

[54] **DRILLING VESSEL AND DRILLING VESSEL MOORING SYSTEM AND METHOD**[75] Inventor: **Frank Allan Bryant**, Houston, Tex.[73] Assignee: **The Offshore Company**, Houston, Tex.[22] Filed: **Oct. 1, 1973**[21] Appl. No.: **402,255**

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[51] Int. Cl. **B63b 21/50**

[58] Field of Search 114/206 R, 230, 5 D; 9/8 P; 175/5, 7; 166/5

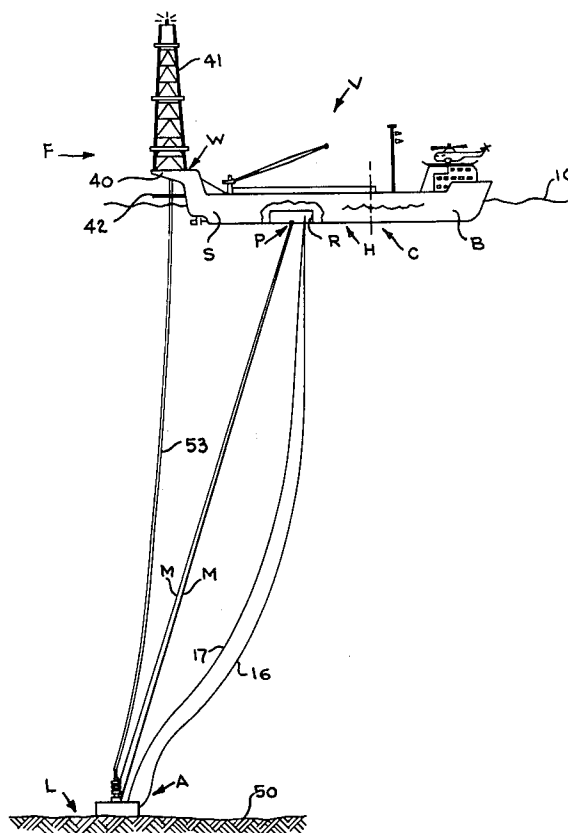
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Primary Examiner—Trygve M. Blix*Assistant Examiner*—Galen L. Barefoot[57] **ABSTRACT**

A drilling vessel and drilling vessel mooring system

and method for maintaining a work area on the vessel over a selected subsurface location are disclosed. The vessel has a pressure center line responsive to the wind and current, a hull with a recess, and a work area on a cantilever extending from the stern. A heavy anchor having a central bore, a ballast chamber and a swivel device is adapted substantially to fill and not to project out of the hull recess when the anchor is stowed and to engage the seabed at the selected subsurface location when the anchor is lowered. The lowering and raising of the anchor is facilitated by controlling the flow of fluid into and out of the ballast chamber to change the anchor's buoyancy. When the anchor is lowered, at least one mooring line is connected to the swivel device and to the vessel between the pressure center line and the work area. As the net force of the wind and water acts on the vessel, the vessel will weathervane about a point on the surface in substantially vertical alignment with the anchor and will maintain its longitudinal axis aligned with the net force of the wind and water and thus will maintain the work area in substantially vertical alignment with the anchor. Drilling equipment extending downwardly from the work area may extend through the central bore of the anchor and will not be subjected to excessive strain as the vessel weathervanes about a point on the surface in substantially vertical alignment with the anchor. This abstract is not to be construed in any way to define or limit the invention set forth below.

2 Claims, 5 Drawing Figures

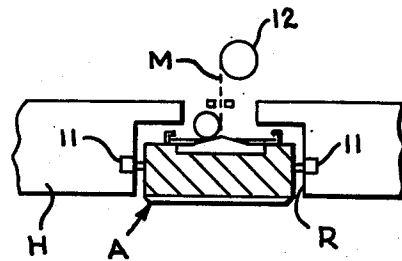
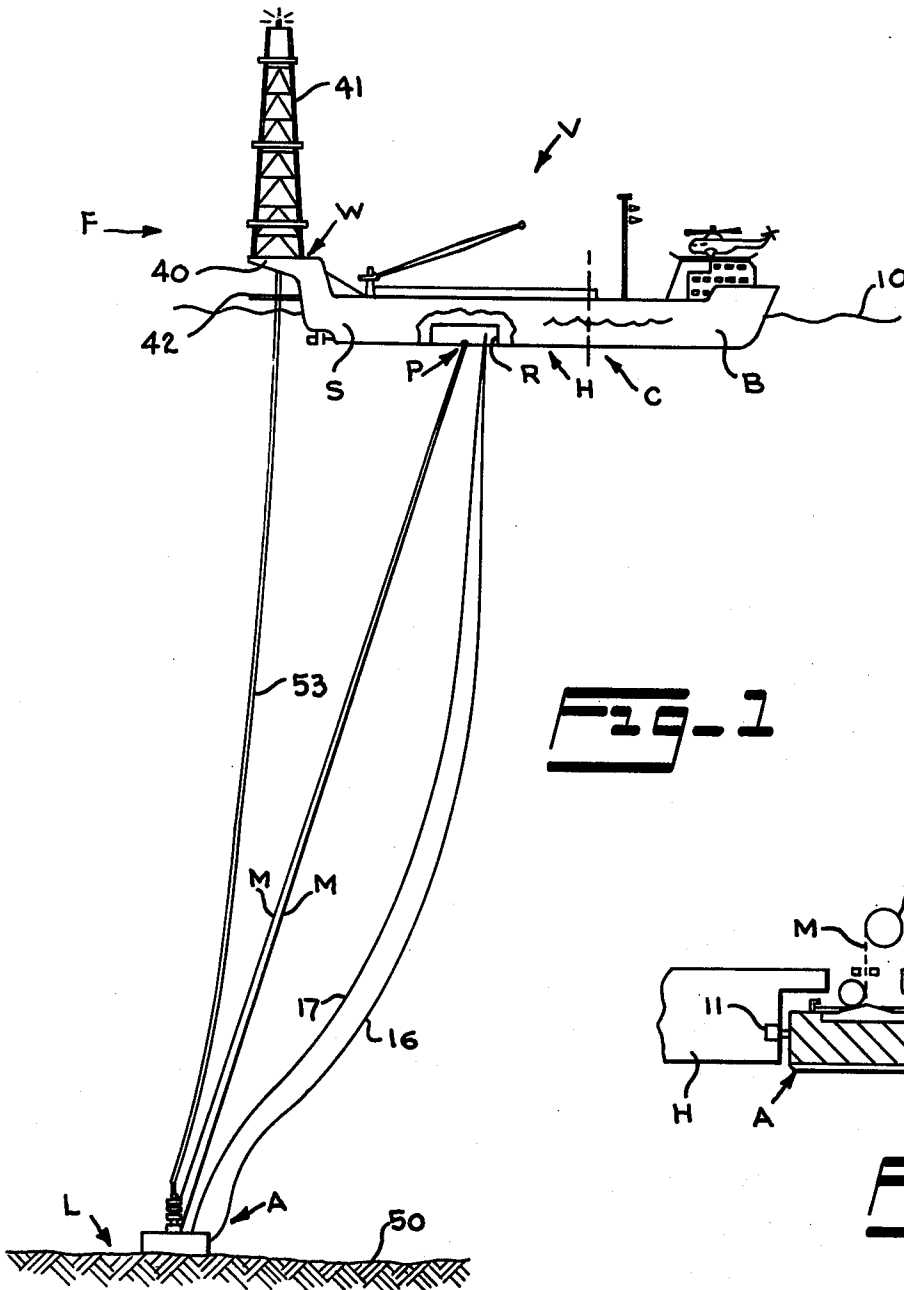


FIG. 2

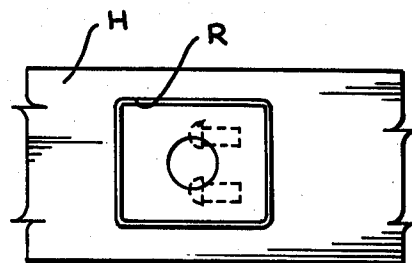


Fig. 5

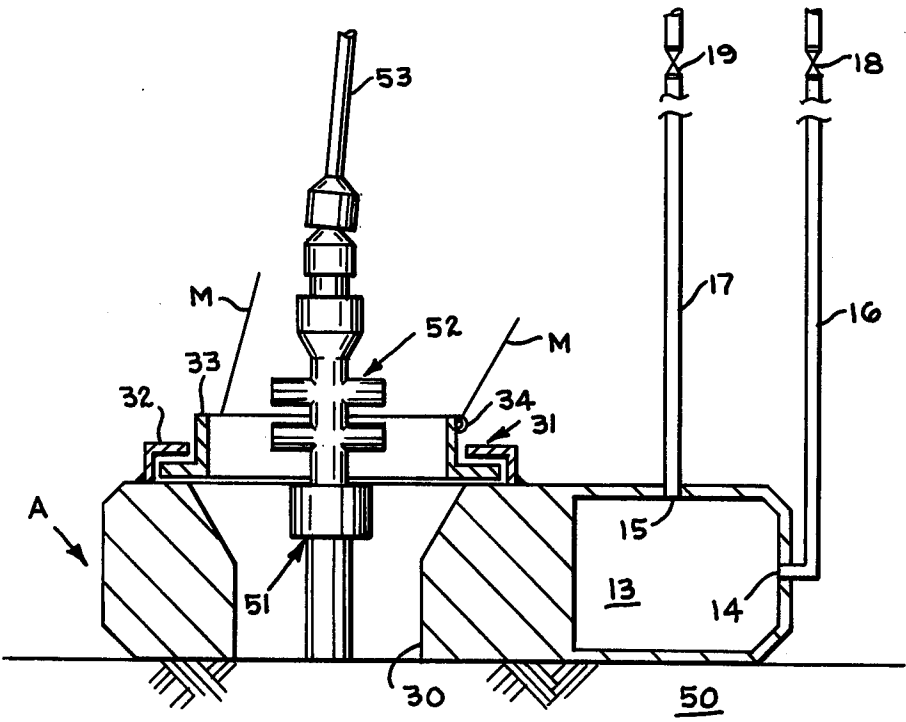
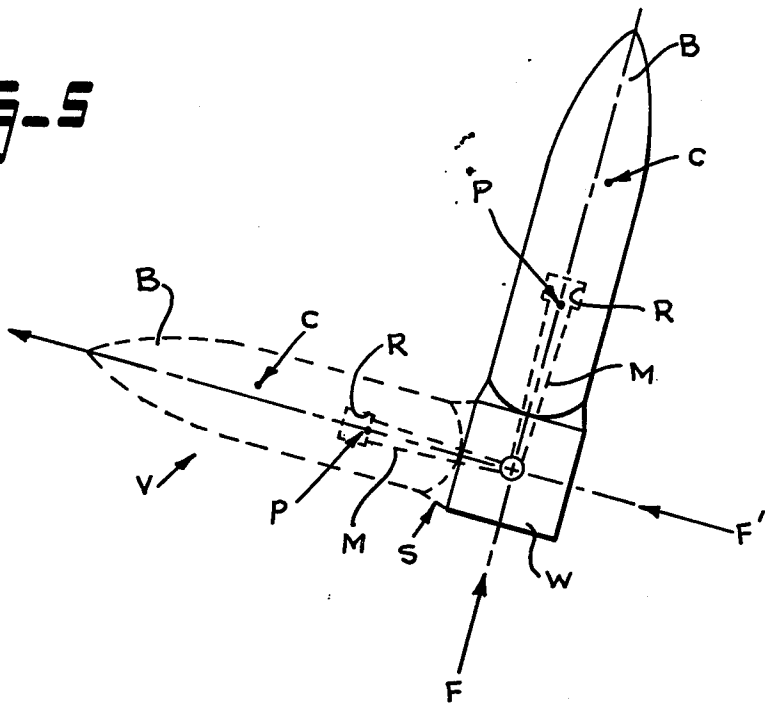


Fig. 4

DRILLING VESSEL AND DRILLING VESSEL MOORING SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field

This invention relates to vessels and to mooring systems and methods for maintaining them over a selected subsurface location. Such systems and methods are particularly important when a drilling string or other riser communicates between the subsurface location and the vessel, because the uncontrolled drifting of the vessel in response to the force of the wind and water would result in excessive strain on the riser, the equipment at the subsurface location, and the vessel itself.

2. Prior Art

In the known prior art, there are two basic manners in which a vessel may be maintained over a selected subsurface location. The vessel may be maintained in a fixed orientation irrespective of the direction of the net force of the wind and water, or the orientation of the vessel may be changed continually in response to the changing direction of the net force of the wind and water.

Maintaining the vessel in a fixed orientation has the advantage of keeping a selected part or work area of the vessel over the selected subsurface location, but has the disadvantage of requiring a relatively complex multiple point mooring system which must be strong enough to resist the force of the wind and water on the vessel from any angle with respect to the vessel. Multiple point mooring systems are generally expensive and are time consuming and awkward to deploy.

Controlling or mooring the vessel so that it swings or weathervanes in response to changes in the direction of the net force of the wind and water can have the advantage of reducing that force on the vessel and thus reducing the requirement for heavy mooring lines and related equipment. The orientation of the vessel can be controlled by a dynamic mooring system including propelling devices, but such a system has the disadvantage of being relatively expensive, hard to maintain and subject to failure. However, the orientation of the vessel also may be changed continually by the relatively simple technique of mooring the vessel primarily at one point only or at adjacent points on the vessel, so that the vessel is free automatically to weathervane with the force of the wind and water. Such weathervaning clearly tends to keep the vessel's longitudinal axis aligned with the net force of the wind and water and thus to reduce that force on the vessel.

A weathervane mooring system will not necessarily maintain a selected work area over a selected subsurface location, but it may do so. See, for example, U.S. Pat. No. 3,481,294 (1969) to Vincent, which discloses a vessel whose stern is fixed to a buoyant chamber which in turn is moored above a selected subsurface location by a plurality of mooring lines anchored at their lower ends to different points of the seabed. U.S. Pat. No. 2,699,321 (1955) to Nelson illustrates mooring the vessel so that it will weathervane about the top of a massive vertical piling which engages the seabed at the selected location and which is held upright in part by a plurality of guy cables anchored to different points of the seabed. However, the Vincent and Nelson systems are complex, expensive and difficult to deploy. There is no mooring system in the known prior art which en-

gages the seabed only at one point, which restrains the vessel primarily by one or more flexible, easy-to-deploy mooring lines, which permits the vessel to weathervane over the selected location in response to the force of the wind and water and which also maintains a selected work area in substantially vertical alignment with the selected location at all times.

In the prior art, various mooring systems are disclosed which include the use of massive anchors which initially are carried by the vessel in stowed position beneath the vessel's hull and which subsequently are lowered to engage the seabed at the selected location. See, for example, U.S. Pat. Nos. 3,154,039 (1964) to Knapp and 2,699,321 (1955) to Nelson. These systems have the advantage that the massive anchors can be lowered or raised between their stowed positions and the seabed without the necessity of lowering or raising the anchors over the side of the vessel. However, these systems have the disadvantage that the anchors protrude beneath the hull and significantly increase the drag on the vessel as it moves through the water.

SUMMARY

Applicant solves the problem of designing a simple and inexpensive mooring system which permits the vessel to weathervane and which keeps a selected work area of the vessel in vertical alignment with the selected subsurface location by providing a single massive anchor and by providing at least one mooring line connected to the anchor and to the vessel at a point between the wind and water pressure center line of the vessel and the selected work area. When the system is deployed, the anchor engages at the seabed at the selected subsurface location and the mooring line extending between the vessel and the anchor restrains the vessel. The mooring line is of such a length that it is taut when the selected work area is in substantially vertical alignment with the anchor. The force of the wind and water impinging on the vessel causes the vessel to weathervane about a point on the surface in substantially vertical alignment with the anchor and the selected work area remains in substantially vertical alignment with the anchor.

Applicant solves the problem of stowing a massive anchor at least partially below the water line without substantially increasing the drag on the vessel under way by providing a recess in the vessel's hull. This recess is of such a size and shape that the anchor substantially fills the recess and does not project therefrom.

An object of this invention is to provide a mooring system which is relatively simple, inexpensive and easy to deploy, which engages the seabed only at one point, which permits the vessel to weathervane over a selected subsurface location and which maintains a selected work area of the vessel in substantially vertical alignment with that location.

Another object is to provide such a mooring system having an anchor which may be stowed at least partially below the waterline without substantially increasing the drag on the vessel under way.

Other objects will be apparent from the drawings, the specifications and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference numerals indicate like parts and wherein the illustrative embodiments of this invention are shown:

FIG. 1 is a view in side elevation of a drilling vessel moored above a selected subsurface location by a mooring system embodying the invention;

FIG. 2 is a view looking upwardly at the bottom of the hull of the vessel showing the anchor in place within a recess in the hull;

FIG. 3 is a view partly in side elevation and partly in section with the anchor in place within the recess in the hull and showing the mechanism for locking and for lowering the anchor;

FIG. 4 is an enlarged view partly in side elevation and partly in section showing the anchor in position on the seabed; and,

FIG. 5 is a schematic plan view of the vessel, showing the vessel in two moored positions above the anchor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drilling vessel V floats on the surface 10 of the sea and has a hull H with a bow B and a stern S. For purposes of force analysis, the net force of the wind and water on the side of the vessel V can be considered to act as though it were impinging only along a single pressure center line C (FIGS. 1 and 5) between the bow B and stern S. The location of line C is primarily a function of the geometric configuration of the vessel and line C will not necessarily be precisely equidistant from the sides of the vessel (See FIG. 5). If the vessel is acted on simultaneously by the wind and water force and by a restraining force (such as the force of a mooring line M) impinging on the vessel at a point P other than along the pressure center line C, then the two forces will develop torque along the longitudinal axis of the vessel and the vessel will tend to swing or weathervane so that its longitudinal axis becomes aligned with the wind and water force. If the vessel initially is positioned so that its stern S faces into the net force F of the wind and water and so that its stern S is in substantially vertical alignment with a selected subsurface location L, then the vessel may be moored so that, as the direction of force F changes and as the vessel weathervanes, its stern S will continue to point into force F and will remain in substantially vertically aligned with location L. This result may be achieved by restraining the vessel by mooring lines M which extend from the location L, which are connected to the vessel at a point P between the line C and the stern S and which are taut when the stern S is in substantially vertical alignment with the location L. As the direction of the force F changes, the torque on the vessel caused by the force F on the vessel and the force of the mooring lines M on the vessel will cause the vessel to weathervane so that its longitudinal axis becomes substantially realigned with force F, causing the stern S to point into the force F, and so that said longitudinal axis intersects a point at the surface in substantially vertical alignment with location L.

This realignment will have the effect of keeping the stern S in substantially vertical alignment with the location L because the force F will keep the mooring lines M taut and, when the mooring lines M are taut and the longitudinal axis of the vessel intersects a point on the surface in substantially vertical alignment with location L, then the stern S will be in substantially vertical alignment with location L. This realignment is illustrated in FIG. 5 in which F designates the net force of the wind

and water from one direction and F' designates that force from a different direction.

As illustrated in FIGS. 1, 2 and 3, a midships recess R is formed within the hull H and extends upwardly from the hull bottom. Initially, a massive anchor A is secured in the recess R by suitable locking means 11. Anchor A substantially fills the recess R and is contained substantially wholly by the recess R so that the anchor A does not project below the bottom of the hull, thereby reducing drag when the vessel is under way. For the purpose of raising and lowering anchor A, a winch 12 is mounted in hull H above recess R. Mooring lines M are connected to winch 12 and the anchor A.

As is shown most clearly in FIG. 4, the anchor A preferably is formed with a ballast chamber 13 which is initially filled with air and which may be filled with water or other appropriate fluid when the anchor is to be lowered. Ports 14 and 15 serve to conduct fluids into and out of the chamber 13. Hoses 16 and 17 are connected by suitable means at their lower ends to ports 14 and 15 respectively. Valves 18 and 19 are disposed in the upper sections of hoses 16 and 17 respectively and may be operated at the surface 10 from the vessel to control the flow of fluid into and out of chamber 13 as desired. For example, when the anchor A is to be raised, its buoyancy may be increased by pumping water out of chamber 13 and replacing it with air.

The anchor A is formed with a central bore 30 through which drilling and production operations may be conducted, as will be discussed below. Further, the anchor A includes a swivel device 31 which is mounted around said central bore 30 and which aids in preventing the entanglement of mooring lines M, as will be explained below. The swivel device 31 comprises an annular retaining shoulder 32 welded to the anchor A and retaining an annular swivel member 33. Swivel member 33 has loops 34 to which the mooring lines M may be fastened. Preferably these loops 34 are spaced apart less than 180° around the circumference of swivel member 33 and the swivel member 33 is free to rotate about the longitudinal axis of the central bore 30 to prevent the entanglement of the mooring lines M. Said longitudinal axis of the bore 30 may be said to be parallel to a vertical axis through the anchor A.

A cantilever 40 extends rearwardly from the stern S and supports a work area W which may carry a drilling rig 41 and other drilling equipment and from which subsurface operations may be conducted. A work deck 42 extends rearwardly from the stern S below the work area W.

When the vessel is positioned above a selected subsurface location L on the seabed 50, the locking means 11 are released and the anchor A is lowered to that location on the mooring lines M. These mooring lines are connected at their lower ends to the loops 34 and at their upper ends to winch 12. The mooring lines M will restrain the vessel V against the force of the wind and water; preferably winch 12 is connected to the vessel at a point or points other than along pressure center line C so that the vessel will weathervane as described above and below. For example, in the preferred embodiment the winch 12 is attached to the vessel between the work area W and the pressure center line C. However, the mooring lines M may be connected at their upper ends to the vessel at any point on the work area end of the vessel, which work area end includes that section of the vessel which extends between the

pressure center line and work area and also includes the work area and any part of the vessel beyond the work area away from the pressure center line. Clearly the lowering of the anchor A, and its subsequent raising, is greatly facilitated by stowing the anchor in the recess R, thus dispensing with the need to raise or lower the anchor over the side of the vessel.

Once the anchor A is lowered onto and engages the seabed 50 at the desired location L, the tensions in the mooring lines M are adjusted so that they are taut when the work area W is in substantially vertical alignment with the selected location L. As the force F of the wind and water acts on the vessel, the vessel will be restrained by the mooring lines M and the vessel will weathervane about the work area W and the stern S will point continually into the net force F of the wind and water and the work area will remain in substantially vertical alignment with the anchor A (See FIG. 5). This weathervaning not only minimizes the mooring loads, but also keeps the work area W in substantially vertical alignment with the selected subsurface location L so that equipment may be extended between the work area W and the location L without undue strain on the equipment or the vessel. The mooring lines M may of course be taken in or paid out to compensate for the changes in the water level or in the magnitude of the net force F of the wind and water.

Once the anchor A is in place and the mooring lines M are adjusted so that the work area W is in substantially vertical alignment with the anchor, drilling and production operations may be conducted through the central bore 30 of the anchor by means of well bore equipment connected with the vessel and extending through central bore 30. FIG. 4 illustrates a well head assembly 51 extending through the bore 30 which assembly includes the usual blowout preventors and other controls, generally indicated at 52. A riser 53 extends from the well head assembly 51 to the work area W. Because the work area W is maintained over the anchor A as the vessel weathervanes, no undue strain is put on the well head assembly 51, controls 52, the riser 53 or the vessel. Further, as the vessel weathervanes, the swivel member 33 rotates, thus preventing the mooring lines M from wrapping around the blowout preventors and other controls 52 or otherwise becoming entangled.

In operation, the vessel V is positioned above the selected subsurface location L, the locking means 11 retaining the anchor A in the recess R are released, and the anchor A is lowered on mooring lines M onto the seabed 50. If desired, the buoyancy of the anchor A may be diminished by admitting water or other suitable fluid into the ballast chamber 13. The tensions in the mooring lines M are adjusted so that the lines are taut when the work area W is in substantially vertical alignment with the anchor A and these tensions may be adjusted from time to time in response to changes in the water level and magnitude of the force F of the wind and water.

Drilling and production operations are conducted through the central bore 30 in the anchor A with the riser 53 extending from the work area W to the anchor A. As the wind and water impinge on the vessel, the vessel will weathervane about a point on the surface in substantially vertical alignment with the anchor A, keeping the work area W in substantially vertical alignment with the anchor A and maintaining the longitudi-

nal axis of the vessel substantially aligned with the net force of the wind and water, because the mooring lines M restrain the vessel at a point P on the work area end of the vessel. When desired, the riser 53 may be taken up, the buoyancy of the anchor A increased by introducing air into the chamber 13 through hoses 16 and 17 and ports 14 and 15 and the anchor raised and stowed in recess R. The anchor A will substantially fill recess R and does not project below the hull bottom, thereby reducing drag on the vessel when it is under way.

Thus, a mooring system has been described which, with the use of a single anchor, enables the vessel simply and easily to be moored so that it always assumes that heading which keeps the work area of the vessel in substantially vertical alignment with the selected subsurface location and which minimizes the net force of the wind and water on the vessel. The single anchor may be deployed quickly without assistance from other vessels and without raising or lowering the anchor over one of the sides of the vessel. The anchor is stowed in a recess in the hull and substantially fills and does not protrude from the recess and thus drag is not substantially increased. The vessel has no large hole in the hull, so that construction costs are decreased and the usable area in the vessel is increased.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details in the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A system for mooring a drilling vessel to a seabed over a selected subsurface location, said vessel floating on the sea surface and having a hull, a longitudinal axis, a wind and water pressure center line and a work area on the vessel from which subsurface drilling and other well operations may be conducted, said work area being longitudinally spaced from said pressure center line and said system comprising:
 - an anchor lowerable from the vessel to the seabed at said selected location;
 - a riser pipe extending from the work area to said anchor;
 - said anchor having a central bore through which well bore equipment connected to said riser pipe may extend, having a ballast chamber for receiving fluid to vary the buoyancy of said anchor, and having a swivel device rotatable around said central bore, said swivel device having connecting means for attachment to mooring lines;
 - means extending from said ballast chamber to said vessel for controlling the flow of fluid into and out of said ballast chamber;
 - the hull of said vessel having a recess for receiving said anchor, said recess being of a size sufficient to contain said anchor substantially wholly within it; and
 - a mooring line connected at its lower end to said swivel on said anchor and at its upper end to said vessel at a point between the work area of the vessel and the wind and water pressure center line of the vessel so that when said mooring line is taut, said work area is in substantially vertical alignment with said selected subsurface location,

whereby, as said vessel drifts in response to the net force of the wind and water, said vessel swings about a point on said sea surface about said selected subsurface location to keep said work area in substantially vertical alignment with said subsurface location and to maintain said longitudinal axis substantially aligned with said net force of wind and water so that said riser pipe is not subjected to excessive bending stresses and remains substantially vertical and drilling and other well operations may be conducted from said vessel on said work area.

2. A system for mooring a floating drilling vessel to a seabed over a selected subsurface location, the vessel having a hull, a longitudinal axis, a wind and water pressure center line and a work area on the vessel from which subsurface drilling and other well operations may be conducted, the work area being longitudinally spaced from the pressure center line, the system comprising:

- an anchor lowerable from the vessel to the seabed at the selected location;
- a riser pipe extending downwardly from the work area to the anchor;
- the anchor having a central bore through which well bore equipment connected to the riser pipe may extend, having a ballast chamber for receiving fluid

to vary the buoyancy of the anchor, and having a swivel device rotatable around the central bore, the swivel device having connecting means for attachment to mooring lines;

the hull of the vessel having a recess for receiving the anchor, the recess being of a size sufficient to contain said anchor substantially wholly within it; and a mooring line connected at its lower end to the swivel on the anchor and at its upper end to the vessel at a point between the work area of the vessel and the wind and water pressure center line of the vessel so that when the mooring line is taut, the work area is in substantially vertical alignment with said selected subsurface location,

whereby, as the vessel drifts in response to the net force of the wind and water, the vessel swings about a point on the sea subsurface location to keep the work area in substantially vertical alignment with the subsurface location and to maintain the longitudinal axis substantially aligned with the net force of wind and water so that the riser pipe is not subjected to excessive bending stresses and remains substantially vertical and drilling and other well operations may be conducted from the vessel on the work area.

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