STABILIZING SYSTEM FOR FLOATING PLATFORM

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HIS AGENT
This invention relates to apparatus for use on the surface of a body of water while carrying out various operations such as exploration, drilling, well boring and completion operations, and well workover and maintenance operations. The invention pertains more particularly to apparatus for stabilizing a floating vessel or platform positioned in a substantially stationary manner at an offshore location for carrying out any of many operations therefrom.

In an attempt to locate new oil fields, an increasing amount of well drilling has been conducted at offshore locations, such for example as off the coasts of Louisiana, Texas and California. Well-drilling operations are being carried out further and further from shore in increasingly deeper water. At present, however, substantially all offshore well drilling is being conducted from a platform having legs affixed to the ocean floor, as by piling, or from mobile drilling platforms or barges having legs which may be extended downwardly through the water and in contact with the ocean floor in order to fiixedly support the barge thereon. To date, using either of the two-above-described platforms, well-drilling operations have been limited to water depth of about 125 feet. The only known deep-water drilling that has been conducted to date has taken place from a converted boat in which a drilling well has been provided. Since boats and floating platforms are prone to roll fairly easily, deep-water drilling operations carried out from vessels of this type can only take place when wind and wave forces are fairly small. When drilling a well from a floating vessel, the vessel motions due to wave action introduced stresses in the drill pipe, tubing and casing strings used that often exceed the safe design stresses under certain weather conditions, thus causing drilling operations to be shut down.

It is therefore an object of the present invention to provide a system for stabilizing floating vessels such as those used in the exploration, drilling and completion of wells, whereby the motions of the vessel due to wave action may be dampened. The motions of a floating vessel or platform due to wave actions can be divided into those in a horizontal plane (surge, sway and yaw) and those in a vertical plane (heave, roll and pitch). Roll and pitch are two different expressions connected with the geometry of the floating vessel, but are essentially the same type of motion. The general term "vertical angular motion" is used herein to describe these two motions and all combinations thereof.

Another object of the present invention is to provide a closed passive stabilizing system designed to reduce the vertical angular motions (i.e., both the roll and pitch) due to wave action on a floating vessel.

Another object of the present invention is to provide a stabilizing system for a floating platform wherein the stabilizing system has a geometrical symmetry and is positioned on the vessel in a manner such that it is independent of the orientation of the plane of motion relative to the platform geometry, thus having an equal stabilizing effect for roll and pitch of the vessel.

A further object of the present invention is to provide a floating drilling or production platform of the semi-submersible type (one relying on freeboard for stability, but having much of its mass underwater) and provided with a stabilizing system from which drilling operations may be carried out economically and safely in deep waters.

Another object of the present invention is to provide a floating platform with a stabilizing system so that the platform can remain upright in hurricanes weather without assistance of any mooring line forces.

Still another object of the present invention is to provide a stabilizing system for a floating platform designed to have a natural period of roll larger than that of the average period of waves to be encountered.

A further object of the present invention is to provide a floating drilling platform with a stabilizing system which substantially minimizes the roll and pitch of the platform thereby precluding subjecting drill pipe or casing to stresses as it hangs from the platform.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a view showing the outboard profile of the floating platform of the present invention in one form;

FIGURE 2 is a plan view of the floating platform of FIGURE 1;

FIGURE 3 is a diagrammatic isometric view of the hull portion of one form of the platform of the present invention;

FIGURE 4 is a diagrammatic plan view of another arrangement of the interconnecting conduit means of the stabilizing system of the present platform; and

FIGURE 5 is an outboard diagrammatic profile of the platform of FIGURE 4.
shown in FIGURE 4, or any one which is preferably geometrically symmetrical. In addition, instead of the columns 11, 12 and 13 being interconnected by horizontal hull members 14, 15 and 16, the vertically extending stabilizing or support columns 11, 12 and 13 may be edly secured to a circular hull 35 shown in FIGURES 4 and 5, which may be divided by suitable bulkheads into any desired number of tanks either for purposes of buoyancy, or for storing materials such as water and fuel oil utilizing drilling operations.

The three corner support or stabilizing columns 11, 12 and 13 are preferably in the form of cylindrical tanks, as illustrated, which may be selectively flooded in order to lower the entire drilling platform in the water, thus stabilizing it by lowering its center of gravity. The stabilizing columns 11, 12 and 13 may be of the same diameter throughout their height, as illustrated in FIGURE 5 and may, for example, be 40 feet in diameter. However, the upper ends 41, 42 and 43 of the stabilizing columns 11, 12 and 13 are preferably reduced in diameter a substantial amount, say 24 feet, a short distance above the water line when the floating platform is in its semi-submerged position, as illustrated in FIGURE 1. The diameter of the lower part of the stabilizing columns 11, 12 and 13 is large in order to reduce the amount of internal water which takes place when large loads are imposed on the floating platform through the full lines and derrick. The upper ends 41, 42 and 43 of the stabilizing columns 11, 12 and 13 are reduced in size to decrease the wave force of the larger waves with heights in excess of a predetermined amount, say 10 feet.

The reduction in diameter of the upper ends 41, 42 and 43 of the support columns 11, 12 and 13 also provides the floating platform with a discontinuous natural period of roll. When the floating platform rolls more than a predetermined amount, say 10 feet, which occurs only in extremely high waves, the corner stabilizing column diameter suddenly changes from 40 feet to 24 feet as the natural period of roll increases from about 17 to 32 seconds. Therefore, if the floating platform were subjected to hurricane waves of a period of 17 seconds so that a resonance build-up occurs, the sudden increase in the natural period of roll from 17 to 32 seconds for roll angles about 5° would destroy any further resonant effects. Since the natural period of roll of the floating platform is a function of the water plane area of the stabilizing columns, a radical change in the natural period of roll of the platform takes place when a wave comes along to dip one supporting column below the surface of the water into the range of reduced diameter on the column. Since the period of the vessel and that of the waves are then different, resonance is destroyed and the amount of roll of the vessel immediately decreases.

The stabilizing columns 11, 12 and 13 serve as the primary ballast tanks with the tanks being filled substantially to the water level 44 when the vessel is positioned as shown in FIGURE 1. Each stabilizing column is provided with a series of circular steel fenders 45 to protect these members from damage by boats. Since the water level inside the stabilizing columns is nearly the same as that outside, a leak caused by a boat rupturing the wall of the column would result in the buoyancy tanks 14, 15 and 16 being deep enough to support the weight of the platform there is little likelihood of their being damaged. Damage to the stabilizing columns would not affect the intact buoyancy tanks so that the platform would neither sink 12 and 13. The smaller diameter 42 and 43 of the stabilizing columns 11, 12 and 13 are separated from columns 11, 12 and 13 by watertight bulkheads (not shown) which would prohibit further flooding of the stabilizing columns which might be damaged. Any suitable type of piping or support system was employed for supplying water to and exhausting the stabilizing columns 11, 12 and 13 and/or any of the floodable buoyancy tanks.

The stabilizing system of the present invention comprises a series of three vertical tanks 46, 47 and 48 which are interconnected at the lower ends thereof by means of horizontal liquid flow conduits 49, 50 and 51 by which the tanks 46, 47 and 48 are arranged in a closed triangular configuration, preferably that of an equilateral triangle. The liquid conduits 49, 50 and 51 are normally open at all times to permit liquid in the lower portions of the tanks to be readily transferred back and forth between tanks. In this case, conduits 49a, 50a and 51a may be in the form shown in FIGURE 4.

The stabilizing system of the present invention is mounted on any suitable type of floating platform, two examples of which are illustrated in FIGURES 3 and 5. The basic hull plan of the floating platform illustrated in FIGURE 3 has the shape of an equilateral triangle and the approximate location of the center of gravity is on the vertical through the centroid of the triangle. For this floating platform the center of roll and pitch is approximately at the center of gravity, which "pitch" in this case being defined as the motion along an axis through the center of gravity parallel with one of the sides of the triangle, and "roll" as the motion around an axis through the center of gravity perpendicular to this side of the triangle. The vertical tanks 46, 47 and 48 are preferably located at an equidistance from a vertical line passing through the centroid of the floating platform, thus forming a three dimensional system designed to counteract effectively all angular vertical motions of the platform. The tanks 46, 47 and 48 are preferably provided with interconnecting air flow lines 52, 53 and 54 which are in communication with the interior of the tanks near the upper ends thereof, thus allowing air to be forced back and forth between the three tanks through the air lines 52, 53 and 54 as a liquid is transferred back and forth between the tanks through the liquid flow lines 49, 50 and 51.

In order to minimize construction costs on a platform similar to that illustrated in FIGURES 1 to 3, the tanks 46, 47 and 48 are installed within the supported tanks 11, 12 and 13, although they may be positioned outside the tank. While the horizontal liquid flow lines 49, 50 and 51 are illustrated as being positioned in the horizontal hull members 14, 15 and 16, they may, in many circumstances, be positioned on the outside, preferably the top, of the hull members 14, 15 and 16 or at any distance thereabove or below. The exact position of the horizontal liquid flow lines 49, 50 and 51 with respect to the center of roll of the platform depends upon the stabilizing system being designed, and increasing stabilizing effect being realized when the horizontal liquid flow lines 49, 50 and 51 are located higher in relation to the center of roll of the platform.

The rolling or pitching motion of an object on the surface of the ocean is greatest when resonance exists between object motion and wave action, i.e., when the wave frequency is equal to the natural frequency of roll or pitch of the object. In case of resonance the motion of the object will be 90° behind the wave action. The present stabilizing system provides a means of reducing roll or pitch of a floating platform. The principle of the system is to reduce resonance. Since the design of any stabilizing system of the present invention depends on the construction of characteristics of the floating platform and the normal conditions under which it is to be used. The stabilizing system of the present invention is designed such that a mass of stabilizing liquid in the tanks 46, 47 and 48 moves in resonance with the motion of the platform. When the mass of stabilizing liquid moves in resonance with the platform motion, and the platform motion is in resonance with the wave action, the stabilizing fluid motion is 90° behind the platform motion and 90° behind the wave action, that is opposite to the wave action. Since wave action is the driving force causing the original roll or pitch of the
platform, an opposing action by a mass of stabilizing liquid moving between tanks 46, 47 and 48 tends to reduce or dampen any angular vertical motion of the platform. A stabilizing liquid in proper amounts, however, could be employed in an opposing action by a mass of stabilizing liquid moving between tanks 46, 47 and 48 tends to re-...

By use of the stabilizing system of the present invention, a reduction of 60% in the vertical motion of the floatation platform of this type may be realized when platforms of this type exhibit a large amplitude of roll or pitch. Although sea water is generally used in the stabilizing system, the use of higher density liquids in the tanks results in larger stabilizing effects on the platform. Thus, in some cases it is probably advisable to employ a weighted stabilizing fluid so that other dimensions of the system could be altered. The amount of stabilizing fluid in the vertical tanks 46, 47 and 48 is preferably adjusted so that there is at least some liquid at all times in the bottom of each of the tanks.

I claim as my invention:

1. A floating vessel comprising a buoyant hull, three upwardly-extending fluid tanks fixedly secured to the hull of said vessel and arranged in a substantially equilateral triangular configuration about a vertical line through the centroid of said vessel, said tanks being partially filled with a liquid, normally liquid-filled laterally-extending conduit means interconnecting the lower portions of said upwardly-extending fluid tanks to permit continual flow of liquid between said tanks, at least a portion of said laterally-extending conduit means having a cross-section sufficient to delay the flow of water through the conduit means so that the velocity of the fluid lags 90° behind the rotational velocity of the vessel, air intake and discharge means in the upper end of each of said tanks, and second conduit means in communication with said air intake and discharge means for interconnecting the upper portions of said tanks.

2. A floating vessel comprising a buoyant hull, three upwardly-extending fluid tanks fixedly secured to the hull of said vessel and arranged in a substantially equilateral triangular configuration about a vertical line through the centroid of said vessel, said tanks being partially filled with a liquid, normally liquid-filled laterally-extending first conduit means interconnecting the lower portions of said upwardly-extending fluid tanks to permit continual flow of liquid between said tanks, at least a portion of said laterally-extending conduit means having a cross-section sufficient to delay the flow of water through the conduit means so that the velocity of the fluid lags 90° behind the rotational velocity of the vessel, air intake and discharge means in the upper end of each of said tanks, and second conduit means in communication with said air intake and discharge means for interconnecting the upper portions of said tanks.

3. A floating vessel comprising a buoyant hull, three upwardly-extending fluid tanks fixedly secured to the hull of said vessel and arranged in a substantially equilateral triangular configuration about a vertical line through the centroid of said vessel, said tanks being partially filled with a liquid, normally liquid-filled laterally-extending first conduit means interconnecting the lower portions of said upwardly-extending fluid tanks to permit continual flow of liquid between said tanks, at least a portion of said laterally-extending conduit means having a cross-section sufficient to delay the flow of water through the conduit means so that the velocity of the fluid lags 90° behind the rotational velocity of the vessel, air intake and discharge means in the upper end of each of said tanks, and second conduit means in communication with said air intake and discharge means for interconnecting the upper portions of said tanks, and fluid flow control means in said first conduit means.

4. A floating vessel comprising a buoyant hull, three upwardly-extending fluid tanks fixedly secured to the hull of said vessel and arranged in a substantially equilateral triangular configuration about a vertical line through the centroid of said vessel, said tanks being partially filled with a liquid, normally liquid-filled laterally-extending first conduit means interconnecting the lower portions of said upwardly-extending fluid tanks to permit continual flow of liquid between said tanks, at least a portion of said laterally-extending conduit means having a cross-section sufficient to delay the flow of water through the conduit means so that the velocity of the fluid lags 90° behind the rotational velocity of the vessel, air intake and discharge means in the upper end of each of said tanks, and second conduit means in communication with said air intake and discharge means for interconnecting the upper portions of said tanks, and fluid flow control means in said first conduit means.
section sufficient to delay the flow of water through the conduit means so that the velocity of the fluid lags 90° behind the rotational velocity of the vessel, air intake and discharge means in the upper end of each of said tanks, second conduit means in communication with said air intake and discharge means for interconnecting the upper portions of said tanks, first fluid flow control means in said first conduit means and second fluid flow control means in said second conduit means, said first fluid flow control means being normally open at all times whereby fluid in said tanks may move from one tank to another.