Oct. 31, 1967 W. W. RAND Re. 26,290

SUBAQUEOUS DRILLING APPARATUS

Original Filed Sept. 17, 1956 3 Sheets-Sheet 1

FIG. 1.

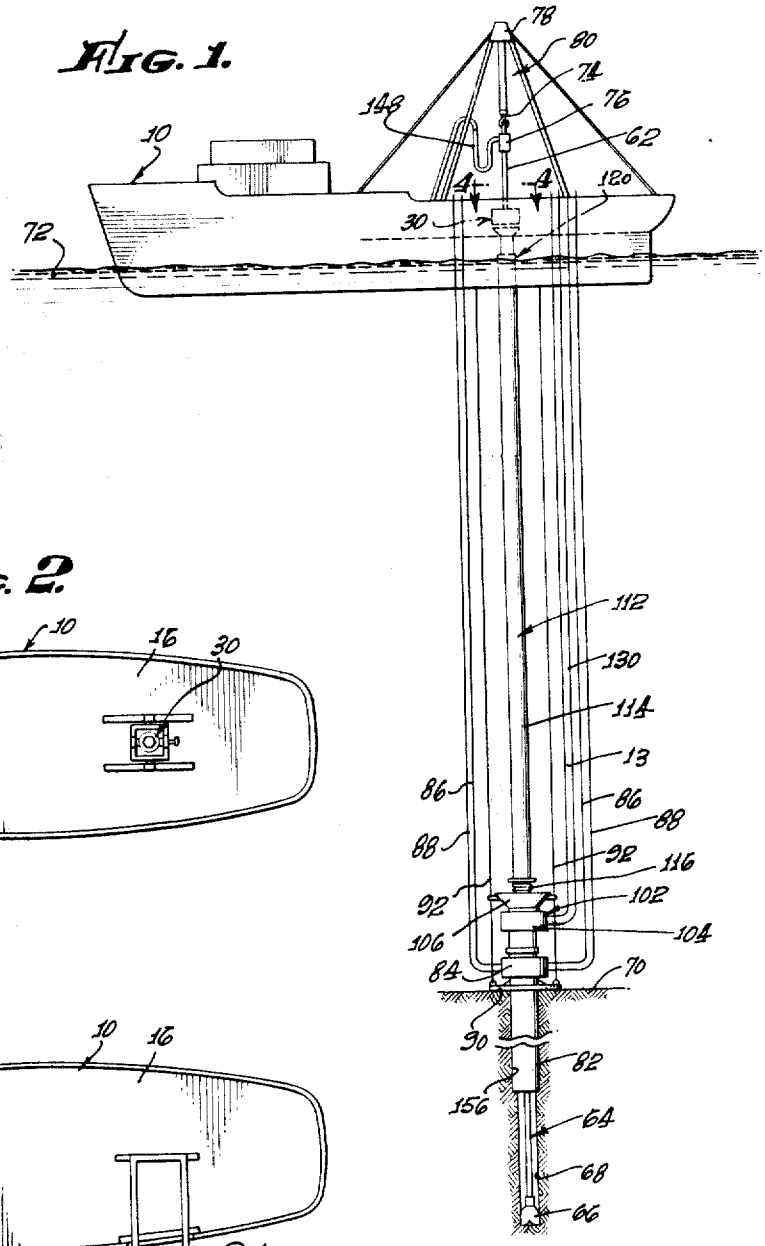
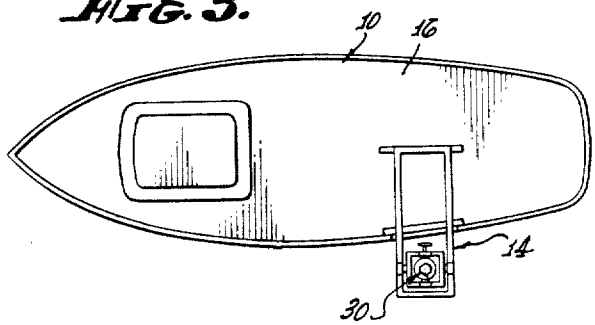


FIG. 2.

FIG. 3.



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SUBAQUEOUS DRILLING APPARATUS

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FIG. 4.

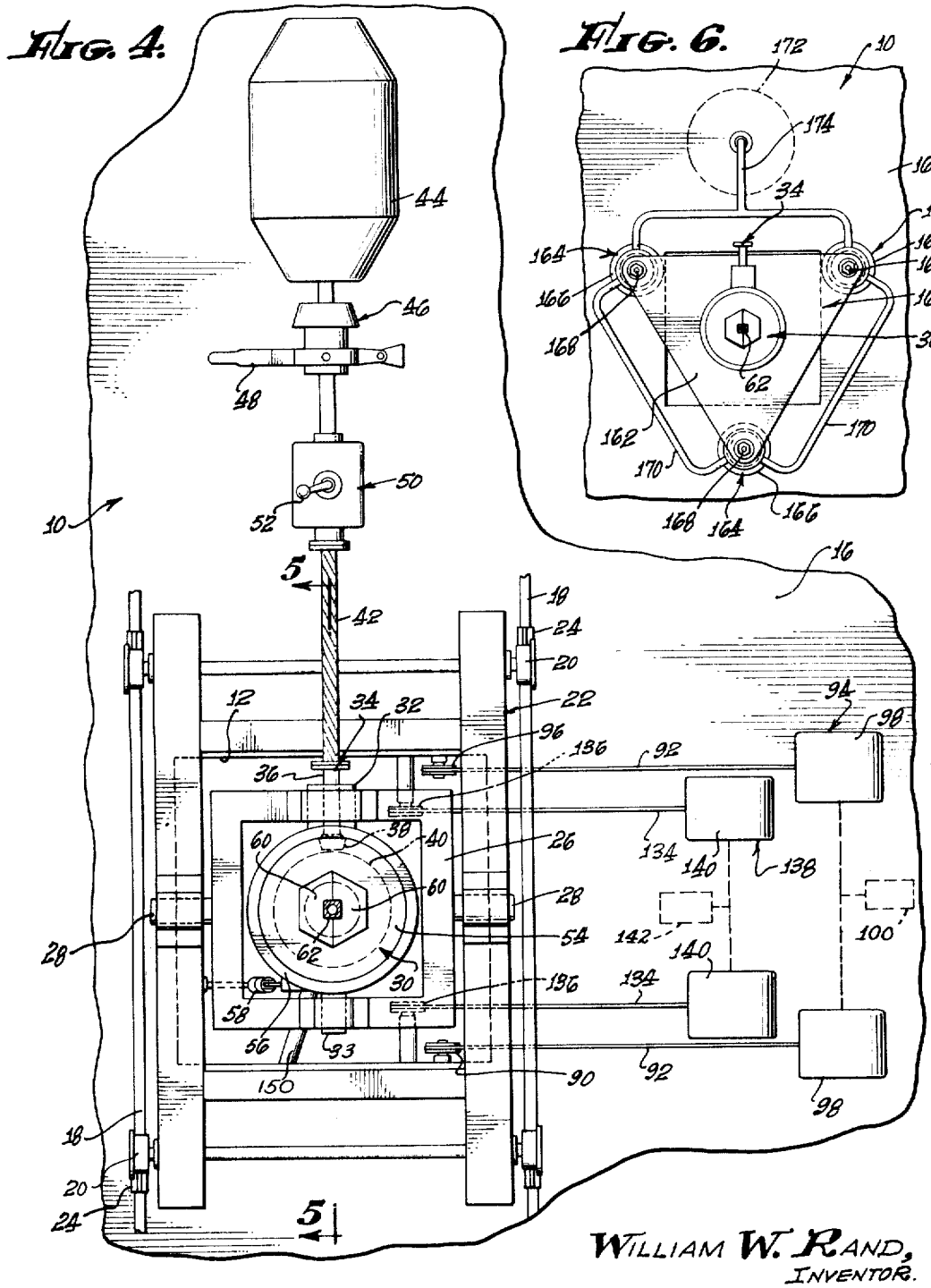


FIG. 6.

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SUBAQUEOUS DRILLING APPARATUS

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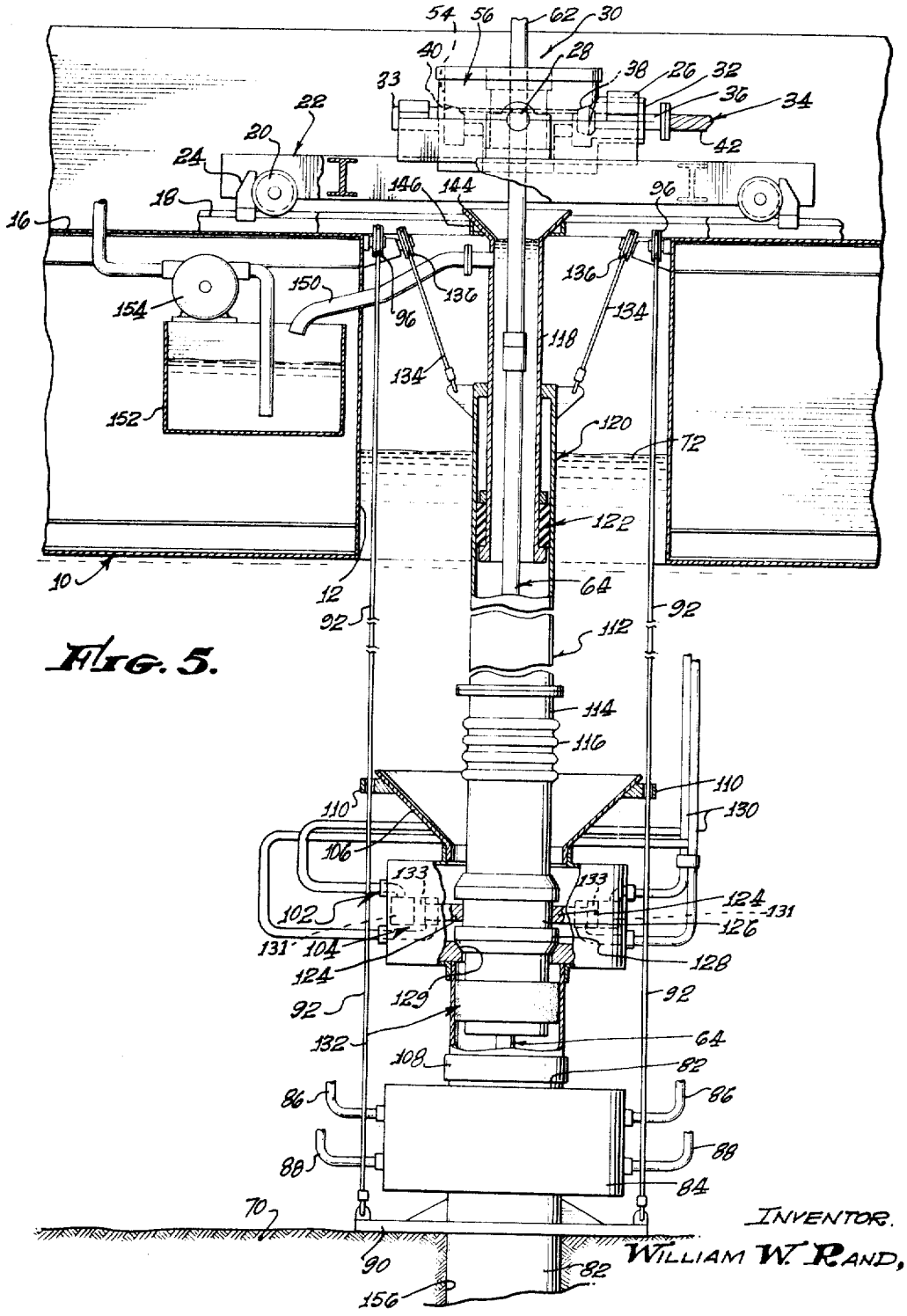


FIG. 5.

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SUBAQUEOUS DRILLING APPARATUS

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Original No. 3,177,954, dated Apr. 13, 1965, Ser. No. 610,062, Sept. 17, 1956. Application for reissue Nov. 18, 1966, Ser. No. 593,220

10 Claims. (Cl. 166—.6)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

In order to achieve subaqueous drilling, a vessel is equipped with rotary drilling equipment including a gimbal-mounted rotary table and equipped with lowering and driving means such as a derrick and associated apparatus.

At the desired location, submerged anchoring means is secured to the earth beneath the body of water. Guide lines extend from the anchoring means to the vessel for guiding equipment to and from the anchoring means. A conductor tube extends from the vessel into latching engagement with tubular wellhead structure secured to the submerged anchoring means, thereby to provide a conduit through which a drill string driven by the rotary table may be lowered into the well and raised therefrom by the derrick.

The present invention relates in general to an apparatus for subaqueous drilling, i.e., an apparatus for drilling into the earth beneath a body of water, and a primary object of the invention is to provide an apparatus which includes a floating supporting structure or platform, such as a boat, barge, or the like, from which all the drilling operations are carried out without any necessity for supporting the platform by means of piles, extensible legs, or the like.

With the foregoing construction, the apparatus of the invention may be transported from one drilling location to another readily and may be placed in operation at a particular location, or removed from such location after drilling operations have been completed, with a minimum expenditure of time and effort, which is an important feature. Also, the present invention permits drilling in considerably deeper water than is possible with structures requiring supporting piles, legs, or the like, since there is no necessity for supporting the platform from the bottom of the body of water, which is another important feature.

An important object of the invention is to provide an apparatus for subaqueous drilling which includes a rotary table and which includes automatic orienting means connecting the rotary table to the floating platform in such a manner that a predetermined orientation for the axis of the rotary table is always maintained despite rolling or pitching of the platform due to the action of wind, waves, and the like.

Another object is to provide an orienting means for the rotary table which includes a gimbal frame between the rotary table and the supporting structure, the gimbal frame being connected to the supporting structure by outer pivots located on an outer pivot axis, the rotary table being connected to the gimbal frame by inner pivots located on an inner pivot axis, and the rotary table being [pivot axis and which extends through one of the inner driven by a drive means which is coaxial with the inner] *driven by a drive means which is coaxial with the inner pivot axis and which extends through one of the inner* pivots. With this construction, the desired axis orientation for the rotary table is always maintained and the drive means for the rotary table is always operative, despite rolling and/or pitching of the floating supporting structure.

Another object is to provide an automatic orienting means for the rotary table which includes at least three interconnected fluid motors supporting the rotary table and each connected to the rotary table and to the floating supporting structure.

Another important object of the invention is to provide a subaqueous drilling apparatus having means for positioning or locating the floating platform relative to a casing set in the earth beneath the body of water, this casing being referred to hereinafter as a "surface" casing since it performs a function somewhat analogous to that performed by the surface casing of a well drilled on dry land.

Another object of the invention is to provide an apparatus which includes an inner casing or conductor tube suspended from the floating platform and extending into *communication with* the surface casing, this conductor tube serving to conduct a drill string driven by the rotary table downwardly into the surface casing.

Another object is to provide packer means forming a fluid-tight seal between the lower end of the conductor tube and the upper end of the surface casing.

Another object is to provide means for latching the lower end of the conductor tube [to] *in communication with* the upper end of the surface casing to prevent separation thereof during drilling.

Another object is to provide an upwardly facing guide funnel [at] *in fixed relation to* the upper end of the surface casing for guiding the lower end of the conductor tube into *communication with* the surface casing and the latching means as the conductor tube is lowered from the floating platform.

Another object is to provide a conductor tube which includes at least one flexible joint to compensate for lateral movement of the floating supporting structure relative to the surface casing, and to provide a conductor tube having at least one vertical slip joint to permit variations in the length of the conductor tube to compensate for vertical movement of the floating supporting structure due to wave and tide action and to compensate for lateral displacement of the floating supporting structure relative to the surface casing. With this construction, even though the lower end of the conductor tube is latched relative to the upper end of the surface casing and is sealed relative thereto by the packer means, the floating platform may move laterally and/or vertically to considerable extents without disturbing the connections between the conductor tube and the surface casing.

An important object is to provide means carried by the floating platform for supporting the conductor tube with a constant supporting force.

Still another object of the invention is to provide an apparatus including supporting lines etxending between the floating platform and the conductor tube and connected to the conductor tube, and including means for maintaining constant and equal tensions in such supporting lines. With this construction, a constant supporting force is applied to the conductor tube at all times, despite lateral and/or vertical shifting of the floating platform relative to the connection between the conductor tube and the surface casing.

Another important object is to provide guide lines extending between the floating platform and the surface casing and connected to the surface casing, and to provide means carried by the floating platform for maintaining constant and equal tensions in such guide lines, a related object being to utilize such guide lines to guide the latch-

ing means and the guide funnel mentioned downwardly from the floating platform into proper [engagement] *communication* with the surface casing. Thus, these guide lines serve as a means for properly positioning various components of the apparatus with reference to the surface casing despite horizontal and/or vertical shifts in the location of the supporting structure relative to the surface casing, which is an important feature.

Another object is to provide an apparatus wherein the rotary table is supported either in a position outwardly of the bow, side, or stern of a boat, barge, or the like, or in a position over a well through the hull of the barge or boat.

Another object is to mount the rotary table, and its orienting means, on a carriage which may be moved between operative and inoperative positions relative to the floating platform.

Another object of the invention is to provide an apparatus having a closed drilling mud circulation system wherein the drilling mud enters the drill string adjacent the upper end thereof through a drilling mud supply line, and is discharged from the conductor tube adjacent the upper end thereof through a drilling mud return line, such a closed mud system being permitted by the interconnected conductor tube and surface casing hereinbefore discussed.

In carrying out the invention in one form thereof, a vessel or other supporting means adapted to float on the body of water carries a derrick and a rotary table for driving a drill string for drilling and working in a well bore underlying a body of water. Submerged anchoring means is set into the earth below the body of water. Flexible guide lines extend between, and are connected to, the vessel and to the anchoring means. Tubular wellhead structure may be guided into position by the guide lines, and that structure is connected to the anchoring means in communication with the casing. To provide a conduit through which a drill string driven by the rotary table may be lowered into the well bore and raised therefrom by the derrick, a conductor tube is provided which extends between the supporting means and the wellhead structure. The lower end portion of the conductor tube is latched to the wellhead structure, preferably by a fluid-operated latching means which can be activated at will from the vessel. Means are provided at the upper end of the conductor tube and in the vicinity of the vessel for supporting it during the time the lower end is attached to the wellhead structure. Means are provided for applying upwardly-directed supporting forces of substantially constant magnitude to the upper portion of the conductor tube. This tube itself may comprise two sections, a lower section to which the upwardly-directed supporting forces are supplied and an upper section extending upwardly into operative position into the vessel with a telescopic joint between the two in compensation for movement of the vessel caused by waves.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results thereof which will be apparent to those skilled in the subaqueous drilling art in the light of this disclosure, may be attained with the exemplary embodiments of the invention described in detail hereinafter and illustrated in the accompanying drawings, in which:

FIG. 1 is a side view, partially in elevation and partially in section, of a subaqueous drilling apparatus of the invention in operation;

FIG. 2 is a semidiagrammatic plan view of the embodiment of FIG. 1;

FIG. 3 is a semidiagrammatic plan view of an alternative embodiment;

FIG. 4 is an enlarged, fragmentary plan view, partially in section, taken along the arrowed line **4—4** of FIG. 1;

FIG. 5 is a sectional view taken along the arrowed line **5—5** of FIG. 4; and

FIG. 6 is a plan view, partially in section, of an alternative embodiment of a rotary table orienting means of the invention.

The subaqueous drilling apparatus of the invention includes a floating platform or supporting structure which is exemplified throughout the drawings as a boat **10**, adapted to float on a body of water **72** it being understood that other floating platforms such as a barge, or the like, may be substituted for the boat shown. In the embodiment of the invention selected for detailed consideration, the drilling operations are carried out through a well **12**, FIG. 5, extending through the hull of the boat **10**. However, it will be understood that the invention is not limited thereto and that the drilling operations may be carried out from a supporting rfame **14**, FIG. 3, extending outwardly from the bow, side, or stern of the boat.

Considering in more detail the embodiment specifically illustrated in FIGS. 1, 2, 4 and 5 of the drawings, a deck **16** of the boat **10** carries tracks **18** on opposite sides of the well **12** through the hull of the boat. Movable along the tracks **18** are wheels **20** of a carriage **22** on which is mounted drilling equipment to be described, the carriage being movable between an operative position over the well **12** to locate such drilling equipment over the well and an inoperative position at one side of the well to leave the well unobstructed. The carriage **22** may be locked in its operative position over the well **12** by means of chocks **24** engaging the tracks **18** and the wheels **20**.

As best shown in FIG. 4 of the drawings, a gimbal frame **26** is mounted on the carriage **22** by means of outer pivots **28** having a common, outer pivot axis. Within the gimbal frame **26** is a rotary table **30** having a rotor **54** rotatable within a stator **56**, the latter being connected to the gimbal frame **26** by inner pivots **32** and **33** having a common, inner pivot axis perpendicular to the axis of the outer pivots **28**. As will be apparent, supporting the rotary table **30** on the carriage **22** through the gimbal means just described results in a constant, usually generally vertical, orientation for the axis of the rotary table **30** despite pitching and/or rolling of the boat **10**. Also, this gimbal support for the rotary table **30** permits the rotary table to tilt relative to the boat **10** to compensate for lateral displacement of the boat to one side or the other of the precise location to be drilled.

The rotary table **30** is driven by a drive means **34** coaxial with the inner pivot axis, i.e., the pivot axis between the rotary table and the gimbal frame **26**. The drive means **34** includes a shaft **36** which extends axially through the inner pivot **32** and which carries a pinion gear **38** at its inner end. This pinion gear is meshed with a ring gear **40** secured to the rotor **54**, whereby rotation of the drive shaft **36** through the inner pivot **32** results in rotation of the rotor.

The drive shaft **36** is driven by a flexible shaft **42** which compensates for relative tilting of the rotary table **30** and the boat **10** in any direction. This flexible shaft may take the form shown, or it may take the form of a rigid shaft equipped with universal joints and sliding splined sections, not shown. The flexible shaft **42** is driven by a motor **44** on the deck **16** through a clutch **46** operable by a lever **48** and through a variable speed transmission **50** having a speed changing lever **52**.

Interconnecting the stator **56** of the rotary table **30** and the carriage **22** is a torque-compensating hydraulic shock absorber **58**. This shock absorber, which, per se, is conventional, is provided with a small orifice through which fluid flows to permit the entire rotary table **30** to tilt slowly to compensate for pitching and/or rolling of the boat **10**, and to compensate for lateral displacement of the boat relative to the precise point to be drilled. However, the shock absorber **58**, due to the small orifice mentioned, checks any sudden movement of the rotary

table **30** tending to result from sudden changes in the torque applied to the rotary table through the drive means **34**, such abrupt torque changes resulting from starting or stopping of the rotary table, or from encountering obstructions to drilling.

From the foregoing it will be apparent that the structure described permits maintaining a predetermined orientation of the axis of the rotary table **30**, which axis is at least substantially vertical, to compensate for pitching and/or rolling of the boat **10** and to compensate for lateral drifting of the boat from the precise location being drilled. The flexible nature of the connection between the drive motor **44** and the rotary table permits relative tilting motion of the rotary table and the boat without interference with the operation of the rotary table. The presence of the shock absorber **58** insures against sudden tilting of the rotary table due to abrupt changes in the torque applied thereto, while still permitting slow relative tilting movement between the rotary table and the boat.

The rotor **54** of the rotary table **30** carries the usual kelly bushing **60** which is engageable with a kelly **62** forming the upper end of a drill string **64** having at its lower end a bit **66**, FIG. 1, for drilling a bore **68** in the earth **70** at the bottom of the body of water **72** on which the boat **10** floats. The drill string **64** is supported in the usual manner by a traveling block **74** which is connected to the upper end of the kelly **62** by a swivel fitting **76**. The traveling block **74** is suspended from a crown block **78** in the usual manner, the crown block being carried by a derrick **80** mounted on the deck **16** of the boat **10** above the well **12** through the hull thereof.

As best shown in FIGS. 1 and 5 of the drawings, a surface casing **82** is set in the earth **70** beneath the body of water **72** and lines at least an enlarged bore **156** at the upper end of the bore **68**. This surface casing carries the usual blowout preventer **84** between upper and lower sections thereof. This blowout preventer may include, as is conventional, gates, not shown, controlled by hydraulic lines **86** and adapted to close around the drill string **64**, and may include gates, not shown, controlled by hydraulic lines **88** and adapted to close the surface casing **82** completely when the drill string is removed thereform. The blowout preventer may be permanently attached to the surface casing **82**, or it may be removable in a manner to be described.

The surface casing **82** is provided, preferably below the blowout preventer **84**, with an anchoring means **90**, which is set with the casing, for at least two guide lines **92** which extend upwardly through the well **12** in the boat **10** to a means **94** carried by the boat for maintaining constant and equal tensions in the guide lines, the latter being trained over pulleys **96** at the top of the well **12**. The means **94** may include fluid motors **98** respectively connected to the guide lines **92**, these motors being connected to each other and to a common source of fluid pressure **100** so as to maintain equal and constant tensions in the guide lines. For example, the fluid motors may be well-known air winches connected to each other and to a common source of air pressure. With this construction, the guide lines **92** are maintained under constant and equal tensions at all times despite pitching and/or rolling of the boat **10**, rising and/or falling of the boat due to wave and/or tide action, drifting of the boat horizontally relative to the axis of the bore **68** in the earth **70** below the body of water **72**, and the like, which is an important feature of the invention. The tension in the guide lines **92** may be varied, as required by operating conditions, by varying the fluid pressure supplied to the means **94**.

The guide lines **92** are utilized for locating the boat **10** relative to the surface casing **82** and are also utilized, in the construction illustrated, to guide a removable means or *tubular wellhead* structure **102** downwardly through the well **12** in the boat **10** into operative engagement with the surface casing **82**. The structure **102** includes at least a latching means **104** and an upwardly facing guide funnel **106**, the functions of which will be discussed hereinafter, the lower end of the structure **102** being automatically and removably connectible to the upper end of the surface casing **82** by a suitable coupling or joint **108** between the latching means **104** and the blowout preventer **84** which coupling or joint is not specifically shown, but which is well known in the art. The *wellhead* structure **102**, including the latching means **104** and the guide funnel **106**, or these elements plus the blowout preventer **84**, is guided into operative relation with surface casing **82** by the guide lines **92** through the expedient of stringing the guide lines through eyes **110** carried by the structure **102**, the eyes **110** being formed on the guide funnel **106** in the particular construction illustrated.

With the foregoing arrangement, the structure **102** is automatically guided into its proper operative position relative to the surface casing **82** by the guide lines **92**, even through the axis of the well **12** in the boat **10** is offset laterally to one side of the axis of the surface casing **82** to a substantial extent.

It will be understood that, if desired, the structure **102** may also be permanently attached to the surface casing **82** before lowering the latter into the bore **156**, in which case the guide lines **92** may be utilized to lower the structure **102** and the casing **82** and to perform a locating function thereafter.

Extending downwardly through the well **12** in the boat **10** into *communication with* the upper end of the surface casing **82** is a conductor tube **112** which houses that portion of the drill string **64** which is between the surface casing and the rotary table **30**. The conductor tube **112** includes a lower section **114** having therein a flexible joint **116** which permits lateral displacement of the axis of the well **12** relative to the axis of the surface casing **82**. The conductor tube **112** also includes an upper section **118** which is connected to the lower section **114** by a slip joint **120**, thereby permitting relative vertical movement of the upper and lower sections to compensate for rising and falling of the boat **10** due to wave action, tide action, and the like. As shown, the slip joint **120** includes a piston means **122** carried by the upper section **118** within and making a fluid-tight sliding fit with the lower section **114**.

The conductor tube **112** is adapted to be lowered into *communication with* the upper end of the surface casing **82** through the guide funnel **106** and the latching means **104**, the purpose of the guide funnel being to align the lower end of the conductor tube with the latching means [and] *in communication with* the surface casing. Thus, proper insertion of the conductor tube through the latching means **104** into *communication with* the surface casing **82** is assured. Considering the function of the latching means **104**, it includes two latch elements **124** insertable into and adapted to close around a reduced-diameter portion **126** of a latching mandrel **128** on the conductor tube **112**, the mandrel being engageable with a seat **129** to align the portion **126** with the latch elements **124**. The latter are preferably hydraulically actuated and are controlled from the boat **10** through hydraulic lines **130**. These lines are connected to opposite ends of cylinders **131** in which are disposed pistons **133** connected to the latch elements **124**. By pressurizing the lines **130** alternately, the elements **124** are alternately moved inwardly and outwardly. As will be apparent, after the lower end of the conductor tube **112** has been guided into alignment with the latching means **104** and the surface casing **82** by the guide funnel **106**, and has been inserted through the latching means into *connection with* the upper end of the [surface casing] *wellhead structure*, the latching means may be energized from the boat by pressurizing the proper line **130** to close the latch elements **124** on the reduced-diameter portion **126** of the latch mandrel **128**,

thereby latching the conductor tube to the [surface casing] *wellhead structure* so that it is anchored thereto.

A packer means **132** is provided between the lower end of the conductor tube **112** and the upper end of the [surface tubing **82**] *wellhead structure 102* to provide a fluid-tight seal therebetween, thereby excluding water from the conductor tube and the surface casing, and confining drilling mud in the drilling mud system to be described within the conductor tube and the surface casing. The packer means **132** may be carried by the conductor tube **112** for insertion into the [surface casing **82**] *wellhead structure 102* through the guide funnel **106** and the latching means **104**, or it may be carried by the [surface casing] *wellhead structure* for insertion of the lower end of the conductor tube thereinto.

The weight of the conductor tube **112** is carried by supporting lines **134** which are connected to the upper end of the lower section **114** of the conductor tube and which are trained over pulleys **136** at the upper end of the well **12** in the boat **10**, these supporting lines being connected to a means **138** for maintaining constant and equal tensions therein. The means **138** is similar to the means **94**, and is shown as including fluid-operated motors **140** respectively connected to the supporting lines **134**, the motors **140** being connected together and to a common source of fluid pressure **142**. The motors **140** may, for example, be well-known air winches. Thus, with this construction, the weight of the conductor tube **112** is supported from the boat **10** in such a manner that a constant supporting force is applied thereto at all times despite vertical or lateral movement of the boat relative to the surface casing, this being accomplished by maintaining constant and equal tensions in the supporting lines **134** in the manner discussed.

The upper end of the upper section **118** of the conductor tube **112** is provided with an upwardly facing guide funnel **144** which serves to guide the drill bit **66** into the conductor tube as the drill string is lowered thereinto. This guide funnel also performs another function, viz., it serves as a mud leveling device and as a mud accumulator to take care of surges in the level of the mud system to be described in subsequent paragraphs. The funnel **144** rests on and is supported by a frame **146** which flexibly attaches the upper section **118** of the conductor tube **112** to the boat **10**, the slip joint **120** permitting upward and downward movement of the upper section **118** of the tube relative to the lower section **114** thereof in response to vertical or horizontal displacement of the boat **10** relative to the surface casing **82**.

Considering the drilling mud system mentioned, this is a closed system by means of which drilling mud is circulated from a mud tank, not shown, through the bore **68** and back to the mud tank. Drilling mud is delivered from the mud tank to a flexible drilling mud supply line **148**, FIG. 1, by a mud pump, not shown. The supply line **148** is connected to the kelly **62** adjacent the upper end thereof to deliver drilling mud into the interior of the drill string **64**, the drilling mud flowing downwardly through the drill string and out the bit **66**. The drilling mud then flows upwardly through the annulus between the drill string **64** and the wall of the bore **68**, carrying with it cuttings removed by the bit. The cutting-laden drilling mud flowing upwardly through this annulus flows into the annulus between the drill string **64** and the surface casing **82**, and then flows into the annulus between the drill string **64** and the lower section **114** of the conductor tube **112**, the packer means **132** providing a fluid-tight seal at the junction of the [surface casing] *wellhead structure* and the lower section of the conductor tube. From the annulus between the lower section **114** of the conductor tube **112** and the drill string **64**, the drilling mud, laden with cuttings, flows upwardly through the annulus between the drill string and the upper section **118** of the conductor tube, to a point just below the guide funnel **144** at the top of the conductor tube. At this point the cutting-laden drilling mud flows through a drilling mud return line **150** into a mud sump **152** in which the cuttings are collected. A mud pump **154** returns clean drilling mud to the mud tank hereinbefore mentioned, for recirculation throughout the closed drilling mud system.

Considering the operation of the invention, it will be assumed that the surface casing **82** is used without a larger casing around it, and that at least the latching means **104** and the guide funnel **106** are installed subsequently, in which case the initital operation to be performed is to set the surface casing **82**, with the blowout preventer **84** thereon, in the earth **70** below the body of water **72**, which may be accomplished in various ways. For example, it may be accomplished by positioning the well **12** through the boat **10** over the desired location and drilling the enlarged bore **156** with the equipment on the boat, the surface casing **82** and the blowout preventer **84** then being lowered into the enlarged bore **156** by means of the guide lines **92**. If desired, the surface casing **82** may be cemented in place with any conventional procedure.

While it was assumed above that the blowout preventer **84** is installed on the surface casing **82** at the time it is set in the earth **70** below the body of water **72**, it will be understood that, as hereinbefore explained, the blowout preventer may also be lowered into place subsequently by making it a part of the structure **102**.

With the surface casing **82** in place, and with the carriage **22** moved to its inoperative position at one side of the well **12**, the structure **102** is lowered through the well **12** on the guide lines **92** into operative engagement with the surface casing, the means **94** being energized to maintain constant and equal tensions in the guide lines. With this procedure, the guide lines serve as a locating means between the boat **10** and the surface casing **82** to insure proper engagement between the structure **102** and the surface casing.

As hereinbefore explained, however, the blowout preventer **84**, the latching means **104** and the guide funnel **106** may also be lowered with the surface casing as a unit.

Once the structure **102** has been properly positioned relative to the surface casing **82**, the conductor tube **112** is lowered into place through the well **12** in the boat **10**, the guide funnel **106** serving to align the conductor tube with and guide it into the upper end of the [surface casing] *wellhead structure*. Once the conductor tube has been inserted into the [surface casing] *wellhead structure*, the latching means **104** is energized through the hydraulic lines **130** to move the latch elements **124** inwardly into closing engagement around the reduced-diameter portion of the latch mandrel **128**, thereby anchoring the lower end of the conductor tube to the [surface casing] *wellhead structure*. The means **138** for maintaining constant and equal tensions in the supporting lines **134** is energized, whereby these supporting lines carry the weight of the conductor tube **112**, and apply thereto a constant supporting force despite movement of the boat **10** vertically and/or horizontally relative to the surface casing. As hereinbefore explained, the flexible joint **116** in the conductor tube **112** permits lateral movement of the boat **10** relative to the surface casing **82**, while the slip joint **120** compensates for vertical and horizontal movement of the boat relative to the surface casing.

The foregoing accomplished, the carriage **22** is wheeled into its operative position over the well **12** and the drill string **64** with the bit **66** thereon is lowered through the rotary table **30**, the conductor tube **112**, and the surface casing **82** into engagement with the bottom of the bore **156**. It will be understood that the kelly bushing **60** carried by the rotor **54** of the rotary table **30** is removed for the foregoing operation, and that the guide funnel **144** at the upper end of the conductor tube **112** serves to align the drill string **64** with and to guide the bit **66** into the conductor tube. Next, the kelly bushing **60** is installed

to provide a torque-transmitting connection between the rotor **54** of the rotary table **30** and the kelly **62**. Thereafter, the motor **44** is activated and the clutch is engaged, whereupon the rotor **54** of the rotary table is driven through the driving connections hereinbefore discussed, whereby the bit **66** drills the bore **68**. As will be understood, the gimbal means connecting the rotary table **30** to the carriage **22** permits relative tilting movement of the boat **10** and the rotary table to compensate for pitching and/or rolling of the boat, lateral displacement of the boat so that the axis of the well **12** therethrough is out of alignment with the axis of the surface casing **82**, and the like. Extending the drive means **34** for the rotary table through one of the inner pivots **32** of the gimbal system permits driving of the rotary table irrespective of the relative angular positions of the rotary table and the boat **10**.

As the rotary table **30** is operated in the foregoing manner to rotate the bit **66** and to cause it to drill the bore **68**, the drilling mud system is placed in operation, drilling mud from the mud tank, not shown, being delivered to the kelly **62** through the drilling mud supply line **148**, the drilling mud then flowing downwardly through the drill string **64** and out through the bit **66** into the annulus between the drill string and the wall of the bore **68**. The drilling mud carries cuttings removed by the bit **66** upwardly through the annuli between the drill string **64** and the wall of the bore **68**, between the drill string **64** and the surface casing **82**, between the drill string **64** and the lower section **114** of the conductor tube **112**, and between the drill string **64** and the upper section **118** of the conductor tube **112**. From the annulus last mentioned the cutting-laden drilling mud flows through the drilling mud return line **150** into the mud sump **152**.

As will be apparent, the subaqueous drilling apparatus heretofore disclosed may be transported from one location to another readily and may be set up in or removed from a particular location with a minimum expenditure of time and effort, there being no necessity for providing supporting means between the earth **70** below the body of water **72** and the supporting structure for the drilling equipment. The use of the guide lines **92** for the structure **102** provides for quick and easy positioning of this structure in operative relation with the surface casing **82**, and the guide funnel **106** provides for quick and easy positioning of the conductor tube, the guide funnel **144** facilitating insertion of the drill string **64** into the conductor tube. Since the supporting lines **134** apply a constant supporting force to the conductor tube **112** despite shifting of the boat **10** relative to the surface casing **82**, the surface casing is not relied upon to carry the weight of the conductor tube, the latching means **104** merely serving to anchor the lower end of *the* conductor tube relative to the [surface casing] *wellhead structure*. The flexibility built into the drive system for the rotary table and into the conductor tube permits substantial shifting of the boat **10** relative to the surface casing **82** both horizontally and vertically without affecting the operation of the system. Also, the conductor-tube structure disclosed, and the disclosed relationship between the conductor tube **112** and the surface casing **82**, permits the use of the closed drilling mud system described, which is advantageous.

Turning now to FIG. 6 of the drawings, illustrated therein is an alternative rotary-table orienting means for compensating for relative tilting of the rotary table **30** and the boat **10**, this orienting means being designated generally by the numeral **160**. As illustrated in FIG. 6, the rotary table **30** is carried by a supporting frame **162** which is connected to the structure of the boat **10** by at least three fluid motors **164**. In the particular structure shown, the fluid motors include cylinders **166** pivotally connected to the structure of the boat and have therein pistons, not shown, equipped with piston rods **168** connected to the supporting frame **162**. The cylinders **166** are interconnected by lines **170**, these lines being connected to a common source of fluid pressure, such as a hydraulic accumulator **172**, by a line **174**. As will be apparent, with this structure the supporting frame **162** will always be maintained in a position providing a predetermined orientation for the axis of the rotary table **30**, despite relative tilting movement of the rotary table and the boat **10**. Normally, the rotary table axis will be vertical, or substantially vertical, it being understood that the rotary table axis may be considerably off vertical in the event that the position of the boat **10** shifts laterally relative to the bore being drilled.

Although I have disclosed exemplary embodiments of my invention herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention as defined by the following claims.

I claim:

1. In a subaqueous drilling apparatus, the combination of: supporting means adapted to float on a body of water; submerged anchoring means including a casing set in the earth below the body of water; flexible guide lines extending between and connected to said supporting means and said anchoring means; a tubular well head structure connected to said anchoring means in communication with said casing, at least part of said well head structure being releasable and engaging and being movable vertically along said guide lines between said supporting means and said anchoring means; a conductor tube extending between said supporting means and said well head structure; flexible supporting lines extending between and connected to said supporting means and said conductor tube and supporting said conductor tube; latch means releasably connecting said conductor tube to said well head structure with said conductor tube in communication with said well head structure; packer means providing a fluid-tight seal between said conductor tube and said well head structure; a drill string extending downwardly through said conductor tube and said well head structure into said casing and having a drill bit at its lower end; means on said supporting means for supporting said drill string; means on said supporting means for rotating said drill string; a drilling mud supply line connected to said drill string adjacent the upper end thereof; and a drilling mud return line connected to said conductor tube adjacent the upper end thereof.

2. An apparatus as set forth in claim **1** wherein said latch means is a fluid operated latch means carried by said well head structure and engageable with said conductor tube, said apparatus including operating fluid supply lines extending between said latch means and said supporting means and connected to said latch means.

3. An apparatus according to claim **1** including: gaseous-fluid-operated motors carried by said supporting means and respectively connected to said guide lines; other gaseous-fluid-operated motors carried by said supporting means and respectively connected to said supporting lines; means for supplying gaseous fluid at constant and equal pressures to the motors first mentioned; and means for supplying gaseous fluid at constant and equal pressures to said other motors.

4. In an apparatus for carrying out operations such as drilling and working in a well bore in a formation underlying a body of water including supporting means adapted to float on a body of water, driving means for a drill string including a rotary table carried by said supporting means and a derrick carried by said supporting means for lowering drilling equipment through the body of water and into operative relationship with the well bore, the combination comprising:

submerged anchoring means including a casing set in the earth below the body of water;

flexible guide lines extending between and connected to said supporting means and to said anchoring means;

tubular wellhead structure engaging and movable ver-

tically along said guide lines between said supporting means and said anchoring means;

means for connecting said tubular wellhead structure to said anchoring means in communication with said casing;

a conductor tube extending between said supporting means and said wellhead structure providing a conduit through which a drill string driven by said rotary table may be lowered into said well bore and raised therefrom by said derrick;

guiding means located adjacent said wellhead structure for bridging the lower end of said conductor tube into position to be connected to said well head structure,

fluid-operated latching means for connecting the lower end portion of said conductor tube to said wellhead structure to form with that structure a continuous conduit between the well bore and said supporting means;

means for actuating said latching means from said supporting means respectively to connect and disconnect said conductor tube from said wellhead structure; and

means connected to the upper portion of said conductor tube for supporting the upper end of said conductor tube in the vicinity of said supporting means during the time said lower end of said conductor tube is connected by said latching means to said wellhead structure.

5. The apparatus of claim 4 in which the connection of said guide lines includes means at the lower ends thereof to secure them to said anchoring means and the opposite ends thereof include in their connection to said supporting means tensioning means for maintaining said flexible guide lines under substantially constant tension thereby to maintain them relatively taut with movement of said supporting means relative to said anchoring means.

6. The apparatus of claim 4 in which said conductor tube comprises telescopically related upper and lower sections slidably sealed together and in which there is further provided for said lower section of said conductor tube supporting means for applying to the upper portion of the lower section of said conductor tube upwardly directed supporting forces of substantially constant magnitude.

7. The apparatus of claim 4 in which a blowout preventer is disposed in communication with said casing and is operative to close said casing after removal of said drill string therefrom.

8. The apparatus of claim 4 in which carriage means are provided on said supporting means for supporting said rotary table and for movement thereof into an operative position for drilling and into an inoperative position providing unobstructed access to the upper end of said conductor tube for transport of drilling equipment therethrough under the control of said derrick.

9. Apparatus for carrying out operations such as drilling and working in a well in a formation underlying a body of water comprising:

a floating vessel;

submerged anchoring means including a casing having an opening therethrough set in the earth below the body of water;

tubular wellhead structure connected to said anchoring means in communication with said casing;

a generally upright elongated hollow conductor tube disposed beneath the vessel so that the upper end of said conductor tube terminates in the vicinity of the vessel and the opposite end terminates in communication with said opening extending through said anchoring means and said tubular wellhead structure;

guiding means located adjacent said wellhead structure for bringing the lower end of said conductor tube into position to be connected to said wellhead structure;

releasable latching means for connecting said lower end of said conductor tube to said wellhead structure;

means supported by said vessel for actuating said latching means to connect said lower end of said conductor tube to said wellhead structure to form with said opening a continuous conduit through which drilling equipment may be moved to and from the well and the vessel and for releasing said latching means to permit said conductor tube and said wellhead structure to be separated from each other;

means supported by said vessel connected to the upper portion of said conductor tube to bring its lower end into position to be engaged by said latching means and upon disengagement of said latching means to raise said conductor tube; and

supporting means connected to the upper portion of said conductor tube for applying thereto upwardly directed supporting forces of substantially constant magnitude.

10. Apparatus to facilitate operations such as drilling and working in a well in a formation underlying a body of water comprising:

a floating vessel;

a generally upright elongated hollow conductor tube disposed beneath the vessel so that the upper end of said conductor tube terminates at the vessel;

means for supporting said upper end of said conductor tube in said vicinity of said vessel;

anchoring means including a casing secured to the formation and having an opening therethrough communicating with the upper end of the well;

wellhead structure connected to said anchoring means in communication with said opening;

fluid-operated releasable latching means for connecting the lower end of said conductor tube to said wellhead structure to form a continuous conduit between the well and the vessel;

a drill string extending down from the vessel through said conductor tube and through the opening in said anchoring means;

means for supporting said drill string in a generally upright position;

means for lowering or raising said conductor tube with respect to the wellhead structure to move it into or out of connecting position therewith;

remote control means for releasing said latching means from the water surface to permit said conductor tube and said wellhead structure to be separated from each other so the conductor tube can be raised from said wellhead structure; and

guide lines extending between and connected to said vessel and to said anchoring means for guiding said wellhead structure into connecting relationship with said anchoring means.

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