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MARINE CONDUCTOR AND PIPE SUPPORT FOR
DRILLING UNDERWATER WELLS
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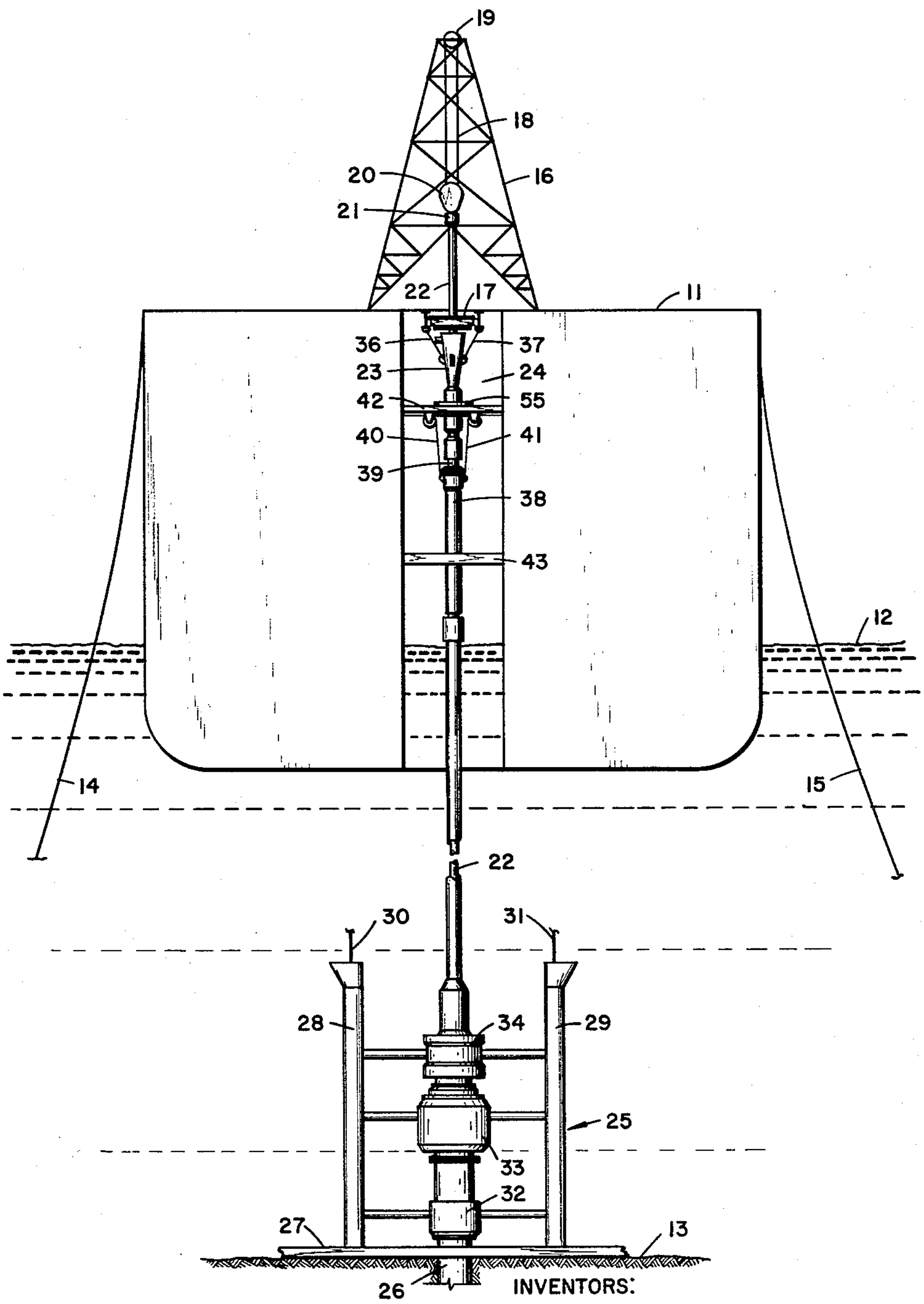

FIG. 1

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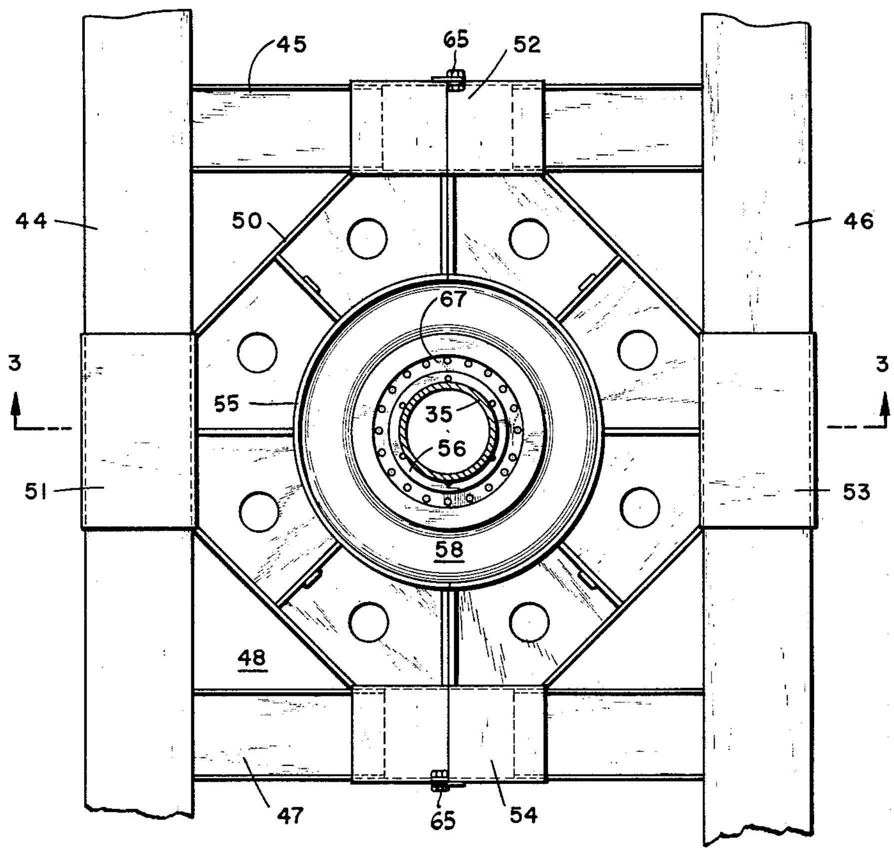

FIG. 2

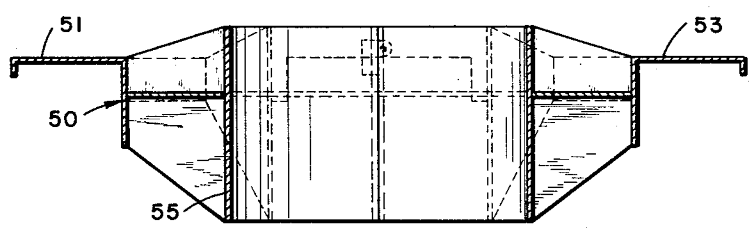

FIG. 3

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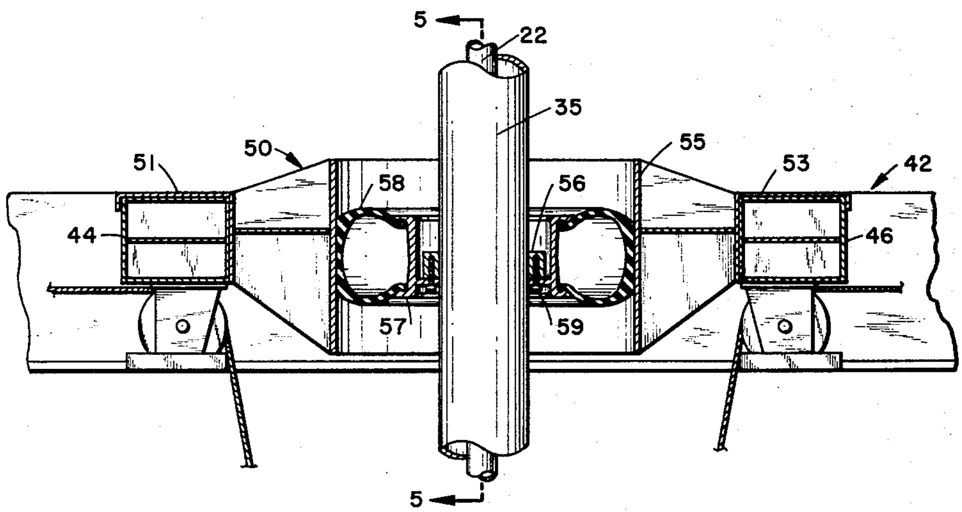

FIG. 4

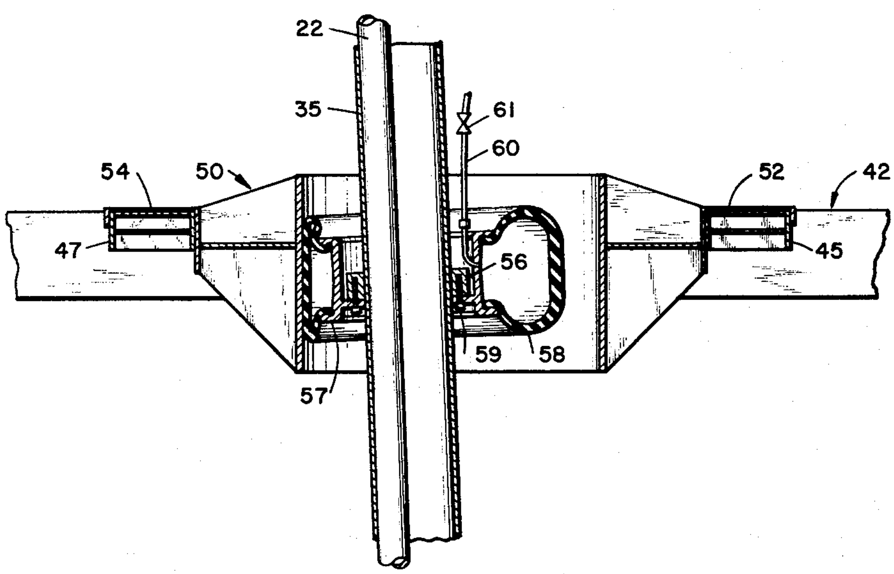

FIG. 5

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MARINE CONDUCTOR AND PIPE SUPPORT FOR DRILLING UNDERWATER WELLS

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5 Claims. (Cl. 175—7)

This invention relates to the drilling of oil and gas wells and pertains more particularly to apparatus for drilling wells at offshore locations where the drilling operations are carried out from a floating base positioned at the surface of the water and the well being drilled is provided with a wellhead assembly positioned below the surface of the water.

Heretofore, most offshore wells have been drilled either from stationary platforms anchored to the ocean floor or from movable barges temporarily positioned on the ocean floor. Regardless of the manner in which the wells are drilled, most wells were completed in a manner such that the outermost tubular member of the well extends upwardly from the ocean floor to above the surface of the water where a wellhead or Christmas tree was mounted thereon for controlling the production of the well. Drilling offshore wells by either of these methods was carried out in much the same manner that wells are drilled on land. Thus, the string of drill pipe that was suspended from the derrick passed through the rotary table in the floor of the derrick and thence downwardly into the wellhead assembly which was positioned just below the operating floor of the derrick or the drill barge, well above the surface of the water. At most, there was only a few feet of drill pipe between the rotary table and the top of the conductor pipe or wellhead assembly on which blowout preventers were usually mounted.

A recent development in the art of drilling wells offshore has been a method for drilling and completing wells from a floating drilling base which was employed to suspend a string of drill pipe therefrom, with the drill pipe extending down through the water to a wellhead or conductor pipe positioned below the surface of the body of water. Generally, the wellhead assembly was positioned on the ocean floor and anchored thereto by cementing a conductor pipe into the ocean floor. With the floating drilling base anchored over the wellhead assembly positioned on the ocean floor, well drilling operations could be carried on in water depths of from 100 to 1500 feet or more. A method of drilling and completing an underwater well on the ocean floor in this manner is described in copending application, Serial No. 830,538, filed July 30, 1959, to Haeber et al.

Since it is practically impossible to anchor a floating drilling unit or barge to the ocean floor so that the barge maintains a fixed position at all times directly over a wellhead assembly positioned on the ocean floor, strings of tubular goods employed in drilling the well from the floating drilling unit are subjected to unusual bending conditions due to the movement of the drilling unit. Movement of a floating drilling unit at the surface of the ocean is caused by wind and wave forces and may take the form of a roll, pitch and/or surge from a position directly over the well being drilled. If the bending forces to which a string of pipe is subjected are too severe, the pipe will be damaged. To prevent damage of a pipe string, for example a string of drill pipe, drilling operations have to be suspended whenever conditions of the sea are such that the drilling unit's movement exceeds the allowable working range or bending limits of the pipe string.

It is therefore an object of this invention to provide apparatus for increasing the working range of a floating

well drilling unit subjected to wave and other forces tending to cause the unit to roll at the surface of a body of water or to move horizontally from a position directly over an underwater well.

A further object of the present invention is to provide apparatus for properly distributing the bending forces induced in a string of drill pipe extending from a floating drilling barge into a wellhead positioned beneath the surface of a body of water when the barge moves from a position directly over the wellhead.

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 diagrammatic view illustrating a floating drilling unit or barge anchored to the ocean floor over a drilling location with a string of drill pipe extending from the barge into a wellhead assembly positioned on the ocean floor;

FIGURE 2 is a plan view of the pipe support apparatus of the present invention when positioned in a support frame on a drilling vessel.

FIGURE 3 is a longitudinal cross-sectional view of the support frame of FIGURE 2 taken along the line 3—3.

FIGURES 4 and 5 are longitudinal views, taken in cross section, of the present pipe support apparatus in its unloaded and loaded positions, respectively.

Referring to FIGURE 1 of the drawing, a drilling barge, vessel or platform **11**, of any suitable floating or floatable type is illustrated as floating at the surface of a body of water **12** and substantially fixedly positioned over a preselected drilling location, as by being anchored to the ocean floor **13** by suitable anchors (not shown) at the ends of anchor lines **14** and **15**. Equipment of this type may be used when carrying out well drilling operations in water varying from about 100 feet to 1500 feet or more in depth. The drilling vessel is equipped with a suitable derrick **16** as well as other auxiliary equipment needed during drilling, such for example as a rotary table **17**, and a hoist system including fall lines **18**, crown block **19**, traveling block **20** and power swivel or elevator **21** adapted to be secured to the upper end of a string of drill pipe **22** extending through the rotary table **17**. The derrick **16** on the drilling vessel **11** is positioned over a drilling slot or well **24** which forms a vertical opening extending vertically through the barge in a conventional manner. When using the equipment of the present invention, the slot **24** of the vessel may be either centrally located or extend in from one edge. Additionally, well drilling operations may be carried out over the side of a barge or vessel without using the slot, if desired. In the event that drilling operations are carried out over the side of a barge, the vertical opening through the barge through which the drill string **22** extends would be in the form of an opening through the platform serving as the base for the derrick **16**.

A wellhead assembly **25** is schematically shown as being positioned on the ocean floor **13** and being fixedly anchored thereto by a conductor pipe or well casing **26** which extends into the ocean floor **13** and is preferably cemented therein. An underwater wellhead assembly of this type is described in copending application, Serial No. 830,538, filed July 30, 1959, to Haeber et al., and may comprise a base plate **27** having a plurality of upwardly-extending guide columns fixedly secured thereto and containing guide lines **30** and **31** extending to the operating deck of the drilling vessel **11** for guiding equipment into place on top of the wellhead assembly **25**. Such equipment may comprise a wellhead connector **32**, blowout preventor **33** and lock and/or seal device **34**. Since these elements do not form a part of the present invention they will not be further described here.

The lock and seal device **34** is secured to the lower end of a marine conductor pipe 35 which may be in the form of a large diameter, say 16 inch, pipe made up in sections to extend from the wellhead assembly 25 to a point beneath the rotary table 17 of the drilling vessel 11. The upper end of the conductor pipe 35 is preferably fixedly secured to the vessel 11 by being hung from cables 36 and 37 in a manner so that it is centered beneath a rotary table 17. The marine conductor 35 is also preferably provided with a telescoping joint consisting of an outer tubular member 38 and an inner tubular member 39 which compensates for rise and fall of the vessel 11 around the marine conductor pipe 35. The lower portion 38 of the telescoping joint which forms the upper end of the marine conductor pipe 35 below the telescoping joint is held upright in any suitable manner, as by cables 40 and 41 which are secured to suitable means for supplying a constant tension to the cables, as for example, constant tension hoist means (not shown).

The drilling vessel 11 may be provided with one or more auxiliary decks 42 and 43 extending across the drilling slot 24 to facilitate the mounting of some of the drilling equipment. Each of the auxiliary decks 42 and 43 has a vertical opening therethrough so that the marine conductor pipe 35 and other related equipment can be readily extended or withdrawn therefrom. As shown in FIGURE 2, the auxiliary deck 42 may include support beams 44, 45 and 46 and 47 which surround a sizeable hole 48 through which drilling equipment may be lowered.

During drilling operations most of the vertical opening 48 is closed by means of a frame 50 provided with laterally-extending plates 51, 52, 53, and 54 which rest on the beams 44, 45, 46 and 47, respectively. As shown in FIGURE 3, the frame 50 has an opening through the center thereof in which is positioned a cylindrical element 55 which is fixedly secured by welding to the frame 50. The frame 50 is preferably of split construction with the two portions being connected together by bolts 65.

In FIGURE 4, the upper end of the marine conductor pipe 35, at the point where it passes through the auxiliary deck 42, is provided with suitable means, such for example as an outwardly-extending flange 56 which may be welded to the marine conductor pipe 35. The flange 56 or any other suitable means may be employed for mounting the rim 57 of an annular resilient horizontal pipe support means 58 concentrically with the marine conductor pipe 35. Suitable connectors such as bolts 59 may be employed to connect the rim 57 to the flange 56. The horizontal pipe support means 58 in its simplest form may take the form of a large, say 5 foot diameter, tire which is resilient and inflatable to various pressures. The tire 58 is provided with a suitable conduit 60 and a valve 61 for putting air in the tire or letting it out. If desired, the conduit 60 may be connected to a source of air pressure with a pressure regulator in the line in order to vary the air pressure to be employed in the tire. The resilient inflatable horizontal pipe support tire 58 is preferably of a diameter equal to the inner diameter of the cylindrical member 55 of the frame 50.

For ease in explanation and descriptive purposes the term pipe string and drill pipe string will be employed, it being understood that the principles discussed hereinbelow apply to any tubular goods that may be used in well operations such as casing, tubing, drill pipe, etc. Also, the principles to be discussed hereinbelow apply to a pipe string being run in or pulled out of a well through a marine conductor pipe, while rotating the pipe string or not rotating the pipe string as the case may be.

In the operation of equipment of FIGURE 1, the drill pipe string 22 is suspended by the hoist system of the derrick 16 and passes down through the rotary table 17 and into the bell nipple 23 at the top of the marine conductor pipe 35. The marine conductor pipe 35 in turn is mounted centrally below the rotary table 17 and extends from a point underneath the rotary table 17 to its connection 34 at the top of the wellhead assembly 25 on the ocean floor 13. While the horizontal pipe support means 58 (FIGURES 4 and 5) is illustrated as being positioned just below the bell nipple 23 of the marine conductor pipe 35 and at a level with the auxiliary deck 42, it is to be understood that the horizontal pipe support member 58 mounted outside the marine conductor pipe 35 may be arranged at any level within the slot 24 of the drilling vessel 11.

The drilling vessel 11 is originally anchored so that a vertical line passes through the rotary table 17, the marine conductor pipe 35 and the wellhead assembly 25 on the ocean floor. As wind and wave forces move the drilling barge 11 horizontally off the center line through the well, the drill pipe string 22 extending through the rotary table and marine conductor pipe 35 first comes in contact with the rotary table 17. A lateral force is developed between the pipe string 22 and the rotary table 17 so that a bending of the pipe string 22 takes place opposite the rotary table, that is, where the two are in contact. At the same time the drill pipe 22 would be centrally located within the marine conductor pipe 35, as illustrated in FIGURE 4 and the marine conductor pipe 35 would in turn be centrally located between the cylindrical element 55 of the frame 50. As the amount of horizontal movement of the drilling vessel 11 increases, the force between the rotary table 17 and the drill pipe 22 increases with a resultant increased bending in the section of pipe string 22 opposite and for some distance above and below the rotary table 17. Generally, the bending is at a maximum at the point of contact between the rotary table 17 and the pipe string 22 and decreases from the point of contact. Continued movement of the drilling vessel 11 in the same direction horizontally causes the pipe string 22 to come in contact with the inner wall of the marine conductor pipe 35, as shown in FIGURE 5. At the same time the marine conductor pipe 35 applies a force to the resilient horizontal pipe support member 58 which is compressed more or less (dependent on its degree of inflation) under its load against the vertical cylindrical member 55 of the support frame 50 which transmits the load to the drilling vessel 11. Thus, an adjustable magnitude of bending is induced in the section of drill pipe opposite the tire 58, relieving some of the bending in the section of pipe opposite the rotary table 17. With continued movement of the vessel 11 in the same direction, the force between the horizontal support tire 58 and the marine conductor pipe 35 causes bending in the drill pipe string 22 at the point opposite the tire 58 to increase, while the force between the rotary table 17 and the drill pipe string 22 and consequently the bending in the drill pipe string 22 at a point opposite the rotary table 17 remains fairly uniform.

If the bending in the pipe string 22 opposite the rotary table 17 was near the maximum stress limit of the pipe at the time the pipe string was opposite the lower point of support opposite the tire 58 and thereafter remains nearly constant, then any additional horizontal movement of the vessel will merely induce an amount of bending in the section of pipe opposite the horizontal support tire 58 without endangering the pipe at the point opposite the rotary table 17. The apparatus of the present invention provides for adjustable additional horizontal support for a drill pipe in order to reduce the bending stresses in the pipe by distributing the bending forces over more length of the pipe. At the same time, the apparatus of the present invention provides means for cushioning the movement of the marine conductor pipe 35 against a fixed structure of the drilling vessel in a manner so as to permit the marine conductor pipe to assume a nonvertical position within the slot of the drilling vessel without damage to the marine conductor pipe. The construction of the tire **58** may be selected so that it may be inflated from say zero to 125 p.s.i. and thus be capable of exerting onto the pipe various reactional forces up to a maximum of 40,000 lbs. at 125 p.s.i. before collapsing to the position shown in FIGURE 5. The maximum bending thus allowed in the pipe is dependent on the magnitude of the tensile stress in the pipe. Therefore, the air pressure in the tire **58** is preferably increased with an increasing hook-load, i.e., the load of equipment hung from the hoist system of the derrick **16**. The supporting tire **58** is preferably no greater than 20 feet below the rotary table **17**.

With conventional floating drilling units, the drill pipe **22** is supported vertically with either slips set in the rotary table or by elevators on the traveling block. In either case, as the drilling vessel **11** surges and/or rolls, a horizontal force develops between the drill pipe **22** and the rotary table **17**. Bending results in the section of pipe opposite the rotary table **17**. The magnitude of the bending stress allowed is a function of the magnitude of the movements of the drilling vessel **11** and the hook or slip load. If the vessel's movements exceed certain limits, the magnitude of the bending will cause damage to the drill pipe **17** and/or the marine conductor pipe **35**. Thus, by providing a horizontal pipe support in addition to the rotary table **17**, the magnitude of the bending stress in the section of pipe opposite the rotary table can be reduced by inducing a second lateral force onto the section of pipe opposite the other horizontal pipe support which is adjustable by degree of inflation of the tire **58**. A power-swivel could be used and connected to the top of the drill string instead of using a rotary table. In such a case a slip bushing or other suitable bearing would be used where the rotary table is normally located.

We claim as our invention:

1. Apparatus for providing horizontal support to a non-vertical section of drill pipe extending from a floating drilling base at the surface of a body of water and through a wellhead assembly positioned below the surface of said body of water, said apparatus comprising
   - a wellhead assembly positioned below a body of water and anchored to the floor of said body of water,
   - a floating drilling base at the surface of the body of water normally positioned over said wellhead assembly, said base having a vertical opening through at least a portion thereof,
   - a drill pipe string depending from said floating drilling base and extending downwardly through said vertical opening in said base and through said water and said wellhead assembly,
   - a marine conductor pipe surrounding said drill pipe string and secured at the lower end to said wellhead assembly and extending upwardly to the drilling base, the upper end of the conductor pipe being arranged for limited movement relative to said drilling base in the vertical opening thereof, and
   - resilient horizontal displacement pipe support means carried by said marine conductor pipe on the outer surface thereof and near the upper end thereof within the vertical opening of said floating drilling base and in engagement at all times during operations with at least a portion of the drilling base forming the vertical opening thereof.

2. The apparatus of claim 1 wherein said resilient horizontal pipe support means includes means for varying the resiliency of said support means.

3. The apparatus of claim 1 wherein said resilient horizontal pipe support means comprises an annular inflatable ring member coaxially mounted on said marine conductor pipe.

4. The apparatus of claim 1 including horizontal frame means removably secured to said floating drilling base over the vertical opening therein, said frame means having a central hole therethrough, a cylindrical element fixedly secured to said frame means on the edge of the hole therethrough, the inner diameter of said cylindrical element being at least equal to that of the resilient horizontal pipe support means.

5. The apparatus of claim 4 wherein said frame means and said cylindrical element are formed of at least portions split along a vertical plane and means for connecting the two portions together.

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