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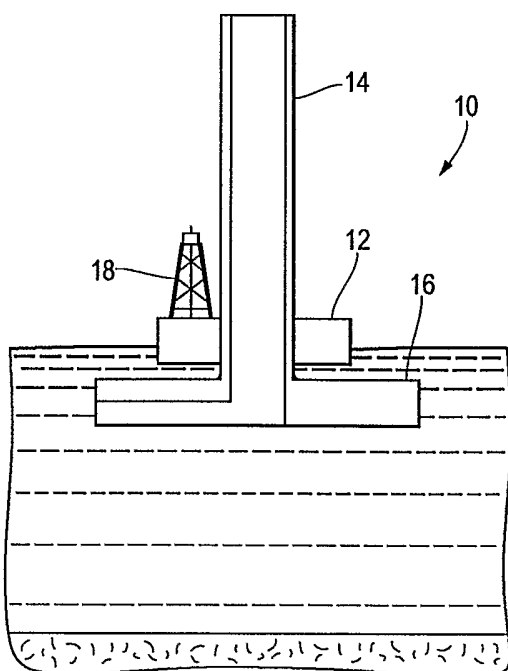
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(54) Title: METHOD AND APPARATUS FOR OFFSHORE DRILLING IN ICE-INFESTED WATERS



(57) Abstract: An offshore structure for placement on a sea floor in a body of water containing moving ice masses, which impart Environmental Loads to the structure; the offshore structure includes a base which contacts the sea floor, the base having sufficient horizontal cross-sectional area such that a bearing pressure and a horizontal shear force, which result from Environmental Loads and which are transferred to the sea floor foundation by the foundation base, are less than at least one of a predetermined shear capacity and a predetermined bearing capacity for the sea floor foundation; and a hollow, watertight topside structure located at or above the waterline of the body which is supported by a support shaft extending vertically from the base through the topside structure.

METHOD AND APPARATUS FOR OFFSHORE DRILLING IN ICE-INFESTED WATERS

This application claims the benefit of the provisional U.S. Application Ser. No.
5 60/688,276, filed June 7, 2005.

Field of Invention

The present invention relates to a method and apparatus for offshore drilling in ice-infested waters.

Background of the Invention

10 Substantial known reserves of oil and gas exist in remote, often inaccessible areas, of the world. Many of these reserves are known to lie below ice-infested waters in the Arctic region, making year round exploration and production of such oil and gas reserves hazardous and uneconomical.

In particular, the problem resides in a permanent polar ice pack that typically
15 exists over much of this Arctic region and varies in extent depending upon the time of year. During the Arctic winter, the size of the ice pack expands to positions very close to (and, in some instances, in direct contact with) the shoreline. In those areas where the permanent ice pack does not come into direct contact with the shoreline, ice sheets which are fixed to the shoreline (known as land-fast ice) cover these areas
20 and may extend 25 miles or more offshore.

In the Arctic Ocean, for instance, the permanent ice pack slowly rotates and circulates, and land-fast ice also moves during the period in which it exists in the Arctic regions. The land-fast ice sheet moves randomly in response to tides, currents, winds and temperature changes. These ice masses in the Arctic may move
25 as much as sixty feet per day and can exert substantial bearing pressures or

horizontal shear forces. These pressures and forces exerted by such ice masses and/or waves are collectively referred to as "Environmental Loads."

In the past, it was believed that the major Environmental Loads acting on such offshore platforms resulted from moving ice masses impinging on the offshore
5 platforms. Therefore, in the past, the limiting factor in the design of an offshore platform was whether it could resist the Environmental Loads. This resulted in efforts to design offshore platforms that resist such Environmental Loads and potentially allow for year-round drilling and production operations in the Arctic region.

One such effort is U.S. Patent No. 4,103,504 ('504 patent), which discloses a
10 stationary offshore platform that employs pre-tensioned vibrating cables regularly spaced around the periphery of a top-side structure of the platform, forming a cable barrier around the top-side structure to break up ice prior to the ice making contact with the platform. The '504 patent also discloses the use of a compressible bladder to prevent the resulting broken ice from encroaching beyond the cable barrier.
15 Another effort is U.S. Patent No. 4,102,144 ('144 patent), which discloses a stationary offshore platform that employs an moveable ice-breaking shield surrounding a top-side structure of the platform; the shield elevates to break ice and is thereafter lowered to discharge the broken ice.

While the platforms disclosed in the '504 and '144 patents may be effective for
20 operation in deepwater Arctic applications, the large top heavy platforms are not designed to provide hydrostatic stability during the transit, installation and operation of the platforms, thereby preventing the installation and operation of a platform in shallower ice-infested waters. Additionally, such platforms require large amounts of costly Arctic grade steel, thereby substantially increasing the capital expense
25 associated with building such platforms.

Although these efforts have advanced the art of drilling and producing hydrocarbons in the Arctic region, there is still a need for economical mobile offshore structures that allow for year-round drilling and production of hydrocarbons in both deep and shallow water in the Arctic.

5 We have now found that employing a hollow and watertight topside structure on a mobile offshore drilling unit provides sufficient positive buoyancy and hydrostatic stability for the drilling unit during the transit to, the installation on, and/or the removal from a offshore drilling or production site.

10 We have also found that employing a large base in conjunction with a single support shaft base prevents slippage between the base and the sea floor foundation, the bearing capacity of the sea floor from being exceeded, and the toppling moment of the mobile offshore drilling units from being exceeded.

Summary of the Invention

15 Therefore, the present invention is directed to a method for utilizing over open water a drilling platform comprising a base, a hollow, airtight topside structure, and a support shaft extending vertically from the base through the topside structure, the method including the steps of maintaining positive buoyancy of the topside structure, lowering the base to the sea floor; and thereafter raising the topside structure along the support shaft until it reaches the top of the support shaft.

20 In another embodiment, the present invention is directed to an offshore structure for placement on a sea floor in a body of water containing moving ice masses, which impart Environmental Loads to the structure; the offshore structure includes a base which contacts the sea floor, the base having sufficient horizontal cross-sectional area such that a bearing pressure and a horizontal shear force, which
25 result from Environmental Loads and which are transferred to the sea floor foundation

by the foundation base, are less than at least one of a predetermined shear capacity and a predetermined bearing capacity for the sea floor foundation; and a hollow, airtight topside structure located at or above the waterline of the body which is supported by a support shaft extending vertically from the base through the topside structure.

The present invention provides for economical access to remote oil and gas reservoirs that have been traditionally inaccessible by conventional drilling methods by allowing for year-round offshore drilling in both deep and shallow waters in the Arctic region.

The present invention also provides for substantial capital costs savings by reducing the amount of steel required typically associated with conventional offshore drilling facilities designed to operate in the Arctic region.

Brief Description of the Drawing

Figure 1 is a cross-sectional view, showing the mobile offshore drilling unit according to the subject invention during transit.

Figure 2 is a cross-sectional view, showing the mobile offshore drilling unit according to the subject invention during installation.

Figure 3 is a cross-sectional view, showing the mobile offshore drilling unit according to the subject invention during operation.

Figure 4 is a cross-sectional view, showing the mobile offshore drilling unit according to the subject invention after operation.

Description of the Preferred Embodiment(s)

While this invention has many different embodiments, the drawings and detailed description illustrate the specific embodiments of the invention. However, the

present disclosure is for the purposes of illustration and example, and is not intended to limit the invention to the specific embodiments disclosed herein.

Referring now to Figure 1, the present invention is a mobile offshore drilling unit **10** that may be used in a body of water that contains moving ice masses. Mobile
5 offshore drilling unit **10** has a topside structure **12**, a support shaft **14**, and a base **16**.

The topside structure **12** may be of any design suitable for conducting offshore hydrocarbon drilling and/or production operations. The topside structure **12**, however, preferably includes a drilling derrick **18** and a hole (not shown) through the topside structure **12** to allow the topside structure **12** to jack itself up and down a
10 support shaft **14**. It is also preferred that the topside structure **12** is hollow and watertight to provide sufficient positive buoyancy and hydrostatic stability for the mobile offshore drilling unit **10** during transit to, installation on, and/or removal from an offshore drilling or production site. The size of the topside structure **12** may vary, depending upon such factors that may include the floating performance of the mobile
15 offshore drilling unit **10** during transit and the working space required for drilling and other related operations. Those skilled in the art will understand and be able to determine the optimal size of the topside structure **12** required for specific drilling operations.

The support shaft **14** suitable for the subject invention may be any support
20 shaft suitable for application on conventional jack-up units. Preferably, however, the support shaft **14** is cylindrical and has a hollow inner diameter (hereinafter referred to as "the moon pool") to allow for drilling and production operations to occur within the support shaft **14**. It is preferred that at least one guiding tube (not shown) is mounted along the inner wall of the support shaft **14** close to the bottom of the base **16**, more

preferably at least two guiding tubes, even more preferably at least three guiding tubes, and most preferably at least four guiding tubes for best results. The size of the support shaft **14** may vary, depending upon such factors that may include water depth, ice load, wave load, seismic load, geotechnical conditions and the moon pool
5 size required for drilling operations. Those skilled in the art will understand the optimal size of the support shaft **14** required for specific drilling operations.

The base **16** suitable for the subject invention is designed to be placed on and in contact with the sea floor. In a preferred embodiment, the base **16** is large enough to prevent slippage between the base and the sea floor foundation, to prevent bearing
10 capacity of the sea floor from being exceeded, and to prevent a toppling moment of the mobile offshore drilling unit **10** from occurring due to the Environment Load that may act on the mobile offshore drilling unit **10**. In a preferred embodiment, the base **16** has sufficient horizontal cross-sectional area such that the bearing pressure and a horizontal shear force, which result from the Environmental Loads and which are
15 transferred to the sea floor foundation by the base **16**, are less than at least one of a predetermined shear capacity exerted by surface ice sheets and a predetermined bearing capacity for the sea floor. The size of the base **16** may vary, depending upon such factors that may include water depth, ice load, wave load, seismic load, and geotechnical conditions resident at the drilling and production site. Those skilled in
20 the art will understand the optimal size of the support base **16** required for specific drilling operations. In a preferred embodiment, a channel (not shown) is built in the bottom of the base **16**. This channel connects the bottom of the support shaft **14** to the sea floor so that the base **16** can straddle across subsea pipelines and umbilicals installed on the well.

During transit of the mobile offshore drilling unit **10** over open water, the base **16** is raised to the bottom of the topside structure **12** so that the mobile offshore drilling unit **10** creates minimum draft during transit. Preferably, the base **16** is deballasted to decrease draft during transit of mobile offshore drilling unit **10**. The
5 topside structure **12** provides the hydrostatic stability during transit, thereby reducing the need for significant ballasting in the base **16** to maintain stability of the mobile offshore drilling unit **10** during transit. It is also preferred that the base **16** is maintained below the surface of the water during transit to reduce the Environmental Load across the larger cross-section of the base **16**. The mobile offshore drilling
10 unit **10** can be moved by its own propulsion or towed by an external craft, such as a conventional towboat during open water season or an ice breaker during the winter season.

Referring now to Figure 2, during installation, once the mobile offshore drilling unit **10** is towed to the targeted location, the base **16** is ballasted down until it reaches
15 the sea floor. The topside structure **12** is then jacked up along the support shaft **14** until it reaches the top of the support shaft **14**. Once the top of the support shaft **14** becomes level with the bottom of the derrick **18**, the topside structure **12** is preferably locked into place. In a preferred embodiment, after the mobile offshore drilling unit **10** is installed and before drilling commences, at least one pile (not shown) will be driven
20 through a guiding tube into the sea floor to help prevent skidding of the base **16** across the sea floor and to guide offshore drilling structures for future operations, such as subsea well intervention.

Referring now to Figure 3, upon completion of the installation, the derrick **18** is preferably skidded over the moon pool (inside the shaft) to start drilling operations. In

a preferred embodiment, drilling operations and well completions are conducted within the inner diameter of the support shaft **14**.

Referring now to Figure 4, after drilling operations are completed and the open water season has arrived, the installation procedure is reversed and the base **16** is raised again for transit to the next location. When the base **16** is raised for transit, the piles driven through the guide tubes into the sea floor during the installation of the mobile offshore drilling unit **10** restricts the lateral movement of the base **16** until sufficient clearance between the base **16** and sea floor is reached. This aids in the prevention of damage to equipment utilized during the drilling and completion of subsea wells. When the mobile offshore drilling unit is installed over existing subsea wells for intervention, the piles will accurately guide the setdown of the mobile offshore drilling unit **10** onto the subsea well.

The present invention provides for economical access to remote oil and gas reservoirs that have been traditionally inaccessible by conventional drilling methods by allowing for year-round offshore drilling in both deep and shallow waters in the Arctic region. This is primarily due to the use of a hollows and watertight topside structure as a stability device during transit and installation of the mobile offshore drilling unit. Consequently, there is no need for significant ballast in the base or a large shaft, thereby making the present invention more accessible to oil and gas reservoirs in shallower waters. Additionally, the use of a large base helps prevent slippage between the base and the sea floor foundation, to prevent bearing capacity of the sea floor from being exceeded, and to prevent a toppling moment of the mobile offshore drilling unit. The use of a large base in combination with only a single support shaft exposed to Environmental Loads allows for the mobile offshore drilling

unit to operate on a year-round basis in the Arctic region, thereby making once inaccessible oil and gas reservoirs, accessible for exploration and production.

The present invention also provides for substantial capital costs savings by reducing the amount of steel required typically associated with conventional offshore drilling facilities designed to operate in the Arctic region. The present invention uses the topside structure as a stability device during transit and installation of the mobile offshore drilling unit. Consequently, there is no need for significant ballast in the base or a large shaft. Additionally, after installation of the mobile offshore drilling unit, the topside structure jacks itself up to the top of the support shaft so that only the support shaft is exposed to Environmental Loads. As a result, the Environment Load impinging on the structure is substantially smaller, reducing the size requirement of the structure, and thereby resulting in a less expensive structure.

That which is claimed is:

1. A method for utilizing over open water a drilling platform comprising a base, a hollow, watertight topside structure, and a support shaft extending vertically from the base through the topside structure, the method comprising the steps of:
- 5 (a) maintaining a positive buoyancy of the topside structure;
- (b) lowering the base to the sea floor; and thereafter
- (b) raising the topside structure along the support shaft until it reaches the top of the support shaft.
- 10 2 The method of claim 1, wherein the topside structure is maintained at about the surface of the water during lowering step (b).
3. The method of claim 2, further comprising the step of ballasting the base during lowering step (b).
- 15 4. The method of claim 3, wherein the support shaft comprises a guiding tube.
5. The method of claim 4, wherein a pile is installed through one or more
- 20 guiding tube into the sea floor.
6. A method for transiting over body of water a drilling platform having a hollow topside structure, a cylindrical support shaft and a base, the method comprising the steps of:
- 25 (a) lowering the topside structure to the surface of the body of water;

(b) maintaining positive buoyancy of the topside structure over the body of water; and

(c) raising the base along a longitudinal axis of the support shaft wherein the base is maintained below the surface of the open water.

5

7. The method of claim 8, further comprising the step of deballasting the base.

8. The method of claim 7, wherein the topside structure is watertight.

10

9. An offshore structure for placement on a sea floor in a body of water containing moving ice masses, which impart Environmental Loads to the structure, comprising:

(a) a base which contacts the sea floor, the base having sufficient
15 horizontal cross-sectional area such that a bearing pressure and a horizontal shear force, which result from Environmental Loads and which are transferred to the sea floor foundation by the foundation base, are less than at least one of a predetermined shear capacity and a predetermined bearing capacity for the sea floor foundation; and

(b) a hollow, watertight topside structure that is supported by a support
20 shaft extending vertically from the base through the topside structure.

10. The offshore structure of claim 9, wherein the topside structure is designed to maintain a positive buoyancy of the offshore structure in the body water.

11. The offshore structure of claim 10, wherein the topside structure is moveable along a longitudinal axis of the support shaft.

12. The offshore structure of claim 11, wherein a guiding tube is mounted
5 along a surface of an inner diameter of the support shaft.

Fig. 1

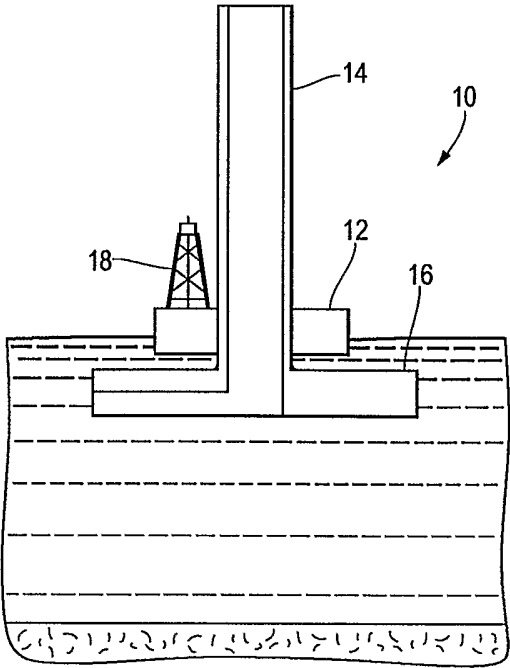


Fig. 2

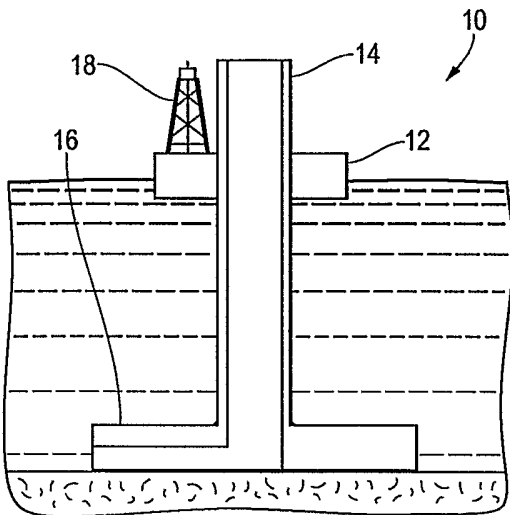


Fig. 3

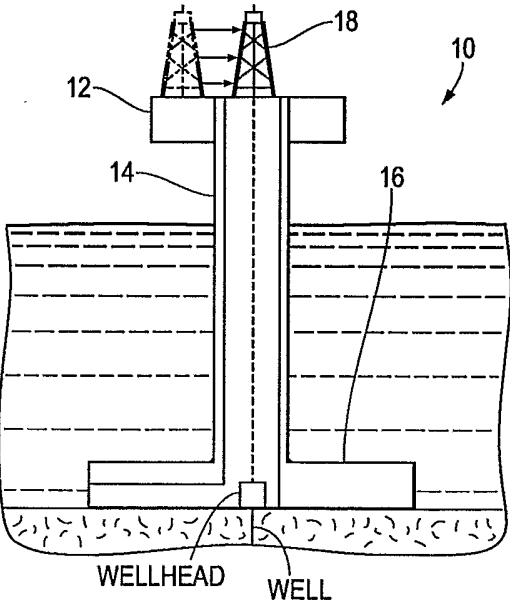


Fig. 4

