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METHOD AND APPARATUS FOR SUBMERGED WELL DRILLING

Filed April 20, 1954

4 Sheets-Sheet 1

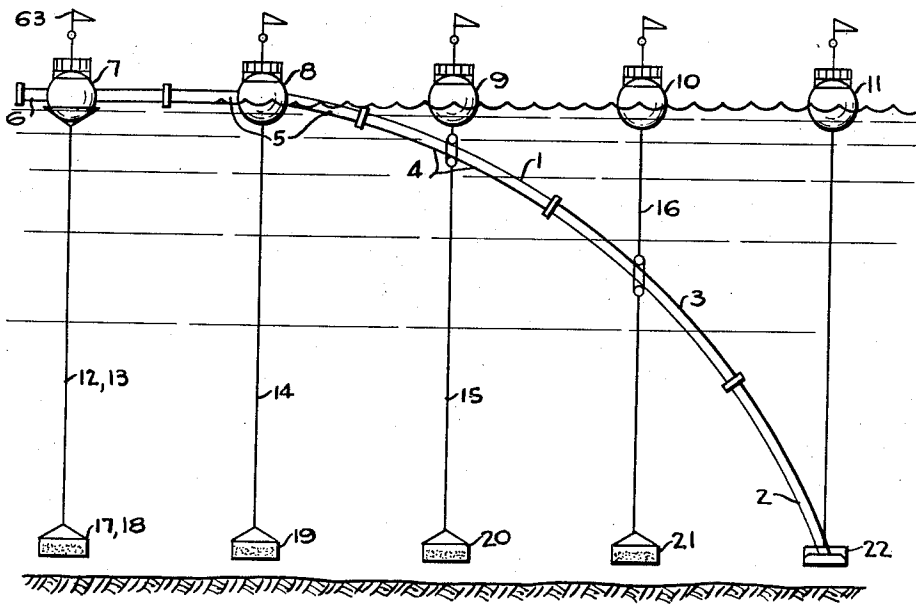


FIG. 1

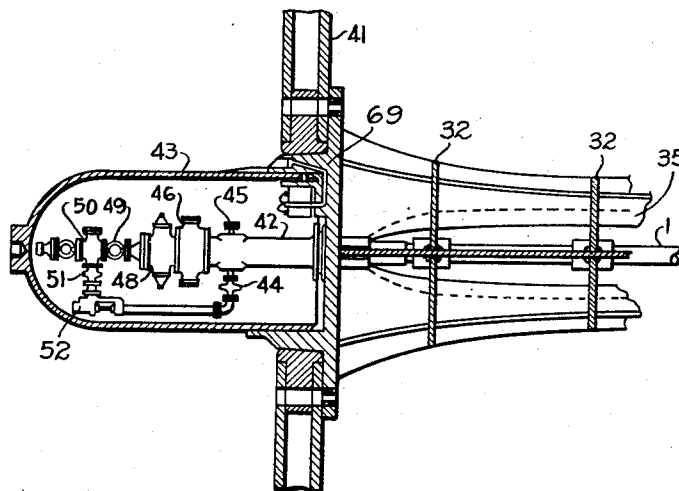


FIG. 9

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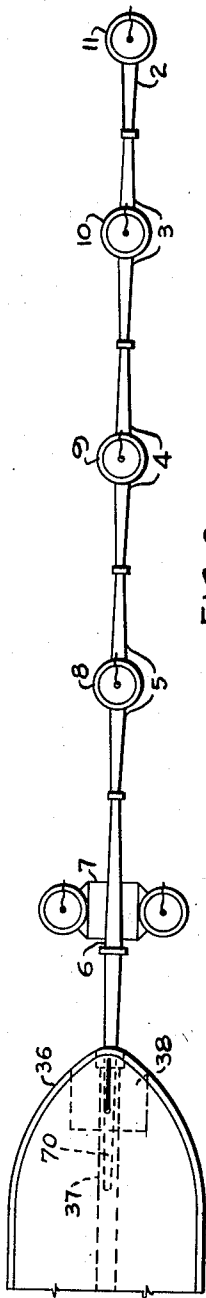


FIG. 3

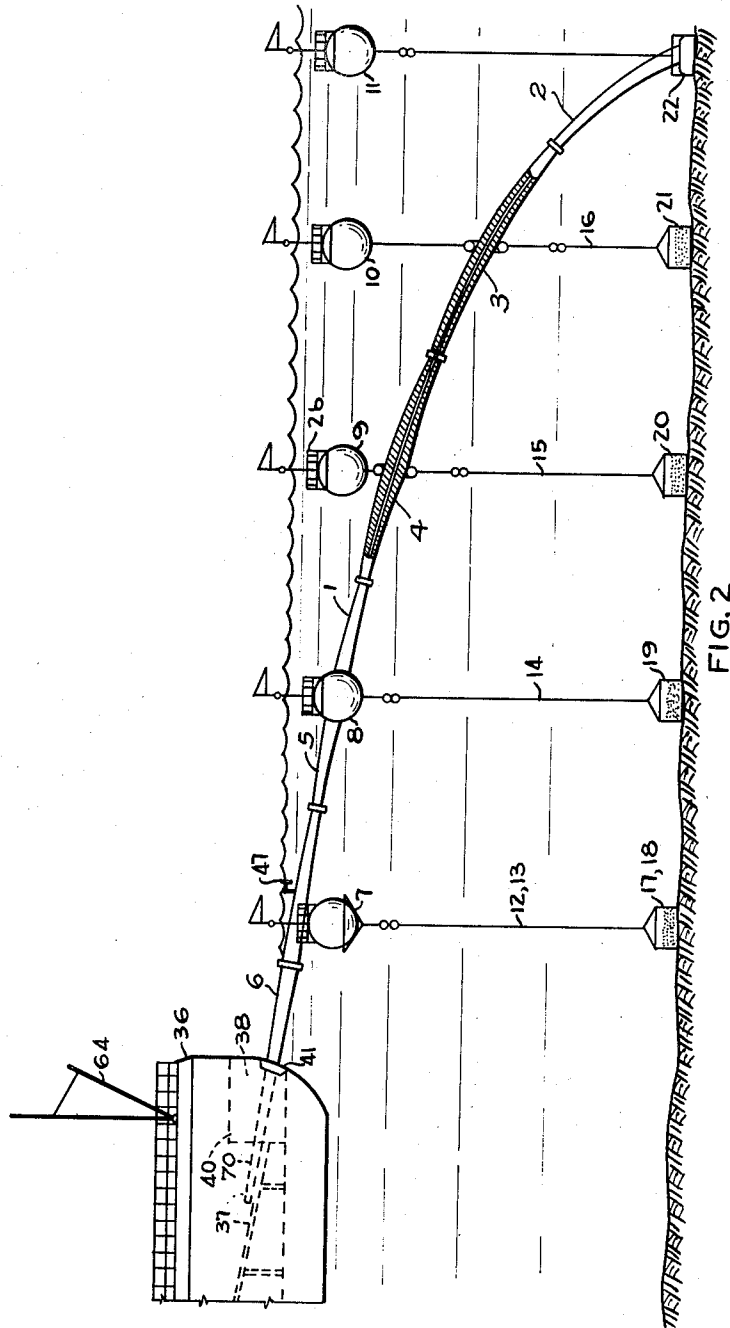


FIG. 2

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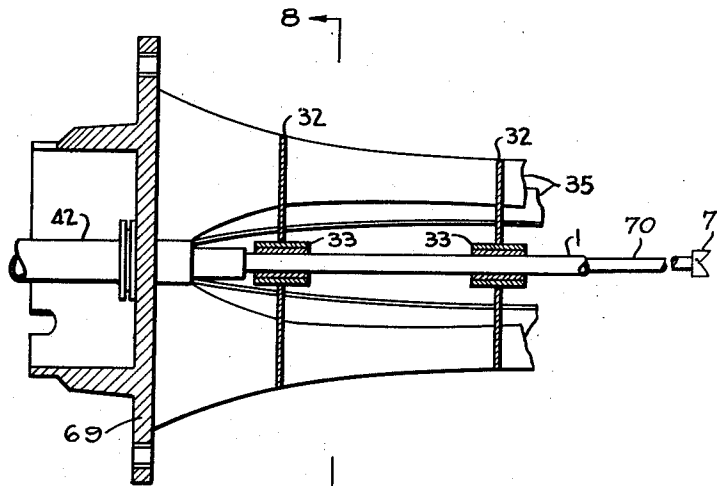


FIG. 7

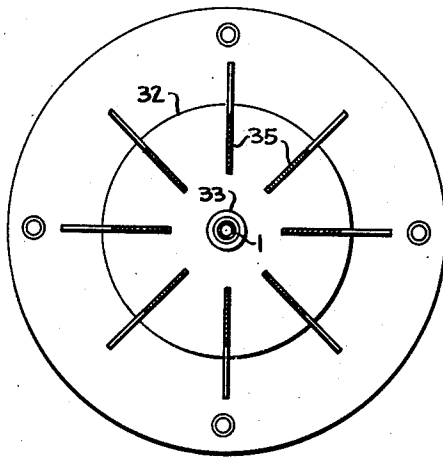


FIG. 8

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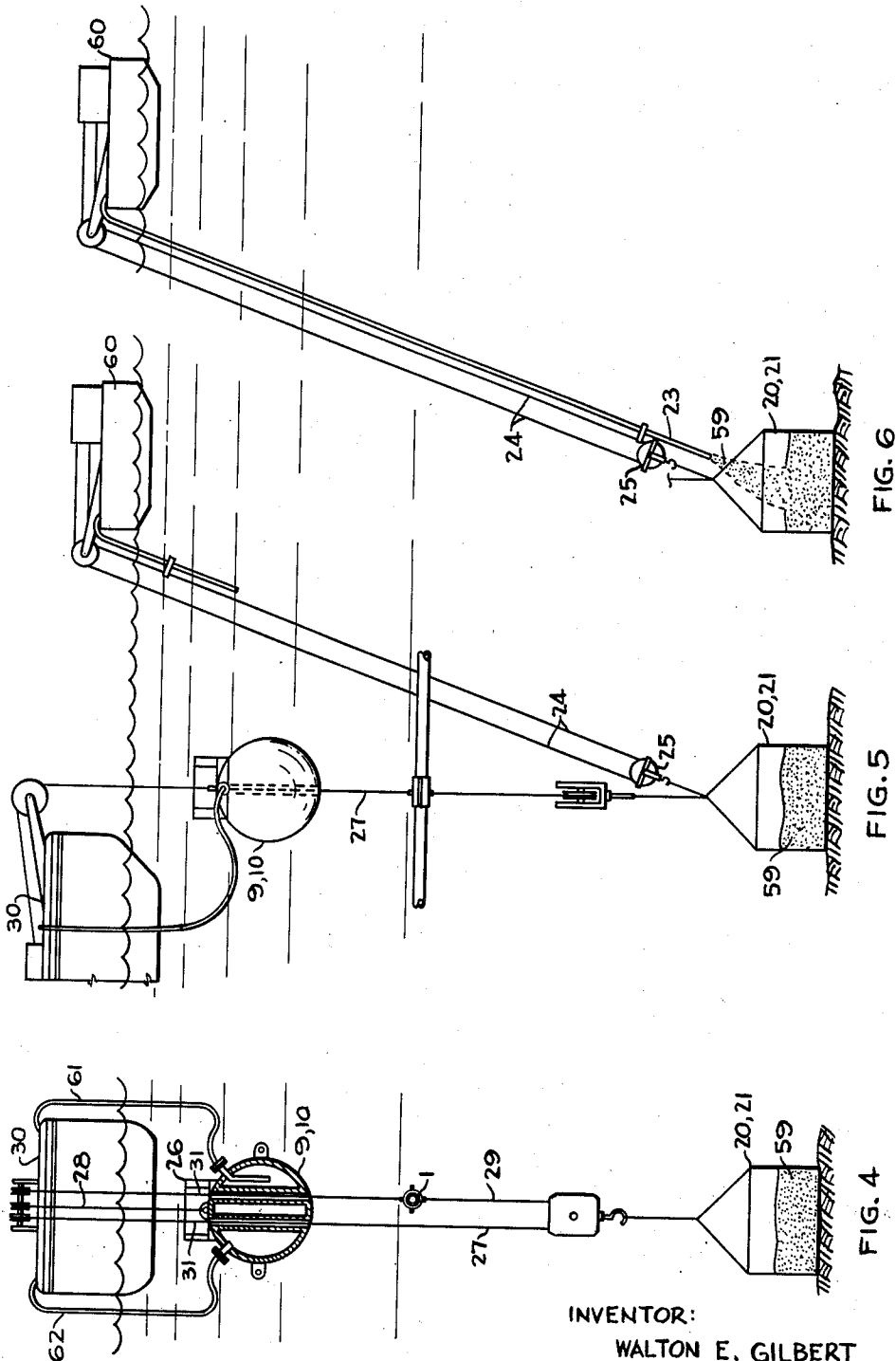
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METHOD AND APPARATUS FOR SUBMERGED WELL DRILLING

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4 Sheets-Sheet 4



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METHOD AND APPARATUS FOR SUBMERGED WELL DRILLING

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Claims priority, application Netherlands April 24, 1953

10 Claims. (Cl. 255—2.5)

This invention relates to the drilling of oil and gas wells and pertains more particularly to a method and apparatus for drilling wells in areas covered by water to a depth of 300 feet or more.

In drilling oil and gas wells in areas covered with water, use has been made in the past of different types of constructions, such as drilling installations installed on sinkable vessels or barges, installations built on piles, artificial islands and similar structures which find support on the bottom while drilling wells. However, the use of these constructions is limited to water of shallow depth.

It is, therefore, the principal object of the invention to provide a method and apparatus for drilling wells in water at greater depths.

Another object of this invention is to provide a method and apparatus for drilling wells in land covered by deep water by employing drilling apparatus which is supported in or on the water throughout the drilling operations.

A further object of the present invention is to provide a method and apparatus for the directional drilling of a well in submerged land from a floating base positioned thereabove.

To this end, according to the invention, a curved outer casing is used which extends from a point near the water level where it is almost horizontal to the bottom where it has a vertical or inclined position and into which drill pipes and other equipment are run. This outer casing, which forms the part of the well lying above the bottom of the water, is therefore employed as a guide tube for the drilling string and bit, inner casing strings, etc. During the drilling of wells, the upper part of the outer casing or guide tube is connected to a barge carrying the drilling installation which must be adapted to be positioned to operate in the almost horizontal direction in which the drilling tools must be inserted into the guide tube and pulled therefrom.

Figure 1 is a side-elevation of the curved guide tube which is in a floating position and is ready to be placed.

Figure 2 is a side-elevation of the guide tube after its lower end has been brought in contact with the bottom and the upper end has been connected to the barge carrying the drilling equipment.

Figure 3 is a plan view corresponding to Figure 2.

Figures 4, 5 and 6 show the various stages of anchoring the guide tube.

Figures 7 and 8 show the uppermost part of the guide tube in two sections which are at right angles to each other.

Figure 9 shows an elevation of this part after completion of the well.

When the present invention is employed in drilling operations, extensive use is made of techniques which are also employed in conventional drilling practice and the following description is therefore restricted mainly to those parts of the method of operation and equipment which differ from those normally employed. Thus, the actual drilling operations and completion of the part of the well below the bottom of the water is carried out in

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the usual way and therefore is not described in detail herein. The part of the well which differs from that normally employed is situated above the bottom of the water. This part (Figures 1, 2, 3) consists of a curved outer casing or guide tube 1 composed of a series of sections 2, 3, 4, 5 and 6. These sections, which may be prebent in the desired form, have sufficient strength and are so handled as to ensure that the elastic limit is not exceeded when they are interconnected, transported and placed into position. The buoyancy of floats 7, 8, 9 and 10 connected to the guide tube must exceed the weight of the guide tube and its appurtenances, e. g., a drill string to be run therethrough by a sufficient margin to ensure that incidental changes of this weight, as for example, while running or removing drill pipe during the drilling process, will not affect essentially the form of the guide tube which is supported by means of floats. Insofar as the buoyancy of floats 7, 8, 9 and 10 exceeds the weight of the guide tube connected thereto, it is absorbed as tension by anchor cables 12, 13, 14, 15 and 16 held by anchors 17, 18, 19, 20 and 21.

Actual drilling operations are preceded by investigations leading to selection of a drilling site. On the selected site soundings are made to determine the depths and the nature of the water bottom, while the movements of the water (tides, waves) which occur are also studied since the information thereby obtained is of importance to the construction and location of the curved guide tube.

Sections 2, 3, 4, 5 and 6 of this guide tube, often prebent in the desired form, may be towed as separate floating units to the drilling site where they are interconnected at or above the surface of the water by means of flanges, couplings, or in any other manner and lowered, care being taken to ensure that no section is stressed beyond its elastic limit. Anchors 17, 18, 19, 20 and 21 may be constructed in the form of open-top tanks which are towed, or transported to the drilling site where they are connected by means of cables to the tube sections 2, 3, 4, 5 and 6 and the floats 7, 8, 9, 10 and 11, after which the anchors are weighted with ballast material, for instance, sand. As shown in Figures 5 and 6, a hose 23 may be used which, by means of line 24 passing over pulley 25 and affixed to the anchor, may be moved with its end to a point above said anchor so as to fill the latter with the sand 59 to be discharged from a barge 60.

The floats as indicated in Figure 4 may each be constructed in the form of a hollow, internally-reinforced sphere fitted at its top with a railed platform 26 which provides working space for a diver handling the opening or closing of the valves, the fixing of cables and the carrying out of similar operations. In Figures 4 and 5 each of cables 27, 28 and 29 is connected to a separately controlled winch carried by barge 30. Anchor cable 27 is employed for lowering anchor 20, cable 28 for lowering float 9 and cable 29 for lowering a section of the curved guide tube. To ensure proper lowering, the buoyancy of the float can be counterbalanced by expelling air from the float by means of water introduced as through a conduit or hose 61, the tube section being meanwhile supported by the barge 30. When anchor 20 has reached the bottom and is weighted with ballast 59 and the tube section and the float have been lowered to its proper depth, the cables 27 and 29 are fixed to the float at the points 31, the buoyancy of the float being restored by expelling the water present therein by means of air supplied through hose 62. Care is thereby taken to ensure that the final air pressure in the float slightly exceeds the mean hydraulic pressure to which the float is subjected. In order to synchronize the lowering operation of the various sections with anchor and float, each of these sections may require a separate vessel.

Float 7 (Figure 3) consisting of two spheres, is em-

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ployed to support the uppermost section 6 of the guide tube when, for instance, owing to rough weather, it is advisable to discontinue drilling operations temporarily and when the well is completed. Float 11 is used to assist in keeping section 2 afloat and in bringing it into place, whilst floats 8, 9 and 10, situated at depths below the surface which are sufficient to prevent serious disturbance by the action of the waves, continuously exert an upward force. Each float may be provided with a mast 63 for aid in visually checking their alignment and marking the site of the well. Section 5 of the guide tube is held by a cable secured to the top of the float and passing through a tubular opening which extends through float 8.

In a typical case, such as that a present described, the sea may be 150 meters or more deep and the guide tube 1 may consist of 10 3/4" 13 3/8" diameter casing depending on the number of casing strings to be inserted and the depth at which the producing layer is expected. The wall thickness is so chosen that the compressive stresses are kept within certain safe limits, thereby taking into account the well pressures to be expected. The wall thickness of each section of the guide tube 1 may be equal throughout the length of the section, or it may be substantially thicker in the center of the sections than at the ends thereof, as illustrated. In the constructions shown in which the support of the guide tube 1 is concentrated at certain points, this tube is assembled of tapered sections which are hinged to the support cables midway, thus ensuring that the support given by the floats and the vessel is properly distributed over the length of the tube, and excessive local curvature of the tube owing to movements of the vessel caused by the action of wind and waves is prevented. Various means well known in the art may be applied for appropriate stiffening of the guide-tube sections. Figures 7 and 8 show the manner in which a stiffening made up of welds is constructed around guide tube 1. Circular plates 32 provided with radial slots and a central hub 33 are slid into the desired position and secured on to the tube by means of half cylinders. Longitudinal plates 35 are then mounted and welded in place, thus providing a continuous reinforcement and supporting structure for the tube from plate 69 which is removably secured to the hull 41 of the barge as shown in Figure 9.

When drilling and well servicing operations are carried out, tube section 6 (Figures 3 and 4) is fixed to the barge 36 and will, for instance, have a length of 30 to 60 meters. If the barge is lying in calm water this section 6 slopes downwards away from the barge at an angle varying between, say, 5° and 10° from a horizontal plane so as to minimize the length of the section affected by the action of the waves. This angle also facilitates the insertion of the drill pipe 70, drill bit 71 and casing in the guide tube.

Barge 36, which should preferably have a length of more than about 70 meters to minimize pitching motion and to ensure easier insertion and extraction of pipes, is provided with a central ramp 37 aligned with section 6 at the point of attachment of the latter to the barge. In the bow of the barge this ramp ends in a space 38 which will herein be referred to as a cellar since its function is similar to that of a cellar in a vertically drilled well. At the end of the cellar 38 a round opening is provided in the ship's side 41 through which the well-head or guide tube extends, which forms a water-tight connection with the barge. The rear end of the cellar is formed by a bulkhead 40 with a door which, when closed, makes the cellar into a compartment separated from the remaining part of the vessel to above the water line and, when the door is open, the cellar 38 and the ramp 37 are in unobstructed communication with each other. The greater part of the drilling operations may be carried out through an opening in the door for inserting and pulling out pipes, it being possible to close this opening (if the cellar is temporarily submerged) by a hydraulically operated shut-

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ting-off device of the type conventional in blow-out preventers.

The barge is moored in alignment with the part of the well which is under water and is kept in alignment by means of mooring cables and winches which may, for instance, be operated from the bridge of barge 36.

The barge is further equipped with derrick cranes 64 in the forecastle, the booms of which can be swung outside the bow of the barge so that they can support the well-head, place it in position and connect it to the vessel, disconnect it again and set the wellhead on cradle float 7. For this purpose section 6 may be provided with the necessary hooks or other gripping devices. If the barge is otherwise rigged for rotary drilling the tools and parts employed in vertical drilling will have to be adapted to drilling in a practically horizontal direction.

Figure 9 shows, partly in elevation and partly in section, the head of a completed flowing well which is situated in the barge and is ready for removal to cradle float 7. This figure may also be taken to illustrate the upper end assembly in place, at the commencement of drilling except that the casing spool 42, in which tube 1 is landed, would then be the only essential wellhead fitting in place and the bell 43 of course would be removed. The primary purpose of this bell is to protect the wellhead attachments against damage particularly during placement and removal of the head to and from the hull 41.

The drill pipe 70 in the curved guide tube is not only subjected to the tensile and torque stresses set up in vertical drilling but in this case reverse bending stresses are also exerted on it, thereby shortening its service life. Since the bending stresses are, however, inversely proportional to the radius of curvature of the curved guide tube they may be kept within safe limits justified from the economical point of view by a proper selection of the radius of curvature. However, in some cases the radius of curvature thus determined may not permit a full quarter circle between the water surface and the bottom of the water. In such cases the hole enters the bottom at an angle and directional drilling ensues to bring the bore to the angle of penetration desired.

The decision as to the type of entry to be used depends upon local conditions including water depths, tides, currents and weather.

In the system described, very high speeds of rotation should be avoided so as not to curtail the life of the drill pipe 70 too much and to prevent vibrations in the guide tube, although rotational speeds of 100 R. P. M. will in most cases be permissible. In order to minimize vibrations special care should also be taken to avoid bent drill-pipe lengths and misalignment between adjacent lengths of drill pipe or casing.

The method may be employed for drilling wells to depths of more than 3,000 meters and when using a 4 1/2" drill pipe, the minimum radius of curvature which can economically be used is about 150 meters, so that for sea depths of less than 150 meters, inclined drilling into the bottom and directional drilling may be necessary.

The invention renders it possible to put the well on production before the wellhead is released from the barge and transferred to the cradle float. In this case the annulus remaining between guide tube 1 and the casing, hung in the casing spool 46, serves as part of the flow line, i. e., as far as off-take connection 47 (Figure 2) which is situated at a sufficient distance from the well-head so that, when the latter is removed from the cradle float 7, this off-take connection and the pipeline connected thereto remain undisturbed.

In the embodiment of Figure 9 the tubing is fastened in the tubing landing head 48 and the oil is discharged via master gate 49, cross 50, flow valve 51, fixed bean 52 and thence to the annulus which is formed with off-take connection 47 as stated above. In some cases the bean may be located at the position of the off-take connection 47. In order to make it absolutely certain that

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no cement remains in the latter space, it is advisable to backwash this space immediately after cementing the casing string by introducing water at 44 and withdrawing it at 47.

I claim as my invention:

1. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling vessel, drilling equipment including a drill string positioned on said vessel, an elongated substantially rigid guide tube in communication between the vessel and the earth formation below the body of water for conducting the drill string and its bit from said vessel to and from said formation, said guide tube extending from said vessel in a substantially horizontal position and forming a substantially rigid support means continuously curved so as to contact the formation at an angle of no greater than 45 degrees to the vertical.

2. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling vessel, drilling equipment including a drill string positioned on said vessel, an elongated substantially rigid guide tube in communication between the vessel and the earth formation below the body of water for conducting the drill string and its bit from said vessel to and from said formation, said guide tube extending from said vessel in a substantially horizontal position and forming a substantially rigid support means continuously curved so as to contact the formation at an angle of no greater than 45 degrees to the vertical, and float means secured to said guide tube for suspending it within said body of water.

3. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling barge, drilling equipment including a drill string positioned on said barge, an elongated substantially rigid curved guide tube in communication between the barge and the earth formation below the body of water for conducting the drill string and its bit from said barge to and from said formation, said guide tube extending from said barge in a substantially horizontal position and forming a substantially rigid support means continuously curved throughout the major portion of its length so as to contact the formation at an angle of no greater than 45 degrees to the vertical, and a plurality of float means secured to said guide tube for suspending it within said body of water.

4. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling barge, drilling equipment including a drill string positioned on said barge, an elongated substantially rigid curved guide tube in communication between the interior of the barge and the earth formation below the body of water for conducting the drill string and its bit from said barge to and from said formation, said guide tube extending from said barge in a substantially horizontal position and forming a substantially rigid support means continuously curved throughout the major portion of its length so as to contact the formation at an angle of no greater than 45 degrees to the vertical, and a plurality of anchored float means secured to said guide tube at spaced points therealong for suspending said guide tube within said body of water.

5. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling barge, drilling equipment including a drill string positioned on said barge, an elongated substantially rigid curved guide tube in communication between the interior of the barge and the earth formation below the body of water for conducting the drill string and its bit from said barge to and from said formation, said guide tube extending from said barge in a substantially horizontal position and forming a substantially rigid support means continuously curved throughout the major portion of its length so as to contact the formation at an angle of no greater than 45 degrees to the vertical, and

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a plurality of anchored float means secured to said guide tube for suspending it within said body of water, said guide tube comprising a plurality of sections connected end to end to form said guide tube, each of said guide tube sections being secured to one of said float means at substantially the mid-point of each section.

6. Apparatus for drilling offshore wells into earth formations covered by a large body of water, said apparatus comprising a drilling barge, drilling equipment including a drill string positioned on said barge, an elongated substantially rigid curved guide tube in communication between the interior of the barge and the earth formation below the body of water for conducting the drill string and its bit from said barge to and from said formation, said guide tube extending from said barge in a substantially horizontal position and forming a substantially rigid support means continuously curved throughout the major portion of its length so as to contact the formation at an angle of no greater than 45 degrees to the vertical, and a plurality of anchored float means secured to said guide tube for suspending it within said body of water, said guide tube comprising a plurality of sections connected end to end to form said guide tube, each of said guide tube sections being secured to one of said float means at substantially the mid-point of each section, the cross-sectional thickness of each section being a maximum value at the mid-point of each section and tapering toward each end of the section.

7. Apparatus for producing offshore wells drilled into earth formations covered by a large body of water, said apparatus comprising a curved well casing curving from a substantially horizontal position above the surface of the water to a substantially vertical position where the casing contacts the formation below said body of water, a curved guide tube surrounding the well casing from the point where the casing enters the formation to the surface of the body of water, valve means closing the top of the well casing and controlling the flow of fluid from the well, and float means secured to said guide tube for suspending the guide tube within said body of water whereby the valve means on said well casing is positioned above the surface of the water.

8. Apparatus for producing offshore wells drilled into earth formations covered by a large body of water, said apparatus comprising a curved well casing curving from a substantially horizontal position above the surface of the water through an arc of at least 45 degrees into contact with the formation below said body of water, a curved guide tube surrounding the well casing from the point where the casing enters the formation to the surface of the body of water, valve means closing the top of the well casing and controlling the flow of fluid from the well, and float means secured to said guide tube at spaced points therealong for suspending the guide tube within said body of water whereby the valve means on said well casing is positioned above the surface of the water.

9. In a method of drilling off-shore wells into earth formations covered by a large body of water by means of a rotatable string of drill pipe, the steps of disposing one end of said drill pipe in a substantially horizontal position, supporting said end above the surface of said water, and guiding the remainder of said drill pipe through an arc of at least 45 degrees until the other end of said drill pipe contacts the formation below the body of water.

10. In a method of drilling off-shore wells into earth formations covered by a large body of water by means of a rotatable string of drill pipe, the steps of disposing one end of said drill pipe in a substantially horizontal position, supporting said end above the surface of said water, guiding the remainder of said drill pipe through an arc of at least 45 degrees, maintaining the other end of said drill pipe in contact with the formation below the body of water, and suspending the curved section of said drill pipe in said body of water.

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