of claims 19 to 22, further comprising detecting a vertical position of the adjustable buoyancy element.

24. A method as claimed in any of claims 19 to 23, further comprising transporting hydrocarbons from a tank to a transport vessel with the offshore loading system.

25. A method of installing an offshore loading system as claimed in any of claims 1 to 18, the method comprising installing the adjustable buoyancy element on the riser.

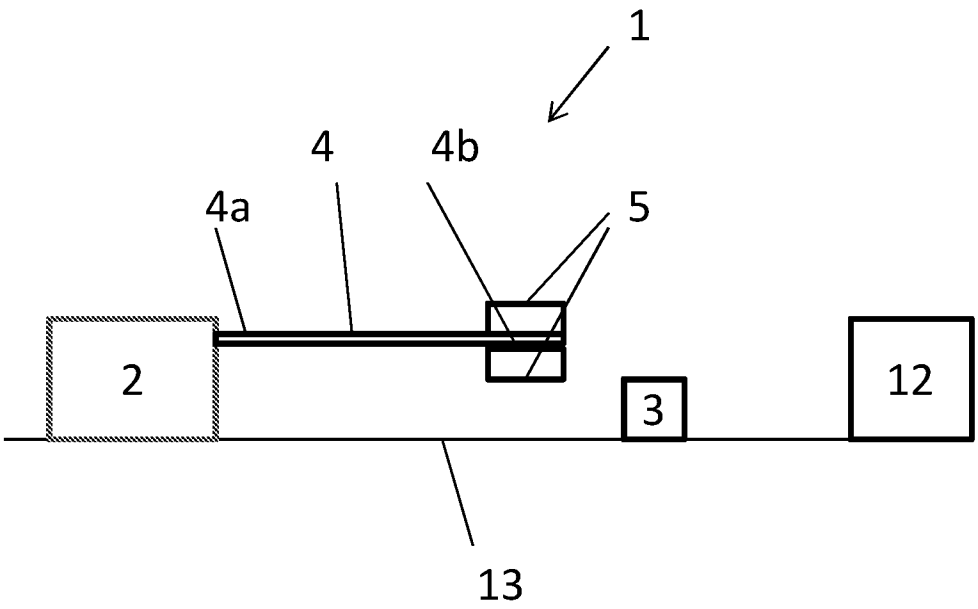


Fig. 1

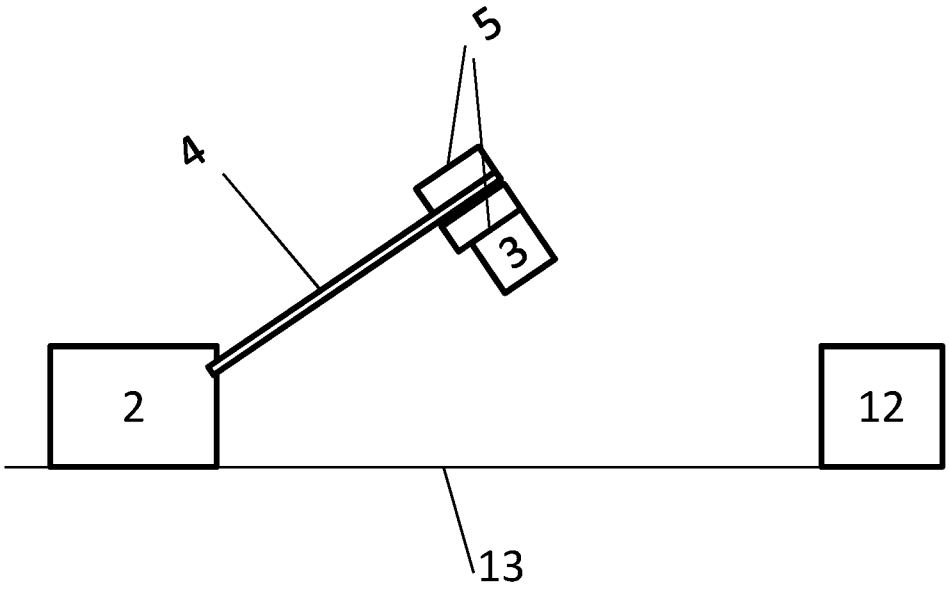


Fig. 2

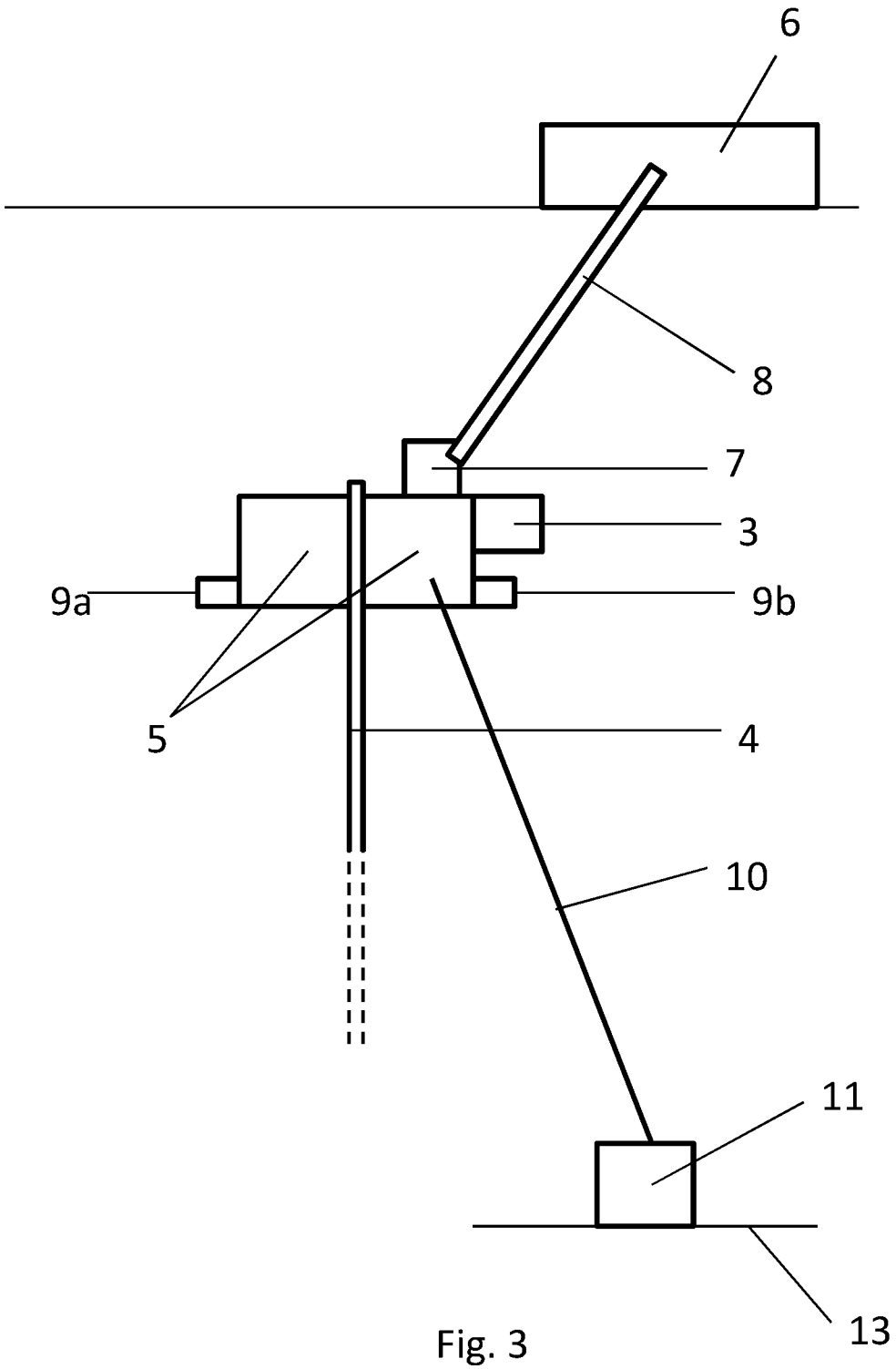


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2020/050102

A. CLASSIFICATION OF SUBJECT MATTER

B63B 27/30 (2006.01), E21B 17/01 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B, E21B, F16L

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

DK, NO, SE, FI: Classes as above.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN, FRENCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013/0266381 A1 (PETTERSEN, P.) 2013.10.10 (paragraphs [0001]-[0002], [0013], [0019], [0043])	1-3, 6-7, 9-11, 13-20, 22-25
A		4-5, 8, 12, 21
Y	US 2012/0103622 A1 (FENTON, S. P. et. al.) 2012.05.03 (paragraphs [0002], [0013], [0017])	1-3, 6-7, 9-11, 13-20, 22-25
A		4-5, 8, 12, 21
A	US 2016/0258553 A1 (ZHANG, Y. et. al.) 2016.09.08	1-25
A	GB 2462638 A (VERDERG ENGINEERING LTD.) 2010.02.17	1-25

☐ 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

"D" document cited by the applicant in the international application

"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	Date of mailing of the international search report
15/06/2020	24/06/2020
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. -	Authorized officer Knut Wigernes Telephone No. +47 22 38 73 73

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2020/050102

Patent document cited in search report / Publication date		Patent family member(s) / Publication date	
US 2013/0266381 A1	2013.10.10	GB 2498900 A	2013.07.31
		NO 20101609 A1	2011.11.28
		WO 2012066031	2012.05.24
US 2012/0103622 A1	2012.05.03	AU 2011239287 A1	2012.05.17
		BRPI 1104364 A2	2015.11.03
		CN 102562009 A1	2012.07.11
		GB 2486520 A	2012.06.20
		MY 154521 A	2015.06.30
		NO 20111412 A1	2012.05.02
		SG 180141 A1	2012.05.30