

[54] MEANS FOR ALTERING MOTION RESPONSE OF OFFSHORE DRILLING UNITS

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[51] Int. Cl.<sup>2</sup> ..... E02B 17/00; E02D 5/72

[58] Field of Search ..... 61/46.5, 53, 46; 114/5 D; 175/9; 37/73

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[57] ABSTRACT

An offshore drilling unit of the self-elevating type having a floatable hull and a plurality of legs movable from a raised position to a lowered position. Apparatus is attached to the legs for altering the response of the unit to movement of the body of water in which the unit is deployed. Apparatus for altering such response may comprise plating on the sides of the lower portions of the legs, longitudinal fins attached to the lower leg portions, flexible bags carried in the lower portions of the legs or any combination of such apparatus. The unit may also comprise a mass carried within the legs and mounted for longitudinal movement with respect thereto for altering the response of the drilling unit to water body movements. The movable mass may be used in conjunction with any of the other apparatus.

2 Claims, 9 Drawing Figures

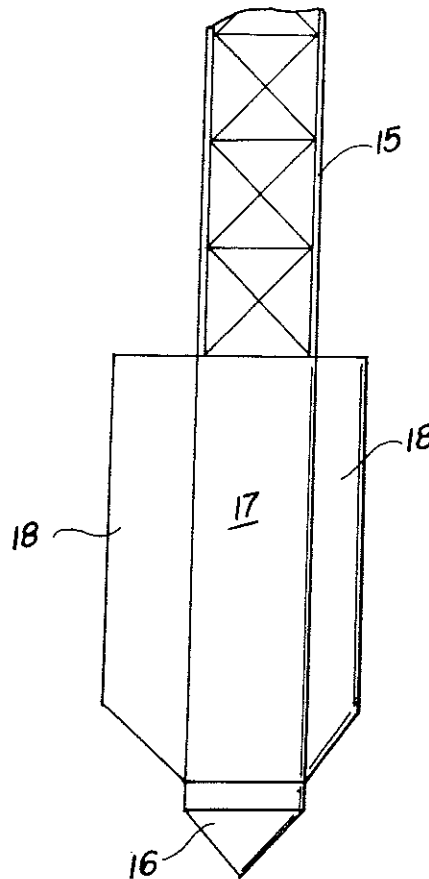


FIG. 1

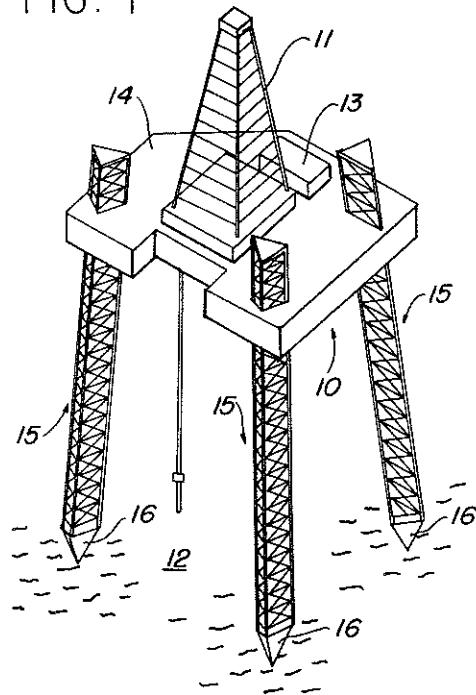


FIG. 2

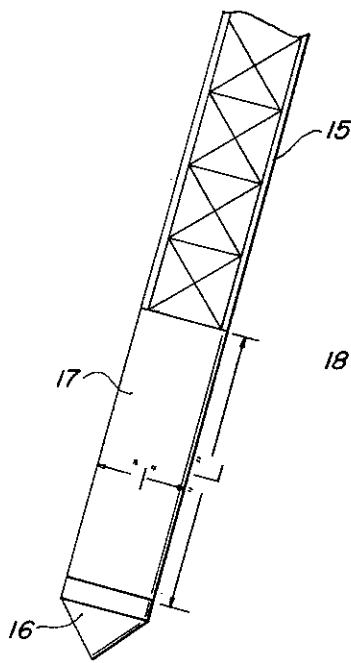
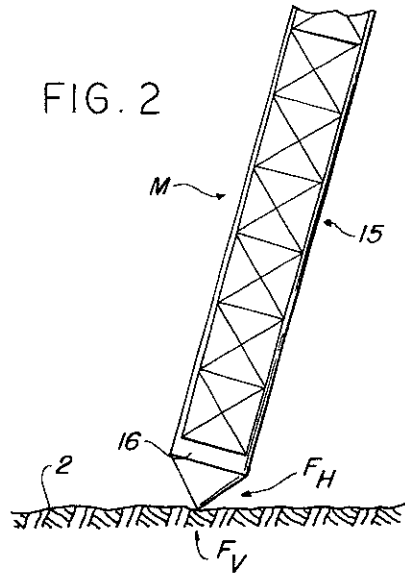


FIG. 3

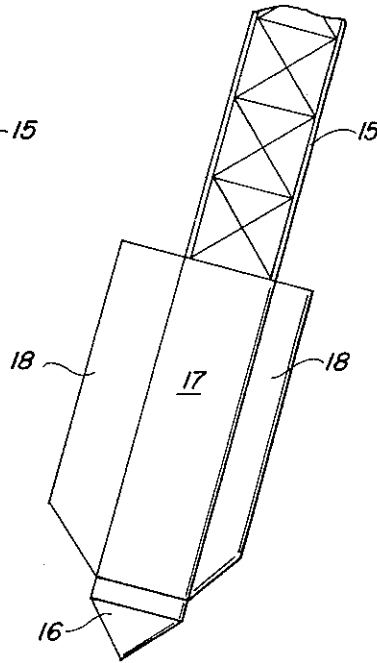


FIG. 4

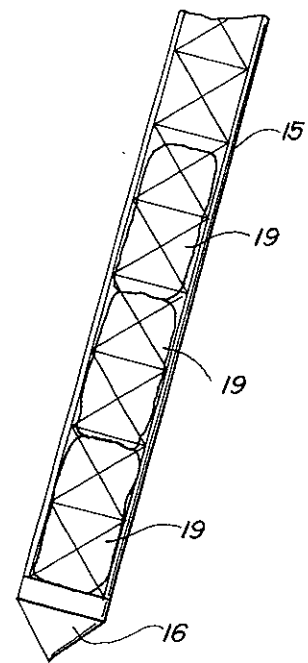


FIG. 5

FIG. 6

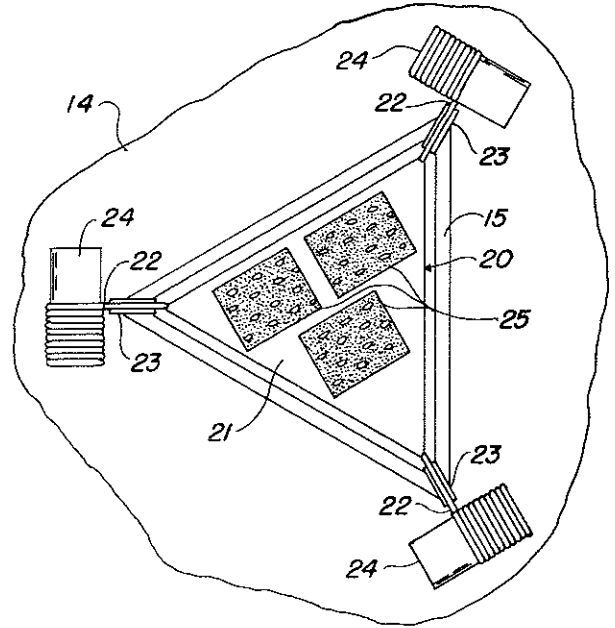
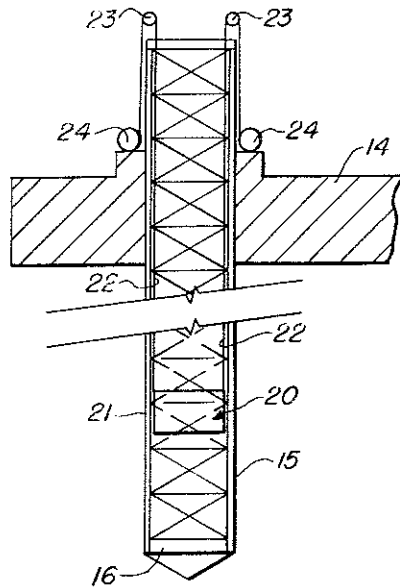


FIG. 7

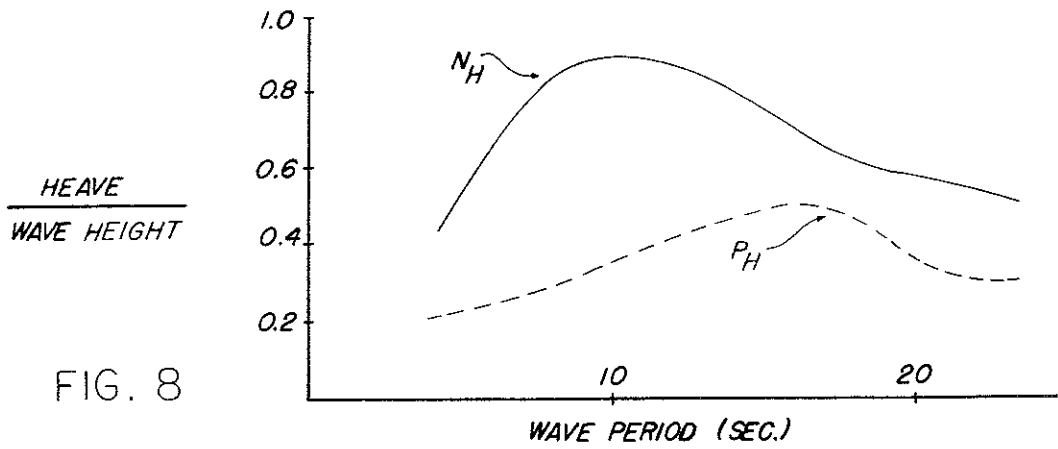


FIG. 8

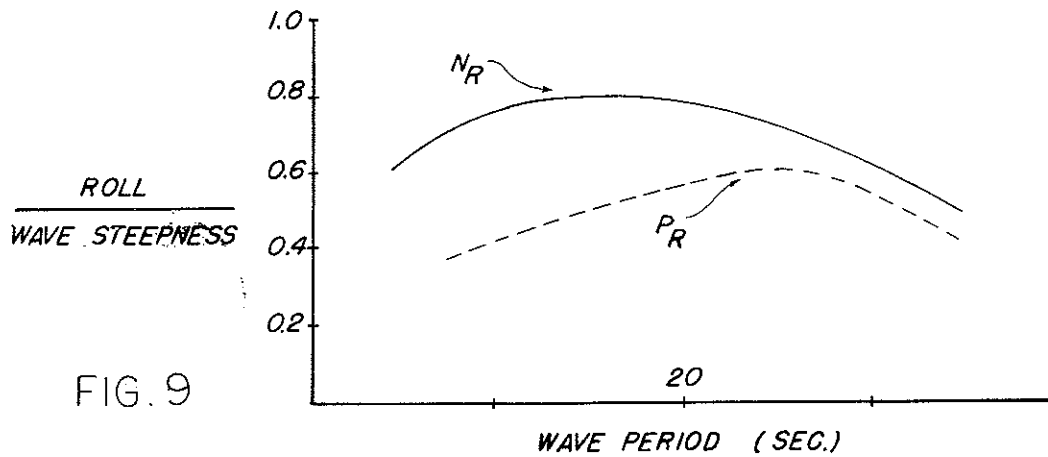


FIG. 9

## MEANS FOR ALTERING MOTION RESPONSE OF OFFSHORE DRILLING UNITS

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention pertains to offshore drilling units. In particular, it relates to units of the self-elevating platform type having a floatable hull and a plurality of legs movable from a raised position, in which the legs are supported by the hull, to a lower position in which the hull is supported by the legs on the floor of a body of water. More specifically, the present invention pertains to apparatus for altering the response of such drilling units to water movements as the unit legs are being moved from the raised position to the lowered position for engagement with the water body floor.

#### 2. Description of the Prior Art

With increasing scarcity of petroleum deposits which are accessible by drilling on land, there has been a corresponding increase in the search for petroleum deposits at offshore locations. In the shallower water depths up to 300 feet, drilling operations are usually conducted from submersible, semi-submersible, or self-elevating platform drilling units. Until very recently, drilling operations in water depths exceeding 300 feet have been performed exclusively from semi-submersible or other types of floating drilling units. However, in the past few years a few jack-up drilling units have been built which are capable of use in water depths of up to 350 feet.

But offshore drilling for oil and gas deposits is proceeding in deeper and deeper water. Furthermore, the trend has also been towards exploration drilling in more hostile environments. Currently, semi-submersible and floating type drilling units are being used on the outer reaches of the Continental Shelf (300-600 feet).

Thus far, design technology has limited the jack-up or self-elevating platform type units to water depths of 300 feet and less. It can be demonstrated that a jack-up drilling unit, if design technology so permits, would be more practical for drilling in depths of 300-500 feet than semi-submersible and floating type units. This is due primarily to the decrease in construction costs and increase in operating efficiencies.

One of the problems encountered in the design of a jack-up drilling unit for water depths of 300-500 feet is the difficulty of getting on and off location. This problem is compounded by the severe wind and wave conditions which may occur in such locations. Size and cost for current types of jack-up rig designs increase almost exponentially with operating water depths.

The difficulty of getting a jack-up drilling unit on and off location increases with increasing water depths and the consequent increase in leg lengths. Motion of the hull causes the spud tanks or feet of the legs to move at velocities proportional to the leg length. Thus, the impact on the legs, as they first hit bottom, increases dramatically with longer legs. This problem is further compounded by the rough sea conditions which prevail in areas where such a large unit may be used. When such a jack-up drilling unit lowers its legs in rough water, the sea conditions may cause the spud feet, attached to the lower end of the legs, to strike the ocean floor with considerable force. Such impact can damage the leg structure and the hull or platform structure it-

self, if excessive. Various types of spud tank or foot designs have been developed for reducing the impact of the unit legs as they first hit bottom in deep water. An especially effective spud tank designed for this purpose may be seen in U.S. Pat. application Ser. No. 286,162.

A floating body may be subjected to three translational motions and three rotational motions. The translational movements are heave (up and down), longitudinal surge (backward and forward motion in a longitudinal direction) and transverse surge (backward and forward motion in a transverse direction). The three rotational movements are pitch (rotation about the transverse axis), roll (rotation about the longitudinal axis), and yaw (rotation about the vertical axis). The combination of these six motions affect the impact on the unit legs as they first hit bottom. Of these motions, heave and roll are usually the most critical with respect to damage to the legs when the legs first hit bottom.

To reduce the effect of heave and roll, various drag and inertia control measures may be taken. Floating drilling platforms of the prior art have been provided with motion damping apparatus. For example, U.S. Pat. No. 3,224,401-Kobus discloses a floating drilling platform which is provided with stabilizing columns having damping ports and damping keels for controlling drag and producing motion damping to prevent resonant amplification and large amplitude motions. However, the prior art does not appear to disclose offshore drilling units of the self-elevating type, the legs of which are specifically provided with means for altering the response of the unit to water.

### SUMMARY OF THE INVENTION

The present invention concerns a new and improved design for an offshore drilling unit of the self-elevating type having a floatable hull and a plurality of legs. The legs are movable from a raised position, in which the legs are supported by the hull, to a lowered position in which the hull is supported by the legs. Means are provided for lowering the legs from the raised position to the lowered position for engagement with the floor of the body of water in which the unit is deployed.

Means are also attached to the legs for altering the response of the drilling unit to movement of a body of water in which it is deployed. The means for altering the motion response of the unit may comprise plating on the sides of the lower portions of the legs, longitudinal fins attached to the lower leg portions, filled flexible bags carried in the lower portion of the legs or any combination of these. Such apparatus alters the motion response of the unit by changing the inertia and drag characteristics of the unit. Motion is damped by increased drag and the natural frequency of the unit may be altered by increasing or decreasing inertia. The primary aim in controlling inertia is to change the natural motion frequency of the unit so that it will not fall in the normal range of wave periods for the body of water in which the unit is deployed, such wave periods being typically in the five to ten second range.

Other means for controlling the inertia of such a unit is disclosed, comprising a movable mass carried within the legs and mounted for longitudinal movement with respect thereto. The mass may comprise a container adapted to receive a variable number of weights so as to vary the mass as required. The container may be connected by cables to power winches, or the like, for

vide tanks which may be filled with water or other liquids. The increased drag provides dampening of motion through the water and the liquid contained in the plated-in tanks 17 increases inertia, altering the natural frequency of the drilling unit.

As shown in FIG. 4, the lower portion of leg 15 may also be provided with longitudinal fin members 18 for further increasing the drag of the leg through the water. Although fins 18 are shown in combination with a plated-in portion 17, they are not so limited. Fins 18 may be used without plating the lower portion of the leg.

FIG. 5 shows another method by which drag and inertia may be increased. In this embodiment one or more bags, preferably made from a flexible material such as rubber, are inserted in the legs 15 and filled with water or other materials. The surface area of the bags 19 increases the drag and the increased mass provided by liquid in the bags increases the inertia. As previously mentioned, drag provides a dampening effect and increased inertia alters the natural frequency of the unit.

Referring now to FIGS. 6 and 7, other apparatus is shown which may be used primarily for altering inertia characteristics of a drilling unit. In this embodiment a movable mass 20 may be installed within the leg 15 for placement at any selected longitudinal position therein. The mass 20 may comprise a container 21 to which is attached a plurality of cables 22. These cables 22 may pass over sheaves or pulleys 23, at the top of the legs, onto corresponding winches 24 mounted on the hull 14. The winches provide the power necessary for lowering or raising the mass 20 to a specified location. An alternate arrangement involves use of a rack and pinion system to move the mass container up and down the interior of the leg. Any number of weights, such as concrete blocks or tanks filled with water 25 may be placed in the container 21 to vary the mass. The weights 25 may be removed, if desired, when the legs are jacked up for moving off location.

The last described system has an added advantage in that the motion response of the drilling unit can be changed for various positions of the leg 15 between fully raised and fully lowered positions. Thus, if the unit becomes synchronous with the waves at some intermediate position, or even close to such a condition, the motion response can be tuned to avoid synchronization by varying the position of the mass 20 suspended within leg 15.

Referring now to FIGS. 8 and 9, the effect of the apparatus of the present invention can be illustrated. In FIG. 8, heave divided by wave height (Y axis) is plotted against wave period in seconds (X axis). In FIG. 9, roll divided by wave steepness (Y axis) is plotted against wave period in seconds (X axis).

As illustrated by the solid line curves  $N_H$  and  $N_R$ , the normal frequency of a drilling unit may be such that maximum heave and roll occur at approximately ten second wave periods. As stated earlier, the wave period for seas in which the unit is to be deployed is typically in the five to ten second range. With the frequency of the drilling unit so close to this value, synchronization

or near synchronization of the motion response of the unit and the wave period is likely. This would result in relatively resonant amplification, large amplitude movements and high velocity movement of the legs with increased likelihood of damage thereto upon impact with the floor of the body of water. By using one or more of the apparatus or systems of the present invention, the natural frequency of the unit can be altered so that maximum heave and roll are at the preferable values indicated by dotted curves  $P_H$  and  $P_R$ . These values can be further reduced by increasing the drag of the legs, by utilizing the drag altering apparatus heretofore described.

It can thus be seen from the foregoing specification, that apparatus may be attached to the legs of a self-elevating type drilling unit for altering the response of the unit to movement of the body of water in which the unit is deployed. Such apparatus alters such response by controlling the inertia and drag characteristics of the unit. The apparatus is simple to manufacture, install and deploy. The effect may be dramatic, greatly increasing the depths in which and the conditions under which such a unit may be used.

Although several embodiments of the invention have been separately described herein, it should be understood that two or more apparatus may be used in combination to produce the desired effects. In fact, many variations of the invention may be made by those skilled in the art without departing from the spirit of the invention and it is intended that the scope of the invention be limited only by the claims which follow.

We claim:

1. An offshore drilling unit of the self-elevating type having a floatable hull; a plurality of legs movable from a raised position, in which the legs are supported by said hull, to a lowered position, in which said hull is supported by said legs; and means for lowering said legs from said raised position to said lowered position for engagement with the floor of a body of water in which the unit is deployed; said legs comprising: a plurality of longitudinal chord members interconnected by bracing members and connected at the lower end thereof to a spud tank for said engagement with said floor of said body of water, and motion response means attached to said legs above said spud tank for altering the response of said unit to movement of said body of water, said motion response means comprising plating on the sides of the lower portions of said legs forming at least one enclosed compartment in which selected volumes of liquid may be introduced and removed to alter the natural frequency of said drilling unit, the longitudinal dimension of the portion of said legs provided with said plating lying in the range of 3 to 15 times the lateral dimension of said legs.

2. An offshore drilling unit as set forth in claim 1 in which said means for altering said response of said unit comprises fin means longitudinally attached to said lower leg portions and projecting outwardly therefrom to increase the drag thereon.

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