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(54) **METHOD OF LOCATING A SUBSEA STRUCTURE FOR DEPLOYMENT**

VERFAHREN ZUM INSTALLIEREN EINER UNTERWASSERSTRUKTUR

PROCÉDÉ DE D'INSTALLATION D'UNE STRUCTURE SOUS-MARINE

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Description

[0001] The present invention relates to a method for locating a subsea structure for deployment, generally for subsequent deployment to a seabed.

[0002] The term "subsea structure" refers to any equipment, tool, machine, package, unit, device or other item or installation to be located and/or installed on or near a seabed, including but not limited to risers, underwater well-head elements in oil fields, manifolds, protection structures, fluid separation, pumping or processing units. Many of such structures are usually relatively 'large' and/or 'heavy'.

[0003] Subsea structures that are intended to be installed on the seabed are usually manufactured onshore. Especially larger subsea structures are transported to a deployment site by towing them through the water behind a suitable vessel. At the deployment site, they are directly lowered from a deployment vessel to an installation site on the seabed. WO 03/074353 A1 shows an example of a method for transporting and installing objects at sea being part of an infrastructure in oil and gas fields offshore. However, towing a large subsea structure all the way from its onshore manufacture has difficulties.

[0004] Subsea structures of lesser size or weight can be transported on the deck of a suitable vessel or transportation barge to the deployment site, at which the subsea structure is then lifted off the vessel and into the sea for subsequent deployment. However, this requires the presence of a crane with usually heavy lifting capacity.

[0005] PI 0306058-6A discloses a pendular method for installing equipment at the bottom of the sea, whereby the equipment can be transported on the deck of a first craft, and then swung like a pendulum until it is near the seabed.

[0006] However, this results in an increased tension on the cable, and potentially a lack of control in the deployment, whilst not reducing in any way the load on the deployment winch.

[0007] It is an object of the present invention to provide an improved method of locating a subsea structure for deployment to the seabed.

[0008] Thus, according to a first aspect of the present invention, there is provided a method of locating a subsea structure beneath a floating deployment vessel for deployment to a seabed comprising at least the steps of:

(a) transporting the subsea structure on a floating transporting vessel near to the deployment vessel;
(b) lowering the transporting vessel to allow the subsea structure to float;
(c) relocating either the transporting vessel or the subsea structure to allow the subsea structure to be separate of the transporting vessel; and
(d) locating the subsea structure beneath the deployment vessel using one or more buoyancy elements with variable buoyancy.

[0009] In this way, the subsea structure is safely transported to its site of deployment on a suitable floating vessel; it can be launched into the sea at a 'splashzone' without requiring a crane or other lifting mechanism; and then its location beneath the deployment vessel for subsequent deployment to the seabed can be controlled by the use of the one or more suitable buoyancy elements. The present invention therefore provides a controlled passage through the splashzone without the requirement for a crane, and can reduce the load on the deployment winch on a deployment vessel by modifying the net submerged weight of the subsea structure with the buoyancy element(s).

[0010] The floating transporting vessel may be any suitable self-propelled ship able to move between a normal sea-faring/travelling/shipping position and a semi-submersible/submerged position. Such vessels are known in the art, for example from Dockwise Shipping B.V. Such vessels generally have an open-deck, and are able to be heavy transport sea and ocean-going vessels. A subsea structure can be located either directly on or next to a suitable deck of the floating transporting vessel, optionally on or within or in association with a suitable frame or cradle. The subsea structure can be 'sea-fastened' to the deck of such a vessel for transportation, and the fastenings for which can be released prior to the commencement of deployment.

[0011] The floating transporting vessel transports the subsea structure near to the deployment vessel. This can include transport next to or otherwise sufficiently within the vicinity of the deployment vessel, preferably such that any umbilicals or cables or like required to be connected between the subsea structure and the deployment vessel can be connected at sea level.

[0012] Once ready to launch at a 'splashzone', usually at or near the deployment site and near or next to the deployment vessel, the floating transporting vessel is able to semi-submerge, generally by the use of one or more buoyancy and/or ballast tanks therein, so as to still be floating, but to have at least a part of the transporting vessel, usually an open-deck, underwater.

[0013] Once the transporting vessel is in its semi-submerged position, the subsea structure can float or be floated at or near sea level, either by itself or by being launched. The transporting vessel may include one or more assistant means such as cranes or winches to assist movement of the subsea structure in relation to the semi-submerged transporting vessel, especially once the subsea structure is able to float, but any such assistant means are not intended to be able to freely lift the subsea structure in air.

[0014] The subsea structure may be associated with one or more buoyancy aids, one or more of which may be fitted onshore, at the deployment site and/or both, to assist its ability to float once the transporting vessel has been lowered to a semi-submerged position.

[0015] Various buoyancy aids are known in the art. Generally it is preferred to use only one type or form of

buoyancy aid to launch and deploy a subsea structure, due to the complexity of making any mechanical changes during such operations.

[0016] Buoyancy aids in the form of one or more air tanks attached to a subsea structure are well known in the art, and are advantageous to reduce the apparent weight of the structure by increasing its buoyancy in water. Such buoyancy aids are used conventionally to reduce the load borne by use of a conventional crane to deploy a subsea structure, but they do not reduce the 'hook load' during lift of the subsea structure from the deck of a vessel, through the splashzone, and through deployment. Such tanks must also be strong enough to be capable of withstanding maximum external hydrostatic pressure without imploding or deforming due to the compressibility of the air contained therein, thus increasing the weight of the tanks and thereby reducing their buoyancy.

[0017] In one embodiment of the present invention, the buoyancy aid comprises the one or more buoyancy elements with variable buoyancy of step (d).

[0018] Preferably, the method of the present invention comprises the further step of providing at least one buoyancy element with variable buoyancy on or connected to the subsea structure during step (b). Optionally, one or more of such buoyancy elements are on or connected to the subsea structure onshore, and are transported to the splashdown and/or deployment site with the subsea structure by the transporting vessel.

[0019] In the present invention, a buoyancy element with variable buoyancy may comprise any arrangement. Preferably, such buoyancy elements comprise one or more sections, parts, tanks and/or chambers able to contain at least a proportion of a buoyancy fluid comprising a wholly or substantially incompressible fluid having a density less than that of sea water. One or more chambers could be formed from a flexible or elastic material to permit the volume thereof to vary and accommodate the volume of buoyancy fluid contained therein.

[0020] Varying the amount of buoyancy fluid in the buoyancy element(s) varies the overall buoyancy of the associated structure in a manner known in the art.

[0021] An external reservoir of buoyancy fluid can be provided to vary the volume of buoyancy fluid within the or each buoyancy element, having the effect of varying the volume of said one or more chambers, etc.

[0022] Such buoyancy elements can also contain air, and optionally also water, at varying times and varying proportions. For example, the or each chamber or tank, etc. could contain a bladder or diaphragm to allow such chamber(s) to simultaneously comprise buoyancy fluid and water, and also to allow the proportions of the buoyancy fluid and water in such chamber(s) to be varied, without allowing the two components to mix.

[0023] Prior to submerging or submersion of the subsea structure, all chambers in the buoyancy element(s) are preferably fully vented of air and replaced with either the low-density incompressible buoyancy fluid and/or water.

[0024] The substantially incompressible nature of the buoyancy fluid means that the buoyancy element can be made form relatively thin and light weight material compared to prior art air tanks, thus reducing the weight of the buoyancy elements and increasing the buoyancy thereof.

[0025] Suitable buoyancy fluids include low molecular weight hydrocarbons such as methanol. In order to further reduce the density of the buoyancy fluid, glass microspheres may be added. Such fluids preferably have a density of between 500 and 600kg/m^3 (the density of seawater being around 1027kg/m^3). However any fluid having a density less than that of seawater may be suitable as the buoyancy fluid. Preferably the buoyancy fluid also has a low viscosity such that it is easily moveable (such as by one or more pumps) between the buoyancy element and an external reservoir, and such fluids include known low viscosity gels and the like.

[0026] The use of one or more buoyancy aids, such as a buoyancy element described above, in association with the subsea structure, may assist the floating of the subsea structure at or near sea level following the lowering of the transporting vessel to its semi-submerged position. Following the floating of the subsea structure, there is relocation of either the floating vessel or the subsea structure (or both) to allow the subsea structure to be separate of the floating vessel. This may involve movement of the semi-submerged vessel, but usually involves the relocation of the floating subsea structure away from the transporting vessel such that the subsea structure is then floating 'free' of the location of the transporting vessel.

[0027] Following the relocation of step (c), the transporting vessel can be fully re-floated in a manner known in the art, generally by the emptying of one or more of its ballast tanks.

[0028] The launch or splashdown of the subsea structure may be separate or remote from the deployment site, and the subsea structure can then be towed the remaining distance to the deployment site. For example, it may be desired to launch the subsea structure in calmer or more sheltered seas, or in or at a calmer or more sheltered site, than occur at the deployment site. Thus, some relocation of the launched and now semi-submersed subsea structure may occur between steps (c) and (d) of the present invention.

[0029] The subsea structure, and/or any associated buoyancy aids such as a buoyancy element, may include one or more guidelines or control lines to assist or control movement of the subsea structure in the sea, either as it floats at or near sea level, or during its subsequent movement, or both. Where the launch or splashdown of the subsea structure is separate from the deployment site, one guideline may be to partly, substantially or fully assist towing of the subsea structure to the deployment site.

[0030] In one embodiment of the present invention, the subsea structure comprises a fastening line. During

transportation of the subsea structure to the splashdown and/or deployment site, the fastening line may not be in use, or may be used to assist securing the subsea structure to the transporting vessel.

[0031] The method of the present invention further comprises the step of securing a fastening line associated with the subsea structure to the deployment vessel at the deployment site. The securing of a fastening line to the deployment vessel may occur at any stage prior to, during or after step (b) and/or step (c), preferably prior to step (b), of the method of the present invention.

[0032] Prior to step (d) of the method of the present invention, one or more buoyancy elements with variable buoyancy are associated with subsea structure. Such association may be by securement or attachment or other connection of the one or more buoyancy elements to the subsea structure, generally in or at a position above the subsea structure. Preferably, at least one such buoyancy element is associated with the subsea structure onshore, and remains associated with the subsea structure during steps (b) and (c) for use in step (d). The association between the buoyancy element(s) and the subsea structure is preferably designed or adapted to accommodate both tensile and compressive forces between the components, which can or may occur during the different phases of the deployment and landing operation. Preferably, the association is also designed or adapted to be remotely released by a Remotely Operated Vehicle (ROV) after the subsea structure is landed on a seabed or other intended working location to allow controlled recovery of the buoyancy element(s).

[0033] A reservoir of buoyancy fluid for the or each buoyancy element may be located at any suitable location, including on one or more floating vessels such as independent storage vessels. By way of example only, one suitable location of a reservoir of buoyancy fluid is on the deployment vessel.

[0034] Fluid communication is required between any such reservoir and the or each buoyancy element, and suitable fluid umbilicals for such fluid communication are well known in the art.

[0035] Step (d) of the method of the present invention comprises locating the subsea structure beneath a deployment vessel, usually at the deployment site, using one or more buoyancy elements as described above. After step (c), and after any relocation to the deployment site, the subsea structure is floating at or near sea level near to the deployment vessel, and the or each buoyancy element provides control of the positioning of the subsea structure beneath the deployment vessel.

[0036] The term "beneath a deployment vessel" as used herein includes the subsea structure being directly beneath the deployment vessel, generally by the connection through one or more generally vertical channels or ports in the deployment vessel, as well as next to or near to a side of the deployment vessel, optionally by the use of one more overhanging pulleys or winches or the like. The present invention is not limited by the exact position of the subsea structure beneath the deployment vessel in preparation for deployment by the deployment vessel, conventionally in a vertically downward direction, of the subsea structure to the seabed.

[0037] PI 0306058-6A shows lowering of equipment from sea level to near the point of installation by the swinging pendulum movement of the equipment downwardly to the seabed. Such equipment undergoes sideward 'freefall' as it travels through the sea and thus creates increased strain on the installation cable.

[0038] By the use of one or more buoyancy elements with variable buoyancy, the present invention is able to provide controlled location of the subsea structure from a floating sea level position, to a suitable position ready for deployment beneath the deployment vessel.

[0039] In particular, by transferring buoyancy fluid in/out of the one or more buoyancy elements to vary the volume of buoyancy fluid in the or each buoyancy element, very close control of the overall buoyancy of the subsea structure can be provided so as to control the relocation of the subsea structure beneath the deployment vessel. In this way, careful and controlled lowering of the subsea structure from the sea level position to a position beneath the deployment vessel, can be carried out without any 'freefall', especially pendular freefall, and consequent strain on the fastening line therebetween.

[0040] Varying the buoyancy of the or each buoyancy element associated with the subsea structure may involve the transferring of one or more of the elements: air, water (generally and preferably seawater) and buoyancy fluids; in, out, within, between, or any combination thereof; the one or more of the buoyancy elements. Means such as pumps, valves, lines, inlets and outlets of the or each buoyancy element are known in the art, and the skilled man is able to provide control of the presence and/or flow of the or each fluid so as to vary the buoyancy of the or each buoyancy element to provide controlled lowering or decent of the subsea structure from its floating sea level position to beneath the deployment vessel. Naturally, the subsea structure has a certain weight, such that the or each buoyancy element requires a certain degree of buoyancy to allow the subsea structure to float even at sea level. This can involve the inclusion of a proportion of air and/or buoyancy fluid in one or more chambers, sections, tanks, etc of the or each buoyancy element. Some water may also be included to prevent over-buoyancy.

[0041] Preferably, prior to submersion of the subsea structure, all air is evacuated from the buoyancy element (s) and replaced by either water and/or buoyancy fluid, thus removing the requirement for the buoyancy element to be designed to accommodate a net external hydrostatic pressure. The transfer of buoyancy fluid and/or water to replace the air also reduces the overall buoyancy of the or each buoyancy element, providing careful control of the rate (and optionally position) of the lowering the subsea structure such that it can be slowly and carefully located beneath the deployment vessel.

[0042] In a particular embodiment of the present invention, step (d) comprises a method of lowering a subsea structure to beneath the deployment vessel comprising the steps of:

providing at least one buoyancy element on or connected to the subsea structure, said at least one buoyancy element comprising one or more chambers containing a buoyancy fluid comprising a substantially incompressible fluid having a density less than that of sea water;
providing a reservoir for said buoyancy fluid at a location remote from said subsea structure;
providing fluid communication between said reservoir and said one or more chambers of said at least one buoyancy element;
transferring said buoyancy fluid between said reservoir and said one or more chambers of said at least one buoyancy element to vary the volume of buoyancy fluid within the at least one buoyancy element and thus vary the overall buoyancy of the subsea structure to thereby initiate and subsequently control the rate of descent of the subsea structure.

[0043] Subsea structures can be deployed to an installation site, generally on the seabed, using a number of known methods. Generally, these involve the lowering of the subsea structure by means of a winch and fastening line from a floating deployment vessel directly beneath the vessel and in a controlled manner.

[0044] The subsequent deployment of a subsea structure used in the present invention to the seabed may optionally but preferably continue to involve one or more of the buoyancy elements used in step (d), preferably by or involving at least partly the replacement of buoyancy fluid by water in a controlled manner to allow the subsequent lowering of the subsea structure beneath the deployment vessel to the seabed.

[0045] Thus, according to a second aspect of the present invention, there is provided a method of locating a subsea structure beneath a floating deployment vessel as defined herein, and of deploying a subsea structure to a seabed comprising the steps of:

(a) transporting the subsea structure on a floating transporting vessel near to a deployment vessel;
(b) lowering the transportation vessel to allow the subsea structure to float;
(c) relocating either the transporting vessel or the subsea structure to allow the subsea structure to be separate of the transporting vessel;
(d) locating the subsea structure beneath the deployment vessel using one or more buoyancy elements with variable buoyancy; and
(e) deploying the subsea structure from beneath the deployment vessel to the seabed.

[0046] Preferably, step (e) comprises replacing buoyancy fluid in one or more of the buoyancy elements with water.

[0047] Embodiments of the present invention will now be described by way of example only, and with reference to the accompanying diagrammatic drawings in which:

Figure 1 shows a first stage of a method of locating a subsea structure according to an embodiment of the present invention;

Figure 2 shows a second stage of the method;

Figure 3 show a third stage of the method;

Figure 4 shows the location of a subsea structure beneath the deployment vessel;

Figures 5 and 6 show the deployment of the subsea structure to the seabed according to another embodiment of the present invention;

Figures 7 to 9 show the recovery of a buoyancy element from the seabed.

[0048] The present invention provides an improved method for locating a subsea structure, especially a large subsea structure for use in oil and gas fields offshore, beneath a deployment vessel, and for subsequent deployment of the subsea structure to the seabed, such as to a deep water seabed location.

[0049] Figure 1 shows the subsea structure 10 located on the open-deck 12 of a floating and sea-faring or seagoing transporting vessel 14, such as the known marine vessel "Sea Serpent". The transporting vessel 14 is able to transport the subsea structure 10 from a dock or other onshore location (not shown) to near the deployment vessel 26 already at a deployment site, or possibly at a more suitable, such as more sheltered, water location for the splashdown.

[0050] Figure 1 shows the option of including a buoyancy element 16 attached to the subsea structure 10. The attachment may occur onshore, or after the subsea structure 10 has been located in the floating vessel 14. The buoyancy element 16 could be in the form of a 'variable buoyancy submersible barge' (VBSB).

[0051] The buoyancy element 16 may include one or more chambers (not shown) and one or more fluid umbilicals 18 able to provide fluid communication for transferring buoyancy fluid between the buoyancy element 16 and a reservoir once required. During transporting of the subsea structure 10 as shown in Figure 1, the fluid umbilical 18 may not be required.

[0052] Figure 1 also shows a support guide 20 above the buoyancy element 16, attached to a fastening line 22. The fastening line 22 may not be required during transporting of the subsea structure shown in Figure 1. The support guide 20 provides even support of the buoyancy element 16 and subsea structure 10 via the fasten-

ing line 22.

[0053] Once near the deployment vessel 26, and possibly at or near the deployment site, Figure 2 shows the lowering of the transporting vessel 14 to a semi-submerged position, generally by the flooding of one or more ballast tanks therein in a manner known in the art. Preferably prior to the lowering of the transporting vessel 14, the fastening line 22 is connected to a suitable winch 24 on the nearby deployment vessel 26. The fastening line 22 may pass through a vertical channel in the deployment vessel 26 to reach the winch 24.

[0054] Similarly, the fluid umbilical 18 is connected to a suitable reservoir 30 on the deployment vessel 26. Meanwhile, any fastenings or other securement of the subsea structure 10 to the transporting vessel 14 can be detached and/or released.

[0055] As the transporting vessel 14 semi-submerges, the subsea structure 10 starts to float at or near the sea level 15, generally because of the buoyancy provided by the buoyancy element 16. The skilled man will be aware of the amount of buoyancy required in the buoyancy element 16 to achieve floating of the subsea structure 10, and generally at least a portion, optionally substantially or all, of the buoyancy element 16, may be air-filled at this time.

[0056] By use of the fastening line 22 and/or one or more other guide or control elements not shown, the floating subsea structure 10 can be relocated gently away from the transporting vessel 14, whilst still floating at or near sea level. The energy required to relocate the floating subsea structure 10 is clearly substantially less than that required to vertically lift any subsea structure in the air by a crane over the side of a transporting vessel and into the sea.

[0057] Once the subsea structure 10 and buoyancy element 16 are 'free' of the transporting vessel 14, generally floating in a different sea area than the location of the transporting vessel 14, the transporting vessel 14 can be re-floated to its normal floating position, for re-use.

[0058] Figure 3 shows the floating subsea structure 10 and buoyancy element 16 next to the deployment vessel 26 following the removal of the transporting vessel 14. By controlled transfer of:

> (a) buoyancy fluid in the reservoir 30 into the buoyancy element 16, optionally into one or more parts, sections, tanks or chambers therein, and distributed therein in an equitable manner; and/or
> (b) water, generally being sea water, through one or more inlets (not shown) into the buoyancy element 16 in a manner known in the art;

the flooding of the buoyancy element (and exhaust of air through one or more outlets (not shown), such outlets optionally being cone-topped to reduce and/or prevent the entrapment of air where not desired), the buoyancy of the buoyancy element 16 is reduced in a controlled manner to allow the lowering of the subsea structure 10 from its floating sea level position gently to a position beneath the deployment vessel 26 along a path 28 shown in Figure 3 by four arrows.

[0059] The buoyancy element 16 may include one or more sections, chambers or tanks able to be 'hybrid' tanks to accept the presence of buoyancy fluid and water, generally in a pre-determined and/or variable volume and/or ratio.

[0060] The use of buoyancy fluid having a density less than that of water and/or the use of water itself, allows the skilled man to very carefully control the buoyancy of the buoyancy element 16 to counter the weight of the subsea structure 10 and allow it to gently sink, preferably until the overall combination of the buoyancy element 16 and subsea structure 10 achieves neutral buoyancy at a position beneath the deployment vessel 26 as shown in Figure 4.

[0061] Preferably, the submerged weight of the subsea structure 10 is reduced (by the use of the buoyancy element 16 containing a combination of water and sufficient low density incompressible buoyancy fluid), so as to be a maximum of 75% of the safe working capacity of the deployment winch 30. However, whilst the submerged weight of the subsea structure 10 has been reduced, the mass of the subsea structure 10 has not been reduced and neither has its inertia. The winch 30 may therefore still comprise or be fitted with specific features, known in the art, to help control the size of dynamic peak loads expected in the fastening line 22 induced by the motions of the deployment vessel 26.

[0062] Figures 3 and 4 also show the use of an ROV (Remotely Operated Vehicle) 34 from the deployment vessel 26 to monitor and/or assist any and all movements of the subsea structure 10 and the buoyancy element 16.

[0063] Once the subsea structure 10 is beneath the deployment vessel 26 as shown in Figure 4, the subsea structure 10 is ready for deployment to the sea bed (such as to an installation site) as shown in Figures 5 and 6.

[0064] Deployment of a subsea structure 10 from a deployment vessel 26 may be carried out by various methods known in the art, generally involving decreasing the buoyancy of one or more attachments to the subsea structure 10.

[0065] In an embodiment of the present invention, further transfer of buoyancy fluid out of the buoyancy element 16 back to the reservoir 30, and replacement therewith by water, provides negative buoyancy to the buoyancy element 16 such that the subsea structure 10 is able to fall to the seabed 36 in a controlled manner.

[0066] The removal of the buoyancy element 16 from the subsea structure 10 once located on the seabed 36, and the recovery of the buoyancy element 16 to the sea surface 15, are shown in Figures 7 to 9. A towing line or pennant 38 can be attached to the buoyancy element 16, and the reverse of some of the steps mentioned hereinabove can occur to increase under control the buoyancy of the buoyancy element 16 to the sea surface 15.

[0067] Various modifications and variations to the de-

scribed embodiments of the invention will be apparent to those skilled in the art without departing from the scope of the invention as defined herein. Although the invention has been described in connection with specific preferred embodiments it should be understood that the invention as defined herein should not be unduly limited to such specific embodiments.

[0068] For example, in one alternative arrangement, the launch or splashdown of the subsea structure 10 shown in Figure 2 occurs in a sheltered water site separate from the deployment site, and the subsea structure 10 and associated buoyancy element 16 are towed by the deployment vessel 26 to the deployment site prior to locating the subsea structure 10 beneath the deployment vessel 26 as shown by the path 28 in Figure 3 leading to Figure 4.

Claims

1. A method of locating a subsea structure (10) beneath a floating deployment vessel (26) for deployment to a seabed (36) comprising at least the steps of:

   (a) transporting the subsea structure (10) on a floating transporting vessel (14) near to the deployment vessel (26);
   (b) lowering the transporting vessel (14) to allow the subsea structure (10) to float;
   (c) relocating either the transporting vessel (14) or the subsea structure (10) to allow the subsea structure to be separate of the transporting vessel; and
   (d) locating the subsea structure (10) beneath the deployment vessel (26) using one or more buoyancy elements (16) with variable buoyancy.

2. A method as claimed in claim 1 wherein the floating transporting vessel (14) is moveable in step (b) between a sea-faring position and a semi-submerged position.

3. A method as claimed in claim 1 or claim 2 wherein the subsea structure (10) is located in step (a) directly on or next to a deck (12) of the floating transporting vessel (14).

4. A method as claimed in any one of the preceding claims further comprising the step of providing at least one buoyancy element (16) with variable buoyancy on or connected to the subsea structure (10) prior to or during step (b).

5. A method as claimed in claim 4 wherein the at least one buoyancy element (16) is on or connected to the subsea structure (10) onshore and/or prior to step (a).

6. A method as claimed in claim 4 or claim 5 wherein the at least one buoyancy element (16) is connected to the subsea structure (10) onshore, and remains associated with the subsea structure during steps (b) and (c) for use in step (d).

7. A method as claimed in any one of the preceding claims wherein the one or more buoyancy elements (16) with variable buoyancy are secured to the subsea structure (10) in or at a position above the subsea structure.

8. A method as claimed in any one of the preceding claims wherein the or each buoyancy element (16) comprises one or more chambers able to contain at least a proportion of a buoyancy fluid.

9. A method as claimed in claim 8 wherein one or more of the chambers are formed from a flexible or elastic material to permit the volume thereof to vary and accommodate the volume of buoyancy fluid contained therein.

10. A method as claimed in claim 8 or claim 9 wherein the buoyancy fluid comprises a wholly or substantially incompressible fluid having a density less than that of sea water.

11. A method as claimed in claim 10 wherein the buoyancy fluid is a low molecular weight hydrocarbon such as methanol.

12. A method as claimed in any one of claims 8 to 11 wherein the buoyancy fluid includes glass microspheres.

13. A method as claimed in any one of claims 8 to 12 wherein the buoyancy fluid has a density of between 500 and 600kg/m^3.

14. A method as claimed in any one of claims 8 to 13 wherein the buoyancy fluid is a low viscosity gel.

15. A method as claimed in any one of claims 8 to 14 further comprising the step of varying the volume of buoyancy fluid within the or each buoyancy element (16) to vary the overall buoyancy of the subsea structure (10).

16. A method as claimed in any one of claims 8 to 15 further comprising providing an external reservoir of buoyancy fluid and transferring buoyancy fluid between the external reservoir and the or each buoyancy element (16).

17. A method as claimed in any one of claims 8 to 16 wherein the or each chamber includes a bladder or diaphragm to allow the chamber(s) to simultaneous-

ly comprise buoyancy fluid and water, preferably to allow the proportions of the buoyancy fluid and water in such chamber(s) to be varied, without allowing the two components to mix.

18. A method as claimed in any one of the preceding claims comprising varying the buoyancy of the or each buoyancy element (16) associated with the subsea structure (10) by transferring of one or more of the elements: air, water, preferably seawater, and buoyancy fluids; in, out, within, between or any combination thereof; the one or more of the buoyancy elements.

19. A method as claimed in any one of the preceding claims wherein prior to step (b), the buoyancy element(s) (16) are fully vented of air and replaced with either buoyancy fluid as defined in any one of claims 10 to 14 and/or water.

20. A method as claimed in any one of the preceding claims comprising the further transporting of the floating subsea structure (10) at or near sealevel between steps (c) and (d).

21. A method as claimed in any one of the preceding claims including the steps of:

providing at least one buoyancy element (16) on or connected to the subsea structure (10), said at least one buoyancy element comprising one or more chambers containing a buoyancy fluid comprising a substantially incompressible fluid having a density less than that of sea water;
providing a reservoir for said buoyancy fluid at a location remote from said subsea structure;
providing fluid communication between said reservoir and said one or more chambers of said at least one buoyancy element;
transferring said buoyancy fluid between said reservoir and said one or more chambers of said at least one buoyancy element to vary the volume of buoyancy fluid within the at least one buoyancy element and thus vary the overall buoyancy of the subsea structure to control the rate of descent of the subsea structure to beneath the deployment vessel (26).

22. A method as claimed in any one of the preceding claims wherein the subsea structure (10) is subsequently deployed to an installation site on the seabed (36) beneath the floating deployment vessel (26).

23. A method as claimed in any one of the preceding claims wherein the subsequent deployment of a subsea structure (10) to the seabed (36) involves the one or more of the buoyancy elements (16) used in step (d), preferably by or involving at least partly the replacement of buoyancy fluid in the buoyancy element(s) by water.

24. A method of locating a subsea structure beneath a floating deployment vessel as claimed in any one of the preceding claims and of deploying the subsea structure to a seabed comprising the steps of:

(a) transporting the subsea structure on a floating transporting vessel near to a deployment vessel;
(b) lowering the transportation vessel to allow the subsea structure to float;
(c) relocating either the transporting vessel or the subsea structure to allow the subsea structure to be separate of the transporting vessel;
(d) locating the subsea structure beneath the deployment vessel using one or more buoyancy elements with variable buoyancy; and
(e) deploying the subsea structure from beneath the deployment vessel to the seabed.

25. A method as claimed in claim 24 wherein step (e) comprises replacing buoyancy fluid in one or more of the buoyancy elements with water.

Patentansprüche

1. Ein Verfahren zum Positionieren einer Unterseestruktur (10) unterhalb von einem schwimmenden Stationierungsschiff (26) zur Stationierung auf einem Meeresboden (36), das mindestens folgende Schritte beinhaltet:

(a) Transportieren der Unterseestruktur (10) auf einem schwimmenden Transportschiff (14) in die Nähe des Stationierungsschiffs (26);
(b) Absenken des Transportschiffs (14), um zuzulassen, dass die Unterseestruktur (10) schwimmt;
(c) Umpositionieren von entweder dem Transportschiff (14) oder der Unterseestruktur (10), um zuzulassen, dass die Unterseestruktur von dem Transportschiff getrennt ist; und
(d) Positionieren der Unterseestruktur (10) unterhalb von dem Stationierungsschiff (26) unter Verwendung von einem oder mehreren Auftriebselementen (16) mit veränderlichem Auftrieb.

2. Verfahren gemäß Anspruch 1, wobei das schwimmende Transportschiff (14) in Schritt (b) zwischen einer Seefahrtsposition und einer halbtauchenden Position bewegbar ist.

3. Verfahren gemäß Anspruch 1 oder Anspruch 2, wobei die Unterseestruktur (10) in Schritt (a) direkt auf

oder neben einem Deck (12) des schwimmenden Transportschiffs (14) positioniert ist.

4. Verfahren gemäß einem der vorangehenden Ansprüche, weiter beinhaltend den Schritt des Bereitstellens von mindestens einem Auftriebselement (16) mit veränderlichem Auftrieb, an oder mit der Unterseestruktur (10) verbunden, vor oder während Schritt (b).

5. Verfahren gemäß Anspruch 4, wobei das mindestens eine Auftriebselement (16) an Land und/oder vor Schritt (a) an der Unterseestruktur (10) ist oder mit dieser verbunden ist.

6. Verfahren gemäß Anspruch 4 oder Anspruch 5, wobei das mindestens eine Auftriebselement (16) an Land mit der Unterseestruktur (10) verbunden wird und während der Schritte (b) und (c) zur Verwendung in Schritt (d) mit der Unterseestruktur verknüpft bleibt.

7. Verfahren gemäß einem der vorangehenden Ansprüche, wobei das eine oder die mehreren Auftriebselemente (16) mit veränderlichem Auftrieb in oder an einer Position über der Unterseestruktur an der Unterseestruktur (10) befestigt sind.

8. Verfahren gemäß einem der vorangehenden Ansprüche, wobei das oder jedes Auftriebselement (16) eine oder mehrere Kammern beinhaltet, die in der Lage sind, mindestens einen Anteil eines Auftriebsfluids aufzunehmen.

9. Verfahren gemäß Anspruch 8, wobei eine oder mehrere der Kammern aus einem biegsamen oder elastischen Material gebildet sind, um zu erlauben, dass sich das Volumen derselben verändert und sich an das darin enthaltene Volumen an Auftriebsfluid anpasst.

10. Verfahren gemäß Anspruch 8 oder Anspruch 9, wobei das Auftriebsfluid ein vollkommen oder im Wesentlichen inkompressibles Fluid mit einer Dichte von weniger als der von Meerwasser beinhaltet.

11. Verfahren gemäß Anspruch 10, wobei das Auftriebsfluid ein Kohlenwasserstoff mit niedrigem Molekulargewicht, wie etwa Methanol, ist.

12. Verfahren gemäß einem der Ansprüche 8 bis 11, wobei das Auftriebsfluid Glasmikrokugeln umfasst.

13. Verfahren gemäß einem der Ansprüche 8 bis 12, wobei das Auftriebsfluid eine Dichte von zwischen 500 und 600 kg/m^3 aufweist.

14. Verfahren gemäß einem der Ansprüche 8 bis 13, wobei das Auftriebsfluid ein niedrigviskoses Gel ist.

15. Verfahren gemäß einem der Ansprüche 8 bis 14, weiter beinhaltend den Schritt des Veränderns des Volumens an Auftriebsfluid in dem oder jedem Auftriebselement (16), um den Gesamtauftrieb der Unterseestruktur (10) zu verändern.

16. Verfahren gemäß einem der Ansprüche 8 bis 15, weiter beinhaltend das Bereitstellen eines externen Speichers an Auftriebsfluid und Überführen von Auftriebsfluid zwischen dem externen Speicher und dem oder jedem Auftriebselement (16).

17. Verfahren gemäß einem der Ansprüche 8 bis 16, wobei die oder jede Kammer eine Blase oder eine Membran umfasst, um zuzulassen, dass die Kammer(n) gleichzeitig Auftriebsfluid und Wasser beinhaltet/beinhalten, bevorzugt, um zuzulassen, dass die Anteile des Auftriebsfluids und des Wassers in (einer) derartigen Kammer(n) verändert werden, ohne zuzulassen, dass die zwei Komponenten vermischt werden.

18. Verfahren gemäß einem der vorangehenden Ansprüche, beinhaltend das Verändern des Auftriebs des oder jedes mit der Unterseestruktur (10) verknüpften Auftriebselements (16) durch Überführen von einem oder mehreren der Elemente: Luft, Wasser, bevorzugt Meerwasser und Auftriebsfluide; in das eine oder die mehreren Auftriebselemente, daraus hinaus, darin, dazwischen oder eine beliebige Kombination davon.

19. Verfahren gemäß einem der vorangehenden Ansprüche, wobei vor Schritt (b) das bzw. die Auftriebselement(e) (16) vollständig von Luft entleert, welche durch entweder Auftriebsfluid, wie in einem der Ansprüche 10 bis 14 definiert und/oder Wasser ersetzt werden.

20. Verfahren gemäß einem der vorangehenden Ansprüche, beinhaltend das weitere Transportieren der schwimmenden Unterseestruktur (10) auf oder nah bei Meereshöhe zwischen Schritten (c) und (d).

21. Verfahren gemäß einem der vorangehenden Ansprüche, umfassend folgende Schritte:

Bereitstellen von mindestens einem Auftriebselement (16) an oder mit der Unterseestruktur (10) verbunden, wobei das mindestens eine Auftriebselement eine oder mehrere Kammern beinhaltet, die ein Auftriebsfluid enthalten, das ein im Wesentlichen inkompressibles Fluid mit einer Dichte von weniger als der von Meerwasser beinhaltet;
Bereitstellen eines Speichers für das Auftriebs-

fluid an einem von der Unterseestruktur entfernten Ort;
Bereitstellen von Fluidaustausch zwischen dem Speicher und der einen bzw. den mehreren Kammern des mindestens einen Auftriebselements;
Überführen des Auftriebsfluids zwischen dem Speicher und der einen bzw. den mehreren Kammern des mindestens einen Auftriebselements, um das Volumen an Auftriebsfluid in dem mindestens einen Auftriebselement zu verändern und damit den Gesamtauftrieb der Unterseestruktur zu verändern, um die Geschwindigkeit des Sinkens der Unterseestruktur auf unter dem Stationierungsschiff (26) zu steuern.

22. Verfahren gemäß einem der vorangehenden Ansprüche, wobei die Unterseestruktur (10) anschließend an einem Installationsort auf dem Meeresboden (36) unter dem schwimmenden Stationierungsschiff (26) stationiert wird.

23. Verfahren gemäß einem der vorangehenden Ansprüche, wobei die anschließende Stationierung einer Unterseestruktur (10) auf dem Meeresboden (36) das eine oder die mehreren in Schritt (d) verwendeten Auftriebselemente (16) bevorzugt durch oder mindestens teilweise einbeziehend das Ersetzen von Auftriebsfluid in dem Auftriebselement/den Auftriebselementen durch Wasser einbezieht.

24. Verfahren zum Positionieren einer Unterseestruktur unter einem schwimmenden Stationierungsschiff gemäß einem der vorangehenden Ansprüche und des Stationierens der Unterseestruktur auf einem Meeresboden, das folgende Schritte beinhaltet:

(a) Transportieren der Unterseestruktur auf einem schwimmenden Transportschiff in die Nähe eines Stationierungsschiffs;
(b) Absenken des Transportschiffs, um zuzulassen, dass die Unterseestruktur schwimmt;
(c) Umpositionieren von entweder dem Transportschiff oder der Unterseestruktur, um zuzulassen, dass die Unterseestruktur von dem Transportschiff getrennt ist;
(d) Positionieren der Unterseestruktur unter dem Stationierungsschiff unter Verwendung von einem oder mehreren Auftriebselementen mit veränderlichem Auftrieb; und
(e) Stationieren der Unterseestruktur von unter dem Stationierungsschiff auf dem Meeresboden.

25. Verfahren gemäß Anspruch 24, wobei Schritt (e) das Ersetzen von Auftriebsfluid in einem oder mehreren der Auftriebselemente durch Wasser beinhaltet.

Revendications

1. Une méthode de positionnement d'une structure sous-marine (10) au-dessous d'un navire de déploiement flottant (26) pour le déploiement sur un fond marin (36) comprenant au moins les étapes suivantes :

(a) transport de la structure sous-marine (10) sur un navire de transport flottant (14) prés du navire de déploiement (26) ;
(b) abaissement du navire de transport (14) pour permettre à la structure sous-marine (10) de flotter ;
(c) repositionnement de soit le navire de transport (14), soit la structure sous-marine (10) pour permettre à la structure sous-marine d'être séparée du navire de transport ; et
(d) positionnement de la structure sous-marine (10) au-dessous du navire de déploiement (26) en utilisant un ou plusieurs éléments de flottabilité (16) de flottabilité variable.

2. Une méthode telle que revendiquée dans la revendication 1 dans laquelle le navire de transport flottant (14) est déplaceable à l'étape (b) entre une position de navigation et une position semi-submergée.

3. Une méthode telle que revendiquée dans la revendication 1 ou la revendication 2 dans laquelle la structure sous-marine (10) est positionnée à l'étape (a) directement sur ou à coté d'un pont (12) du navire de transport flottant (14).

4. Une méthode telle que revendiquée dans une quelconque des revendications précédentes comprenant en sus l'étape de fourniture d'au moins un élément de flottabilité (16) de flottabilité variable sur ou raccordé à la structure sous-marine (10) avant ou pendant l'étape (b).

5. Une méthode telle que revendiquée dans la revendication 4 dans laquelle cet au moins un élément de flottabilité (16) est sur ou est raccordé à la structure sous-marine (10) à terre et/ou avant l'étape (a).

6. Une méthode telle que revendiquée dans la revendication 4 ou la revendication 5 dans laquelle cet au moins un élément de flottabilité (16) est raccordé à la structure sous-marine (10) à terre, et reste associé à la struture sous-marine pendant les étapes (b) et (c) pour être utilisé à l'étape (d).

7. Une méthode telle que revendiquée dans une quelconque des revendications précédentes dans laquelle ce ou ces éléments de flottabilité (16) de flottabilité variable sont fixés à la structure sous-marine (10) dans ou au niveau d'une position au-dessus de

la structure sous-marine.

8. Une méthode telle que revendiquée dans une quelconque des revendications précédentes dans laquelle le ou chaque élément de flottabilité (16) comprend une ou plusieurs chambres capables de contenir au moins une proportion d'un fluide de flottabilité.

9. Une méthode telle que revendiquée dans la revendication 8 dans laquelle une ou plusieurs des chambres sont formées à partir d'un matériau souple ou élastique afin de permettre au volume de celles-ci de varier et de recevoir le volume de fluide de flottabilité contenu dans celles-ci.

10. Une méthode telle que revendiquée dans la revendication 8 ou la revendication 9 dans laquelle le fluide de flottabilité comprend un fluide entièrement ou substantiellement incompressible ayant une densité inférieure à celle de l'eau de mer.

11. Une méthode telle que revendiquée dans la revendication 10 dans laquelle le fluide de flottabilité est un hydrocarbure de faible masse moléculaire comme le méthanol.

12. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 11 dans laquelle le fluide de flottabilité comporte des microsphères de verre.

13. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 12 dans laquelle le fluide de flottabilité a une densité comprise entre 500 et 600 kg/m^3.

14. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 13 dans laquelle le fluide de flottabilité est un gel de faible viscosité.

15. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 14 comprenant en sus l'étape de variation du volume de fluide de flottabilité à l'intérieur du ou de chaque élément de flottabilité (16) pour faire varier la flottabilité d'ensemble de la structure sous-marine (10).

16. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 15 comprenant en sus la fourniture d'un réservoir externe de fluide de flottabilité et le transfert de fluide de flottabilité entre le réservoir externe et le ou chaque élément de flottabilité (16).

17. Une méthode telle que revendiquée dans une quelconque des revendications 8 à 16 dans laquelle la ou chaque chambre inclut un sac gonflable souple ou une membrane permettant à la ou aux chambres de comprendre simultanément du fluide de flottabilité et de l'eau, pour permettre de préférence la variation des proportions de fluide flottabilité et d'eau dans cette ou ces chambres, sans permettre aux deux composants de se mélanger.

18. Une méthode telle que revendiquée dans une quelconque des revendications précédentes comprenant la variation de la flottabilité du ou de chaque élément de flottabilité (16) associé à la structure sous-marine (10) en transferrant un ou plusieurs des éléments suivants : de l'air, de l'eau, de préférence de l'eau de mer, et des fluides de flottabilité ; dans, hors de, à l'intérieur de, entre ou toute combinaison de ceux-ci ; ce ou ces éléments de flottabilité.

19. Une méthode telle que revendiquée dans une quelconque des revendications précédentes dans laquelle préalablement à l'étape (b), le ou les éléments de flottabilité (16) sont complètement purgés d'air, lequel est remplacé avec soit du fluide de flottabilité comme défini dans une quelconque des revendications 10 à 14 et/soit de l'eau.

20. Une méthode telle que revendiquée dans une quelconque des revendications précédentes comprenant en sus le transport de la struture sous-marine flottante (10) au ou prés du niveau de la mer entre les étapes (c) et (d).

21. Une méthode telle que revendiquée dans une quelconque des revendications précédentes incluant les étapes suivantes :

fourniture d'au moins un élément de flottabilité (16) sur ou raccordé à la structure sous-marine (10), ledit au moins un élément de flottabilité comprenant une ou plusieurs chambres contenant un fluide de flottabilité comprenant un fluide substantiellement incompressible ayant une densité inférieure à celle de l'eau de mer ;
fourniture d'un réservoir pour ledit fluide de flottabilité à une position éloignée de ladite structure sous-marine ;
fourniture d'une transmission de fluide entre ledit réservoir et lesdites une ou plusieurs chambres dudit au moins un élément de flottabilité ;
transfert dudit fluide de flottabilité entre ledit réservoir et lesdites une ou plusieurs chambres dudit au moins un élément de flottabilité pour faire varier le volume de fluide de flottabilité à l'intérieur de cet au moins un élément de flottabilité et donc faire varier la flottabilité d'ensemble de la structure sous-marine pour contrôler la vitesse de descente de la structure sous-marine jusqu'au dessous du navire de déploiement (26).

22. Une méthode telle que revendiquée dans une quelconque des revendications précédentes dans laquelle la structure sous-marine (10) est par la suite déployée vers un site d'installation sur le fond marin (36) au-dessous du navire de déploiement flottant (26).

23. Une méthode telle que revendiquée dans une quelconque des revendications précédentes dans laquelle le déploiement ultérieur d'une structure sous-marine (10) sur le fond marin (36) implique un ou plusieurs de ces éléments de flottabilité (16) utilisés à l'étape (d), de préférence par ou impliquant au moins partiellement le remplacement de fluide de flottabilité dans le ou les éléments de flottabilité par de l'eau.

24. Une méthode de positionnement d'une structure sous-marine au-dessous d'un navire de déploiement flottant telle que revendiquée dans une quelconque des revendications précédentes et de déploiement de la structure sous-marine sur un fond marin comprenant les étapes suivantes :

(a) transport de la structure sous-marine sur un navire de transport flottant prés d'un navire de déploiement ;
(b) abaissement du navire de transport pour permettre à la structure sous-marine de flotter ;
(c) repositionnement de soit le navire de transport, soit la structure sous-marine pour permettre à la structure sous-marine d'être séparée du navire de transport ;
(d) positionnement de la structure sous-marine au-dessous du navire de déploiement en utilisant un ou plusieurs éléments de flottabilité de flottabilité variable ; et
(e) déploiement de la structure sous-marine du dessous du navire de déploiement vers le fond marin.

25. Une méthode telle que revendiquée dans la revendication 24 dans laquelle l'étape (e) comprend le remplacement de fluide de flottabilité dans un ou plusieurs des éléments de flottabilité par de l'eau.

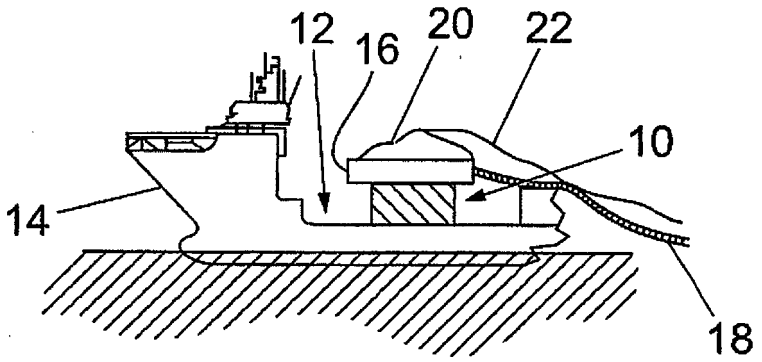


Fig. 1

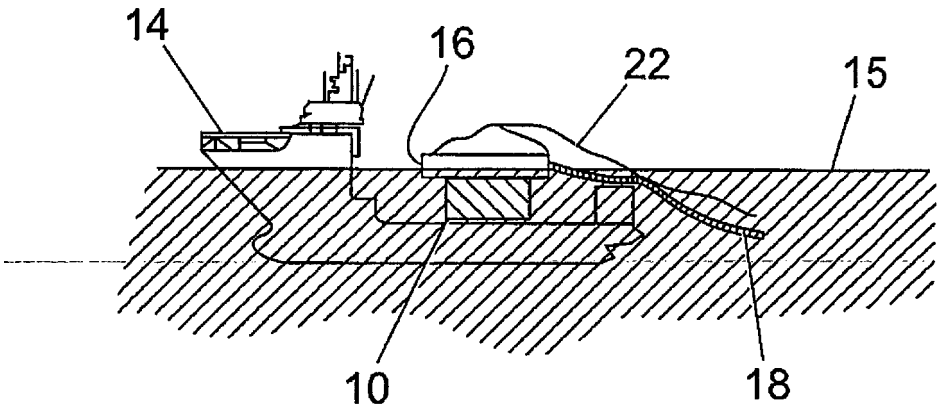


Fig. 2

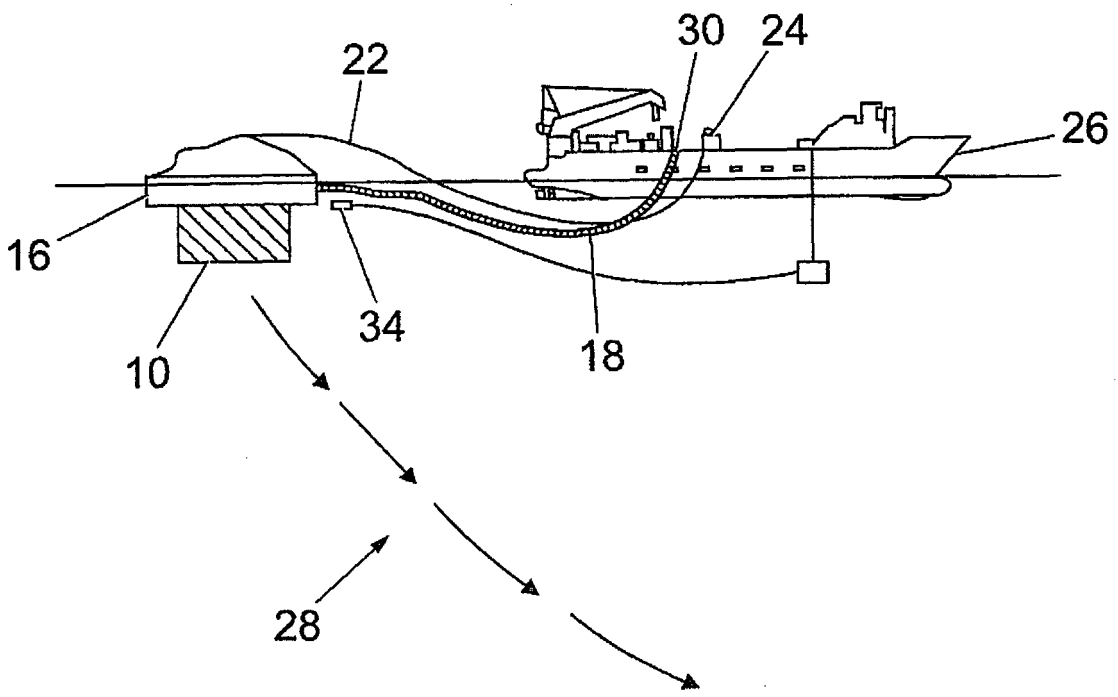


Fig. 3

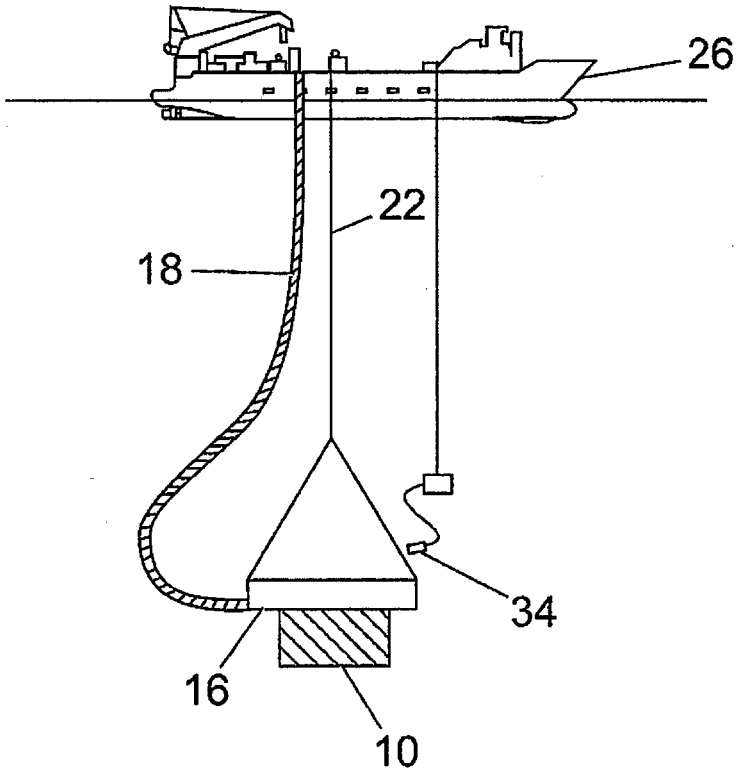


Fig. 4

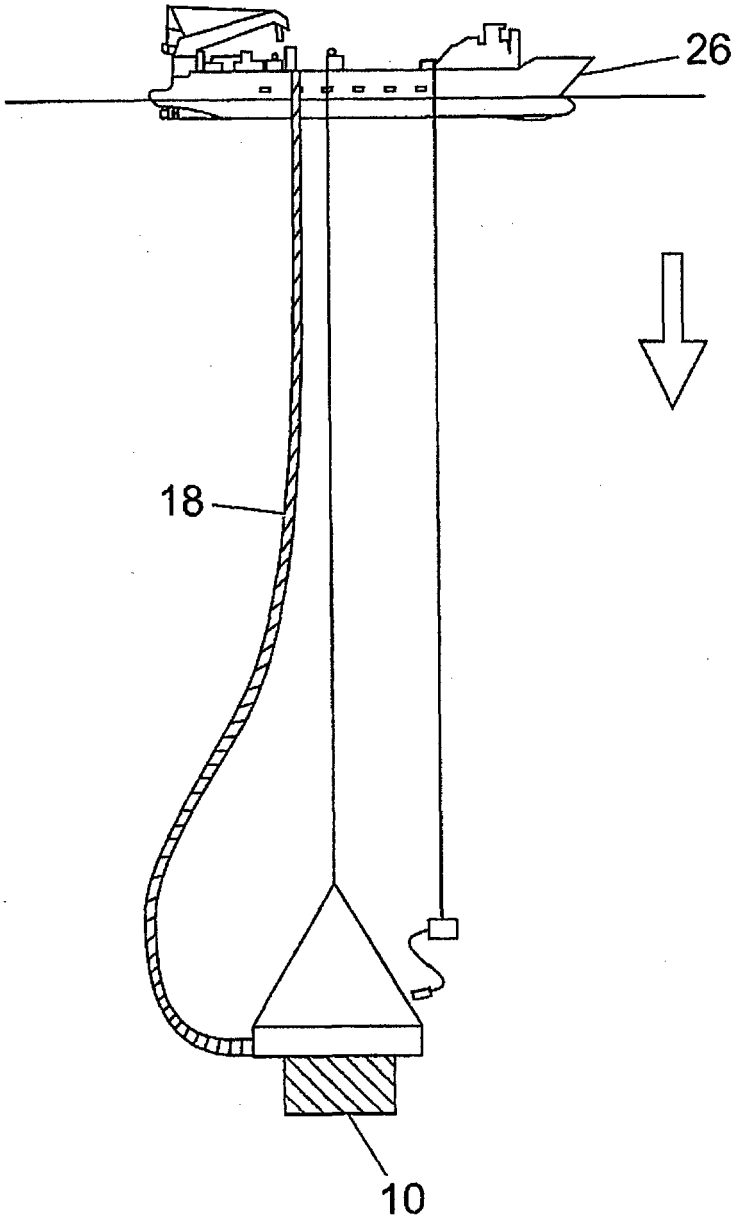


Fig. 5

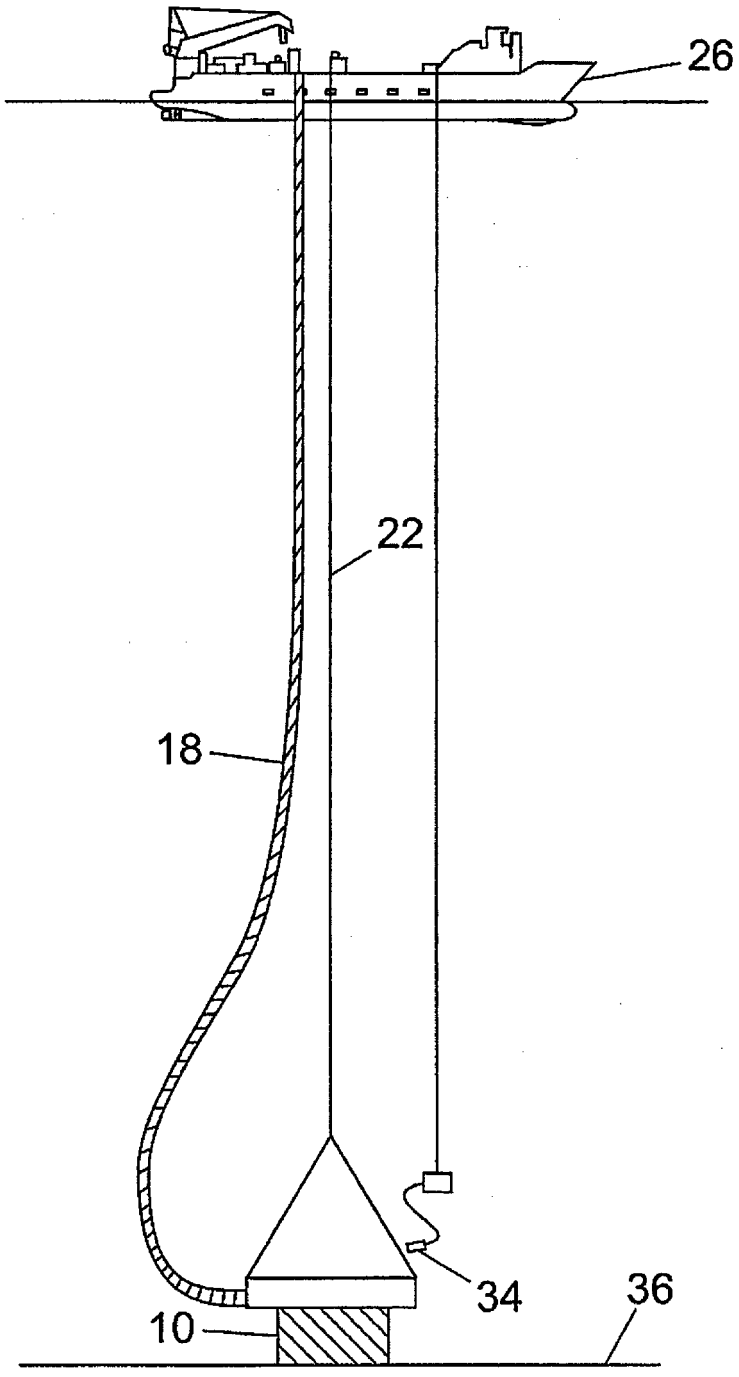


Fig. 6

Fig. 7

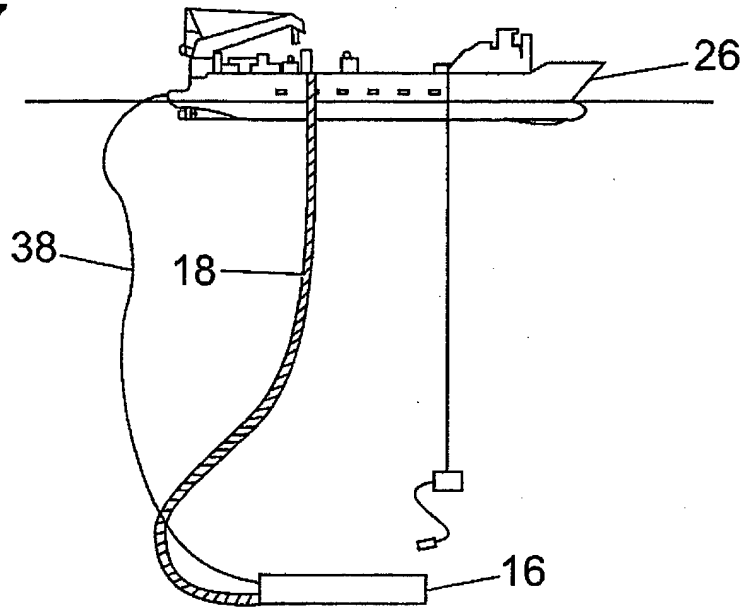


Fig. 8

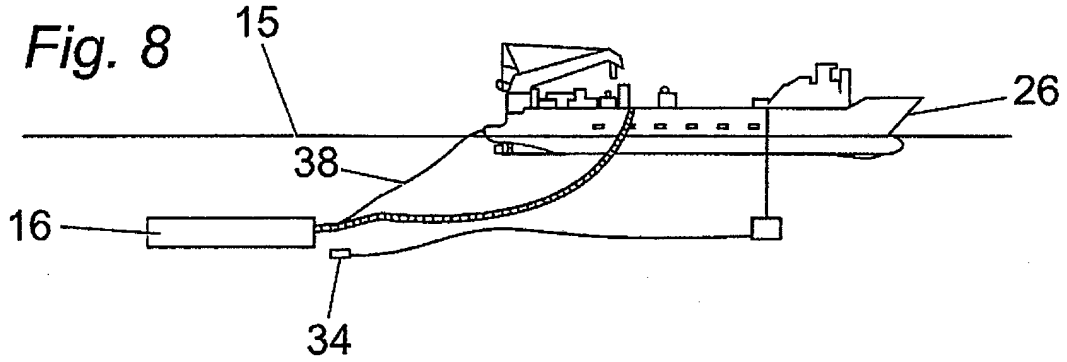
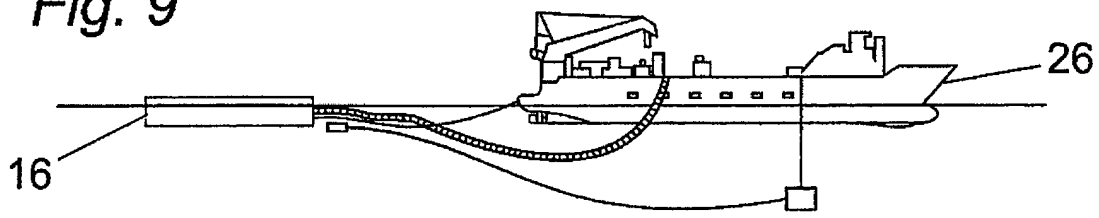


Fig. 9



REFERENCES CITED IN THE DESCRIPTION

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