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[54] **METHOD AND APPARATUS FOR CARRYING OUT UNDERWATER WELL OPERATIONS**

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[58] **Field of Search** 61/46.5, 69; 175/27, 7; 166/.5; 114/.50

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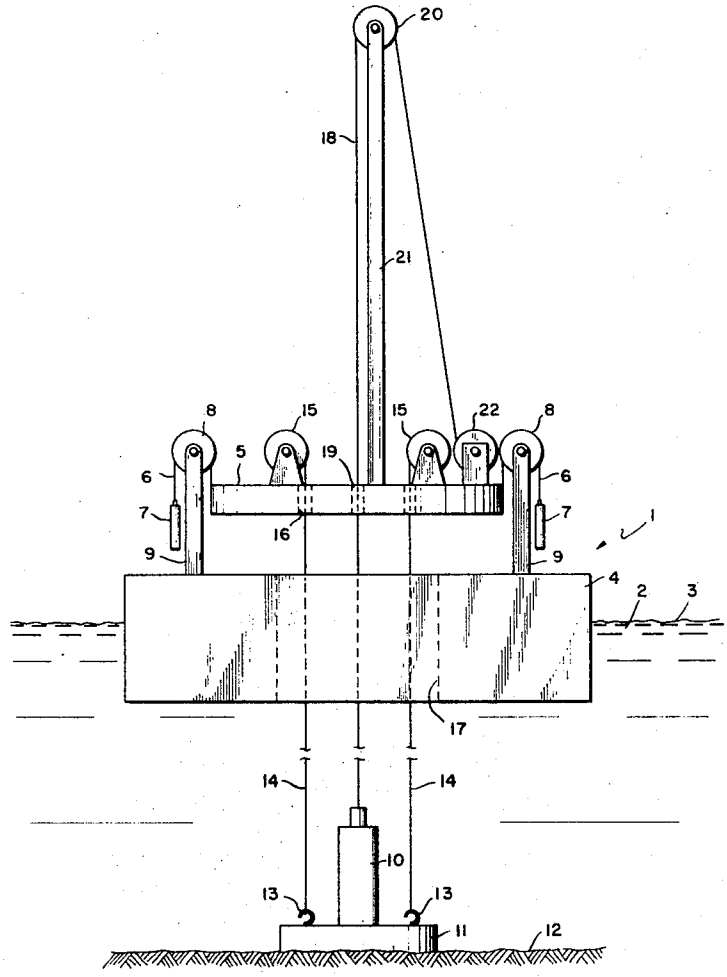
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[57] **ABSTRACT**

Method and apparatus for carrying out operations with respect to an underwater well wherein a cable is secured between the well and a platform mounted on a floating vessel over the well site. The platform is mounted for vertical movement relative to the vessel and is continuously biased in an upward direction during said relative movement to maintain the drill pipe under tension and compensate for up and down movement of the vessel.

8 Claims, 2 Drawing Figures



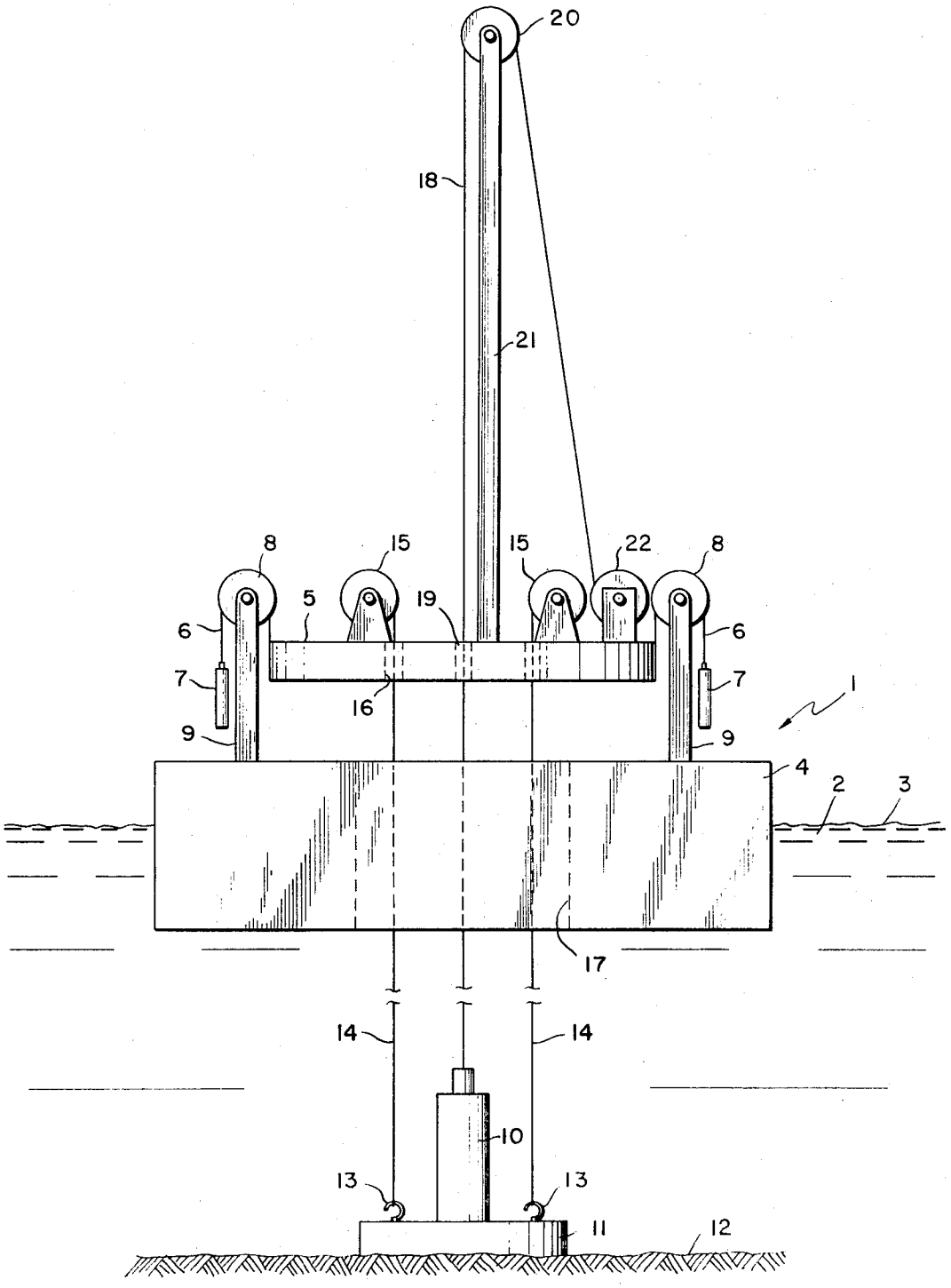


FIG. 1

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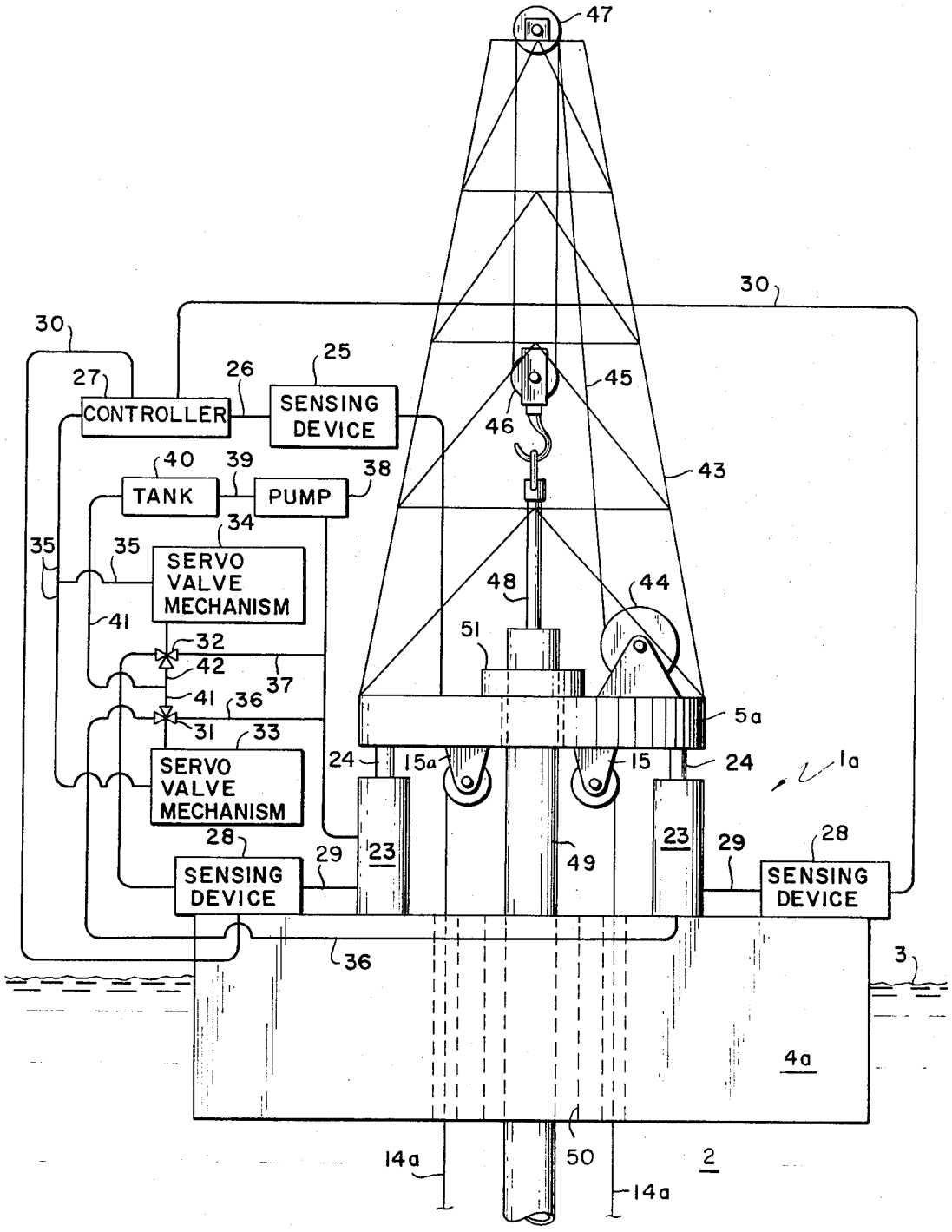


FIG. 2

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METHOD AND APPARATUS FOR CARRYING OUT UNDERWATER WELL OPERATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and to an apparatus for carrying out well operations under the surface of a body of water.

2. Description of the Prior Art

In deep water, floating structures are sometimes used, from which underwater operations are carried out, e.g., on an oil or gas well. Difficulty is often experienced if the floating structure tends to heave and to move vertically because of waves, since it is rather disturbing when it is necessary to carry out from the floating structure operations on a fixed submerged object such as an oil well, a gas well or a pipeline.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method and an apparatus having the advantage that the influence of the heave and of the vertical movement of the floating structure is compensated for, so that they no longer disturb the operations to be carried out under water.

The method according to the invention therefore comprises securing at least one flexible cable at one end thereof to a fixed point below the surface of the body of water, securing the other end of the cable to cable-engaging means on a platform which is secured to a vessel such that it is movable at least in substantially vertical direction with respect to the vessel, applying a substantially constant force between the platform and the vessel such that the force acting on the platform is directed upwards and tensioning the cable such that the load on the flexible cable is equal to the force applied between the platform and the vessel minus the weight of the platform and any equipment thereon, and carrying out operations from the platform below the surface of the body of water.

A floating structure for carrying out the method according to the invention comprises a platform so secured to a floating vessel that it is movable relatively to the vessel, at least in substantially vertical direction with respect to the vessel, means on the structure for applying a force between the platform and the vessel, and cable-engaging means on the platform for engaging a cable which is suitable to be arranged substantially vertical between the cable-engaging means and a fixed point below the surface of the body of water on which the structure may float.

The invention may be carried into practice in various ways but two specific embodiments will now be described by way of example with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic sideview of an embodiment of a floating structure suitable for carrying out the method according to the invention.

FIG. 2 is a diagrammatic sideview of partly in block form of a modified embodiment of a floating structure suitable for carrying out the method according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 and 2 show structures 1 and 1a floating on a body of water 2 having a surface 3, which structures 1 and 1a comprise vessels 4 and 4*a* and platforms 5 and 5*a*, respectively. The platforms 5 and 5*a* are so secured to the floating vessels 4 and 4*a*, for example, by suitable vertical guide means (not shown), that they are vertically movable relatively to the vessels 4 and 4*a*.

In the embodiment shown in FIG. 1, cables 6 are secured to the platform 5, the other end of each cable 6 being provided with a weight 7 and each cable 6 being led over a pulley 8. Each pulley 8 is rotatably secured to a pillar 9 which is supported by the vessel 4. Each pulley 8 is arranged at a level above the highest possible position of the platform 5 relatively to the vessel 4. The platform 5 is in its highest position relative to the vessel 4, if the weights 7 are supported by the deck of the vessel 4.

The vessel 4 is positioned above a submerged well head 10 by means known per se such as anchors and anchor cables. The wellhead 10 rests with its base 11 on the bottom 12 of the body of water 2. This base 11 is provided with connecting means 13 for connecting the lower ends of cables 14 to the base. The upper ends of these cables 14 are attached to the cable engaging means 15 of winches (not shown) which are mounted on the platform 5. The cables 14 pass through openings 16 provided in the platform 5 and through a U-shaped depression 17 of the side wall of the vessel 4.

Maintenance or other operations can be carried out in the well via the wellhead 10 by means of a cable 18 passing through an opening 19 of the platform 5 and being guided over a pulley 20 rotatably secured to a pillar 21 which is supported by the platform 5. One end of the cable carries a tool (not shown) for performing operations within the well, and the other end of the cable 18 is wound around a drum 22 which can be actuated by means of a driving mechanism (not shown). The drum 22 as well as the driving mechanism are mounted on the platform 5.

The floating structure as shown in FIG. 1 is used as follows:

One end of each cable 14 is latched on to the base 11 of an oil well (not shown) in a manner well known in the art, such as by using divers, guiding cables or a remotely operated propulsion device having a television camera. Although the connecting means 13 have been shown in the drawing in the form of a hook, it will be understood that the other connecting means may be used as well such as connections known in the art which can be remotely controlled and which include emergency releases.

The upper ends of the cables 14 pass together through the depression 17 of the vessel 4 and separately through holes 16 provided in the platform 5. Each cable 14 is connected to the cable-engaging means 15 of winches (not shown). By activating the winches, the cables 14 will be tensioned and the platform 5 will move downwards against the action of the weights 7. The total load on the cables 14 will then be equal to the total force applied between the platform 5 and the vessel 4, which force is supplied by the weights 7 suspended from the cables 6, minus the weight of the

platform and any equipment thereon. If the weights 7 have been brought in an intermediate position between the extreme positions which they can reach, the winches are stopped and blocked against further rotation.

If the vessel 4 moves vertically because of waves, the platform 5 will remain in its position relative to the bottom 12 of the body of water 2. The vessel 4 on moving upwards displaces the pillars 9 and the pulleys 8 upwardly. Since the platform 5 is retained by the cables 14, it cannot move upwards and the pulleys 8 are rotated and the weight 7 displaced.

The platform 5 also remains stationary and at the same distance from the bottom 12 when the vessel 4 moves downwards, since the cables 14 are kept taut under influence of the weights 7. During this downward movement of the vessel 4, the weights 7 are displaced and the pulleys 8 rotate in a direction opposite to the direction of rotation during the upward movement of the vessel 4.

From the above, it will be clear that, irrespective of the waves, the platform 5 will always remain at the same distance from the bottom 12 and that the cables 14 will always be kept under tension.

From the platform 5, drilling or wireline operations can be carried out. The platform 5 can be provided with conventional equipment for carrying out wireline operations, for example, equipment as shown in FIG. 1 and indicated by the numbers 18, 19, 20, 21 and 22. Since this equipment does not form part of the invention, it will not be discussed in detail. The wellhead 10 is provided with a high-pressure seal through which the cable 18 can pass, and this cable as well as the tool (not shown) suspended from this cable can be entered into the well via the wellhead 10 by means of diver operation.

The tensioning of the cables 14 need not necessarily occur by means of the winches (not shown) of which the cable-engaging means 15 form part. If desired, the winches may be used only for storage of the cables 14, and paying these cables out to a length at which they are connected at their lower ends to the cable-connecting means 13. Thereafter, the cables can be tensioned by exerting a force between the platform 5 and the vessel 4 to move the platform in an upward direction. This may be reached by keeping the weights 7 in a certain position during the placement of the cables 14, and thereafter leaving the weights 7 free. It will be understood that such operation is only possible if there are no, or only very small waves at the water level 3.

Emergency controls (not shown) are provided to stop the platform 5 from shooting upwardly in the event of one or both of the cables 14 breaking or becoming loosened.

The embodiment as shown in FIG. 2 is provided with a hydraulic system for moving the platform 5*a* relatively to the vessel 4*a* instead of the system comprising weights 7 as shown in FIG. 1. It is remarked, however, that instead of weights or a hydraulic system it is also possible to use a pneumatic, hydro-pneumatic, or an electrical system, if desired. On the vessel 4*a*, a number of (for example, four) hydraulic cylinders 23 is arranged in each of which a plunger or piston (not shown) is present which is axially movable in the cylinder 23. To each plunger or piston a bar or rod 24 is secured, of which the upper end is connected to the platform 5*a*. The connection of the bars or rods 24 with the platform may be direct or through a gimbal support. The axial (vertical) movement of the bars or rods 24 may be controlled by any suitable control system which senses the deviation or any derivative of the deviation of the platform 5*a* from the desired horizontal plane. In the system as shown in FIG. 2, the deviation of the platform 5*a* from the desired horizontal plane is sensed by a sensing device 25. From the sensing device 25 signals can be transmitted through a line 26 to a controller 27. The tension in the cables 14*a* which are at their upper ends connected to the cable-engaging means 15*a* can be sensed in a manner known per se by sensing devices 28 which are each connected to one of the cylinders 23 by lines 29. Each sensing device 28 is connected to the controller 27 by a line 30 through which signals can be transmitted from the sensing device to the controller. The controller 27 can process the signals, received from the sensing devices 25 and 28, and can decide on the hydraulic pressure required in the cylinders 23 to keep the platform 5 in the desired horizontal plane and to keep the cables 14*a* under the proper load. The controller 27 can then regulate the pressure in the cylinders 23 accordingly, e.g., by operating three-way control valves 31 and 32 by sending through lines 35 signals to servo-valve mechanisms 33 and 34. The valves 31 and 32 are arranged respectively in lines 36 and line 37 which each connects the pressure side of a liquid-pump 38 with a corresponding cylinder 23. The suction side of the pump 38 is connected through a line 39 to a tank 40 containing a suitable liquid, for example, oil. A drain line 41 connects the valve 31 with the top of the tank 40 and a drain line 42 connects the valve 32 to the drain line 41. By properly positioning the three-way valves 31 and 32, liquid can be pumped from the tank 40 to the cylinders 23 and/or be drained from the cylinders 23 so that the proper pressure will be obtained in each of the cylinders 23. By means of the hydraulic system as described above the platform 5a will, irrespective of the waves, always remain in the desired horizontal plane and the cables 14*a* will always be kept under the required load.

On the platform 5*a* can be located conventional equipment for carrying out drilling operations, for example, a derrick 43, a hoist 44, a cable 45, a traveling block 46, and a crown block 47.

The communication with a well via a (not shown) submerged wellhead takes place via a pipe string 49 which at its lower end is connected to the wellhead and at its upper end passes through an opening 50 in the platform 5.

The operation of the embodiment as shown in FIG. 2 is as follows:

When the vessel 4a has been located above the well in which maintenance operations are to be carried out, the cables 14a are operatively positioned with their lower ends connected to the wellhead or a point in the neighborhood of this wellhead as described above with respect to the embodiment of FIG. 1. This point is a fixed point located below the surface 3 of the body of water 2. By actuating the cable engaging means 15*a*, the cables 14*a* are tensioned, and, since the load on the cables is sensed by the sensing devices 28, the cylinders

23 are controlled such that the desired load is exerted in the cables 14a. It will be understood that by a suitable manipulation with the cable-engaging means 15a, a desired neutral position of the rods 24 relative to the cylinders 23 will be obtained.

Tensioning of the cables 14a during wave action exerted on the vessel 4a will result in immobility of the platform 5*a* relative to the bottom of the body of water, and consequently, relative to the wellhead of a well in which operations are to be carried out. In this position of the platform 5a the tube string 49 is lowered from the platform to the wellhead and connected thereto either by diver assistance or by means of automatic or remotely controlled coupling equipment known in the art.

The upper end of the tube string 49 is immobile with respect to the platform 5*a*, notwithstanding the wave action exerted on the vessel 4*a*, and may be coupled to the platform 5*a* by a clamping means 51. Such clamping means are well known and need no further description. By actuating the cable-engaging means 15*a*, the load on the cables 14a may now be partly removed from these cables to the pipe string 49. This, however, is not necessary, and the operations to be carried out in the well by means of the string 48 suspended from the hook of the traveling block 46 may be carried out with either the cables 14*a* and/or the pipe string 49 under load. It will be understood that when the string 49 is loaded by the action of the hydraulic system, the load exerted thereon will have to be sensed and the data obtained to be fed to the controller 27.

The wellhead, or other submerged equipment on which operations are to be carried out by means of the method and/or apparatus according to the invention need not be located on the bottom of the body of water, but may also be located above or below this bottom. It is, however, really essential that the flexible cables 14a or the pipe string 49 are connected at their lower ends to a point below the water level, which point has a constant distance with respect to the bottom of the body of water.

It is to be noted that instead of the weights or the hydraulic system as described above a pneumatic, hydro-pneumatic, or electric system may also be used. It is, for example, possible to keep the pressure in each cylinder 23 substantially constant in all positions of the platform 5*a* by connecting each cylinder 23 to a corresponding pressure tank (not shown), containing gas and having a volume which is large relative to the volume of the corresponding cylinder 23.

Furthermore, attention is drawn to the fact that instead of one pipe string 49 as shown, it is possible to use a plurality of pipe strings which are parallelly or concentrically arranged.

It will be understood that although the wave compensated platform, as described in the embodiment of the invention according to FIGS. 1 and 2 is mounted above the vessel, the invention is not limited thereto. Similar results will be obtained when securing the platform to one of the sides of the vessel in such a manner that it is movable at least in a substantially vertical direction with respect to the vessel.

The embodiments as shown in FIG. 1 may, if desired, also be combined with a pipe string 49 as described with reference to FIG. 2.

The winch 22 (FIG. 1) need not be placed on the platform 5, but may be mounted on the vessel 4 at a sufficient distance from the platform. The cable 18 is then guided from the winch, over a guide pulley mounted on the platform 4, and over the pulley 20. A similar arrangement may be made in the embodiment as shown in FIG. 2.

We claim as our invention:

1. A method of carrying out operations on a well having a wellhead positioned under the surface of a body of water, comprising the steps of:
- arranging a platform on a floating vessel such that the platform is moveable at least in a substantially vertical direction with respect to the vessel;
- positioning the vessel above the wellhead;
- securing one end of each of a plurality of flexible cables to at least one fixed point below the surface of the body of water;
- securing the opposite end of each of the cables to winch means operatively connected to the platform;
- applying between the platform and the vessel a substantially constant force upwardly directed with respect to the platform and of magnitude sufficient to move the platform and any equipment thereon upwardly with respect to the vessel;
- after securing the cables to the fixed point, actuating the winch means to adjust the length of the cables to a length selected to maintain the platform at a selected distance from the bottom of the body of water; the selected distance being one from which the platform is free to move vertically both upwardly and downwardly with respect to the vessel;
- tensioning the cables to prevent upward movement of the platform with respect to the vessel under the applied substantially constant force when the vessel is at rest; and
- carrying out underwater operations from the platform.

2. The method according to claim 1, wherein the force between the platform and the vessel is created by means of at least one weight.

3. The method according to claim 1, wherein the force between the platform and the vessel is created by a piston arranged in a fluid cylinder.

4. An apparatus for carrying out operations at offshore well locations comprising:
- a base fixedly positioned adjacent the well below the surface of the body of water;
- a floating vessel,
- a work platform operatively connected to said floating vessel so that said work platform is vertically moveable with respect to said floating vessel,
- means for applying vertically directed force between said work platform and said floating vessel,
- a plurality of flexible cables operatively connected between said work platform and said base,
- cable-engaging means on said work platform for engaging each of said cables, and
- wench means mounted on the platform, one winch means operatively associated with each of said cable-engaging means for adjusting the length of said cables and thereby adjusting the tension in said cables.

5. The structure as claimed in claim 4, in which the means for applying a vertically directed force to the platform comprises at least one cable having one end secured to the platform and the other end to a weight, the cable being led over a pulley which is arranged on the structure at a level above the highest position of the platform relatively to the vessel.

6. The structure as claimed in claim 4, in which the means for applying an upwardly directed force to the platform comprises at least one cylinder arranged on the structure, a piston arranged in the cylinder, a connection between the piston and the platform, a pressure source communicating with the cylinder, and means for controlling the pressure in the cylinder.

7. The structure as claimed in claim 6 in which a system is present for keeping the pressure in the cylinder substantially constant in all positions of the platform relatively to the vessel.

8. The structure as claimed in claim 7, in which the system for keeping the pressure in the cylinder constant comprises a pressure tank containing gas and having a volume which is large relative to the volume of the cylinder, and a fluid connection between the cylinder and the pressure tank.

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