Feb. 16, 1965 B. J. BULLARD 3,169,586

UNDERWATER WELL-DRILLING METHOD

Filed March 11, 1963

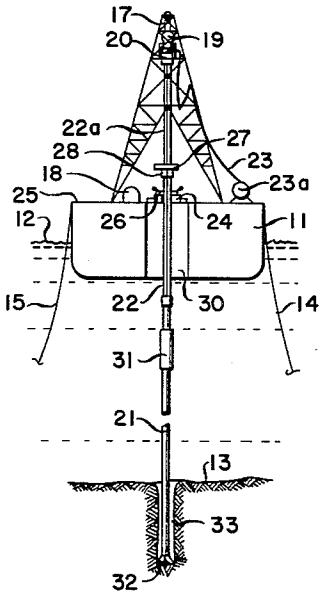


FIG. 1

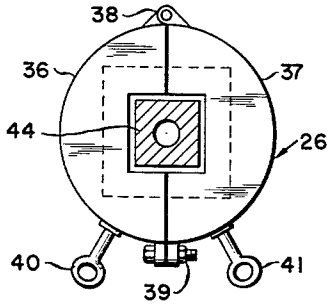


FIG. 4

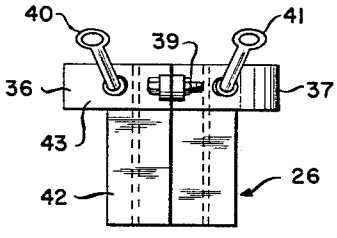


FIG. 5

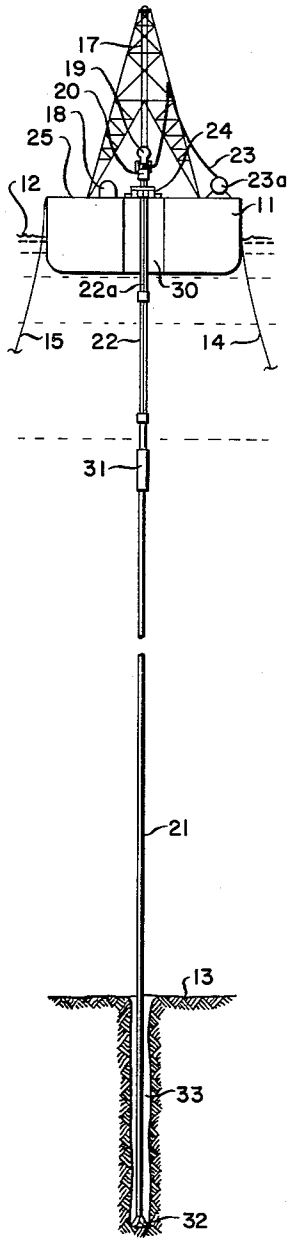


FIG. 2

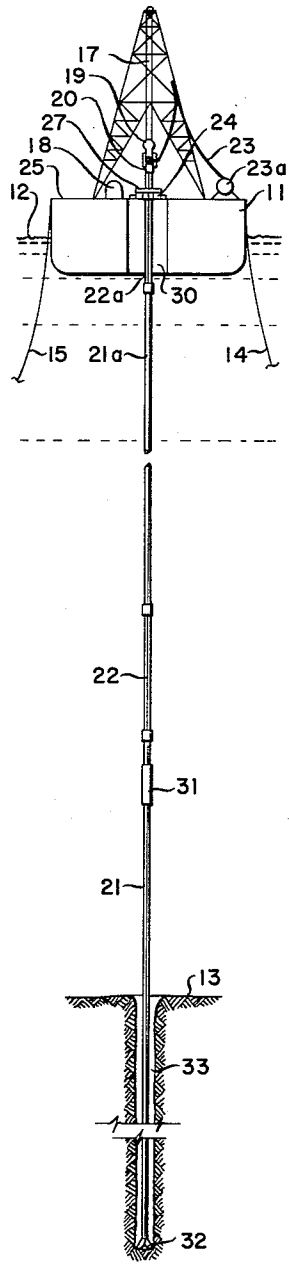


FIG. 3

INVENTOR:
B. J. BULLARD
BY: J. H. McCarthy
HIS AGENT

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UNDER WATER WELL-DRILLING METHOD

Billy J. Bullard, Oklahoma City, Okla., assignor to Shell Oil Company, New York, N.Y., a corporation of Delaware

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6 Claims. (Cl. 175—5)

This invention is related to the underwater drilling of oil and gas wells and pertains more particularly to methods and apparatus for maintaining contact with a hole drilled in the ocean floor during well drilling operations.

During recent years, the continued search for oil has resulted in developing methods and apparatus for drilling underwater wells at locations where the water may range from 100 to 1500 feet or more in depth. In these locations it is customary to position the well head at a considerable distance below the surface of the water, preferably on the ocean floor, so that it is not a hazard to the navigation of ships in the area. One method of drilling and completing wells in this manner is described in co-pending patent application Serial No. 830,538, filed July 30, 1959, and entitled "Underwater Well Completion Method." One of the most important operations in the drilling of an underwater well is that of starting the well and installing the conductor or foundation pipe in the ocean floor. This operation may be carried out in any one of several ways, one of which is described in U.S. Patent 2,929,610, issued March 20, 1962 to H. Stratton. In the described method of the patent, a drill bit drills a hole in the ocean floor slightly larger in diameter than the diameter of the well conductor or foundation pile which is subsequently slipped down along the drill pipe and into the hole during which time drilling fluid is pumped down the drill pipe and up the outside of the foundation pile. A problem arises at the start of drilling operation where a drill string is provided at the top thereof with a kelly which is rotated by means of a rotary table on the operating deck of the vessel. Thus, after the first 30 or 45 feet of hole has been drilled in the ocean floor, it is necessary to disconnect the kelly from the top of the drill pipe, add an additional section of drill pipe, reconnect the kelly to the top of the added section of pipe, and then continue drilling the well with the kelly in the rotary table.

However, a drill string must normally be pulled up in order to remove the kelly and add a section of pipe to the upper end thereof. In pulling the pipe up of course it would be pulled out of the hole in the ocean floor and it would be extremely difficult, without considerable luck, to stab the drill bit at the lower end of the drill string into the previously drilled hole in order to continue drilling operations. One means of overcoming this problem is disclosed in co-pending patent application Serial No. 226,877, filed September 28, 1962, wherein a drilling vessel is provided with a lower deck at which point the drill string may be suspended while an extra section of pipe is being added to the drill string below the kelly. If drilling is being carried out in soft formations, it is feasible in some instances to overcome the problem by employing a power swivel attached to the top of the drill string for drilling the first 50 or 100 feet of hole in the ocean floor. This solution could not be used however, when drilling in certain rocky formations.

It is therefore, a primary object of the present invention to provide a method and apparatus for drilling an underwater well with normal drilling equipment without losing contact with the hole in the ocean floor when it is necessary to add more sections of drill string when starting a well.

A further object of the present invention is to provide a method and apparatus whereby a Kelly section may

be employed in a conventional rotary table during the start of underwater well drilling operations which are carried out without losing contact with the hole drilled in the ocean floor.

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

FIGURES 1 through 3 are diagrammatic views taken in longitudinal projection illustrating a floating vessel positioned over a drilling location during the sequential steps of starting a well, adding an additional Kelly section to the drill string, and drilling more hole after additional sections of drill pipe have been added between Kelly sections of a drill string.

FIGURES 4 and 5 are plan and front elevation views of one form of a hinge-type removable drive bushing adapted to be positioned in a rotary cable.

Referring to FIGURES 1 through 3 of the drawing, a drilling vessel, barge or platform 11, of any suitable floating or floatable type is illustrated as floating on the surface of a body of water 12 while being substantially fixedly positioned over a pre-selected well location by suitable vessel positioning means well-known to the art, or by being anchored to the ocean floor 13 by anchor lines 14 and 15 running to anchors (not shown). Equipment of this type may be used when carrying out well drilling operations or well work-over operations in water varying from about 150 feet to 1500 feet or more in depth. The drilling vessel 11 is equipped with a suitable derrick 16 containing a fall line system 17 which includes a suitable hoist 18, travelling block 19 and suitable hook and swivel or other connector means 20 adapted to be connected to the top of the drill pipe 21 during well drilling operations and being adapted to circulate a drilling fluid therethrough in a manner well-known to the art. A kelly, consisting of Kelly sections 22 and 22*a*, which are sections of pipe having a square or non-round outer surface, is interposed between the top pipe section of the drill string 21 and the swivel 20. A hose 23 for circulating mud from a pump 23*a* into the top of a drill string is connected to the swivel 20.

The vessel 11 is also provided with other auxiliary equipment needed during well drilling operations, such for example as a rotary table 24 positioned on the operating deck 25 of the vessel. In FIGURE 1 the lower Kelly section 22 is shown as being provided with a split-type drive bushing 26 which is illustrated as seated in the rotary table 24 with drilling operations being carried out. The upper Kelly section 22*a* is provided with a normal Kelly drive bushing 27 which is slidably secured to the kelly and rests on the lower shoulder 28 of the upper Kelly section 22*a*.

The split-type drive bushing 26 is illustrated in one form in FIGURES 4 and 5 as having two body halves 36 and 37 split vertically and preferably secured together along one edge by a vertical hinge pin 38 and on the other side by any suitable easily removable or disconnectible connector means, such as a bolt 39. Rigid lifting handles 40 and 41 may be provided if desired. The lower section 42 of the drive bushing 26 is of a shape to fit within a central opening of the rotary table while the flange section 43 above it prevents it from falling through. In FIGURE 4 a square Kelly section 44 is shown as being positioned within the opening of the center of the drive bushing 26. A drive bushing of the type shown in FIGURES 4 and 5 is preferred for use with the lower Kelly section 22 since it may be readily disconnected from the kelly without loss of operating time and it is only used when drilling the hole to a depth equal to the length of the lower Kelly section 22.

It is to be understood, however that a normal Kelly drive bushing, such as that illustrated at 27 on the upper

Kelly section 22*a*, may also be employed on the lower Kelly section 22, if desired. Additionally, if there are no working shoulders such as shoulder 28 between the Kelly sections 22 and 22*a*, a single drive bushing 27 could be employed for both the Kelly sections 22 and 22*a*. Preferably, the rotary table is provided with a gimbal mounted drive bushing of the type made by Abegg and Rinehold Company, Los Angeles, California and described in the 1962–63 edition of Composite Catalog of Oil Field Equipment and Services, page 123.

While the kelly has been described as having two Kelly sections 22 and 22*a*, the lower Kelly section 22 is actually in the form of a square section of drill pipe since its upper tool joint is provided with a right-hand thread so as to fit into the normal right-hand thread at the lower end of the upper Kelly section 22*a*. The upper Kelly section 22*a* on the other hand is a true kelly with its upper tool joint being provided with a left-hand threaded connection so as to connect to the swivel 20. In describing the lower Kelly section 22 as being a section of square drill pipe it is to be understood that the cross-sectional configuration may be square, octagonal, hexagonal or any other non-round configuration. Since there is the possibility that the threaded sections of kelly may be caused to unscrew one from the other, they are preferably fixedly anchored together in any suitable manner as by temporarily welding them together in a manner which can be easily removed after the lower Kelly section has passed through the rotary table. Preferably, a cement is applied to the threads of adjacent Kelly sections before they are screwed together so that they cannot be unscrewed under forces encountered in normal drilling operations. The cementing material may be a thermoplastic material which, upon heating, say to 400° F., will lose its bonding strength so that the threaded connection can be broken and unscrewed.

The derrick 16 is positioned over a drilling slot or well 30 which extends vertically through the barge in a conventional manner. When using equipment of the present invention, a slot 30 in the vessel 11 may be either centrally located or extend in from one edge. Alternatively, drilling operations may be carried out over the side of the vessel without use of a slot. For example, the drilling vessel may be provided with a deck portion which overhangs the hull of the vessel.

The drill string 21 preferably includes a telescoping joint in its length to compensate the rise and fall of the vessel 11 relative to the drill string 21. The length of the telescoping joint 31 is selected to be preferably slightly greater than the expected rise and fall of the vessel so that the drill bit 32 will remain in drilling contact with the bottom of the well or hole 33 regardless of weather conditions at the surface. The telescoping joint 31 may be near the upper end of the drill string at the start of the drilling operation, as shown in FIGURE 1, or it may be located just above the drill or bit collars in the form of a bumper sub in a manner well-known to the art. The bumper sub may have a telescoping length of say 5 feet, and more than one bumper sub may be employed if desired. Although for ease of illustration the drill string 21 is shown as a unitary length of pipe, it is well-known that a pipe string or drill string used in well drilling operations is made up by threadedly connecting together several short (say 30 feet) sections of pipe to make up a pipe string of the desired length.

FIGURES 1 through 3 illustrate the start of the method of the present invention in which an underwater well is drilled from a floating vessel 11 positioned at the surface of the water. In starting a well the drilling vessel 11 is first positioned at a selected drilling location. The drill string 21 having a bit 32 at the lower end thereon is lowered from the vessel into contact with the ocean floor. Several of the bottom sections of the pipe forming the lower end of the drill string 21 may be thick-walled type in the form of drill collars, if desired. The drill string

21 includes a kelly or Kelly sections 22, 22*a* at the upper end thereof which are slidably positioned in the bushings 26 and 27, respectively, of the rotary table in a manner well-known to the art. Drilling is commenced by the rotary table 24 being driven by suitable motor means to rotate the lower Kelly section 22 and the drill string 21 connected to its lower end. At this time the split type drive bushing 26 is temporarily connected to the lower section of kelly 22. As the drill bit 32 is drilled into the ocean floor, the Kelly section 22*a* slides down through the bushing 26 in the rotary table 24 until the upper end thereof reaches the bushing 26.

At this time, in conventional well drilling operations from land, the kelly is pulled upwardly together with the drill string and the top pipe section of the drill string just below the kelly is wedged in the rotary table and supported therefrom by means of slips positioned around the drill pipe in a manner well-known to the art. The kelly 22 is disconnected from the suspended pipe or drill string 21, a new section of pipe is connected in its place, the kelly is then connected to the new section of pipe, and the drill string and the kelly are lowered so that the kelly is in the rotary table again. Drilling of the well is then continued. In disconnecting and picking up the kelly, the drive bushing of the rotary table normally comes with it. It is apparent from the above description that if the drill string is pulled up and suspended from the rotary table of the drilling vessel in the above described manner, the lower end of the drill string will be pulled out of the hole 33 of the ocean floor and cannot readily be blindly inserted back into the hole by conventional drilling practices. It is therefore important that at least the lower end of the drill string 21 remain in the hole 33 in the ocean floor at all times during drilling operations.

In the drilling method of the present invention, instead of pulling the drill string 21 back to the rotary table in order to support it while an additional length of pipe is added to the upper end thereof, drilling is continued until the upper end of the lower Kelly section is at the rotary table and the telescoping joint or drill string section 31 is in an extended position. The rotary table 24 is then stopped temporarily while the split type drive bushing 26 is discontinued from the lowermost Kelly section 22. The entire drill string is then lowered a short distance until the Kelly drive bushing 27 on the upper Kelly section 22*a* is seated in the rotary table. Rotation of the table 24 is started again and drilling is continued with the upper Kelly section 22*a* being positioned in the rotary table bushing and sliding downwardly therethrough as more hole is drilled in the ocean floor.

When additional hole has been drilled in the ocean floor equal in depth to at least some and preferably the entire length of the upper Kelly section 22*a*, drilling operations are suspended and the entire drill string 21 is raised by means of the fall-line system 17 until the upper end of the Kelly section 22 is above the rotary table so that it can be securely wedged and supported therefrom in a manner well-known to the art, as by the use of slips. The two Kelly sections 22 and 22*a* are then disconnected one from the other and a section of drill pipe 21*a* (FIGURE 3) is secured to the top of the lower Kelly section 22. The upper Kelly section 22*a* is connected to the added section of pipe 21*a* and then the entire drill string is lowered by means of the fall-line system 17 until the Kelly drive bushing 27 is again seated in the rotary table. Drilling operations are then continued in a normal manner and these steps are repeated for each section of drill pipe that is added to the drill string. Thus, as shown in FIGURE 3, the lower Kelly section 22 is left in and becomes a part of the drill string and subsequently moves down into the hole 33 in the ocean floor if the hole being drilled is of a depth greater than the depth of the water in which well operations are being carried out. For safety of operations it is preferred that the bumper sub or telescoping pipe joint 31 in the

drill string be allowed to drill off its full length prior to changing from the lower kelly section **22** to the upper Kelly section **22***a*. This operation takes place after the upper shoulder of the lower Kelly joint **22** has reached the split drive bushing **26** by merely continuing rotation of the drill string and the weight of the drill string **21** below the telescoping joint **31** will cause the telescoping joint **31** to become extended to its full length. In disconnecting the lower Kelly section **22** from the upper Kelly section **22***a* it may be necessary to heat the connection between the two in order to soften a cement bonding material, in the event that such a material was used.

A normal kelly is generally provided with round shoulders or tool joints at each end thereof with the non-round portion of the kelly extending between the shoulders. The shoulders are provided whereby the kelly may be engaged by a pair of tongs. Since these shoulders would not operatively engage a Kelly drive bushing in a rotary table, drilling is continued with the upper shoulder of the lower Kelly section at the rotary table until the telescoping section of drill string has become extended preferably a distance at least equal to the length of the shoulders.

I claim as my invention:

1. In a method of drilling an underwater well from a floating drilling vessel equipped with a rotary table for engaging the upper and lower coupled together sections of a kelly in a drill string having a telescoping section in its length, the steps of the method comprising

(*a*) drilling a hole in the ocean floor while the lower section of kelly is in engagement with the rotary table,

(*b*) continuing drilling of the hole while the upper section of kelly is in engagement with the rotary table,

(*c*) stopping drilling of the hole and securing the drill string to the vessel at a point below the upper Kelly section,

(*d*) installing a pipe section in the drill string between the Kelly sections, and

(*e*) continuing drilling of the hole with the upper Kelly section in engagement with the rotary table.

2. The method of claim 1 including the step of continuing drilling of the hole with the lower Kelly section in engagement with the rotary table until the telescoping section of drill string is in an extended position.

3. The method of claim 2 wherein drilling is continued until the telescoping section of drill string has become extended at least a distance substantially equal to the length of coupling portions of the Kelly sections.

4. A method of drilling an underwater well from a drilling vessel at the surface of the water said vessel being equipped with a rotary table and a hoist system, said method comprising the steps of

(*a*) positioning said vessel at a selected drilling location,

(*b*) lowering from the vessel into contact with the ocean floor a drill string having a bit at its lower end, a telescoping section intermediate the ends thereof and two Kelly sections at the upper end thereof,

(*c*) inserting the lowermost Kelly section into operative engagement with the rotary table,

(*d*) drilling a hole in the ocean floor by applying a rotating force to the lowermost Kelly section to rotate the drill string,

(*e*) continuing drilling until the upper end of the lowermost Kelly section is at the rotary table and the telescoping drill string is in an extended position,

(*f*) lowering said upper Kelly section into operative engagement with said rotary table,

(*g*) continuing drilling with the upper Kelly section in the rotary table,

(*h*) subsequently suspending drilling operation and securing said drill string to the drilling vessel at a point below the upper Kelly section,

(*i*) disconnecting the upper Kelly section from the top of the drill string,

(*j*) coupling a section of drill pipe to the top of the lowermost Kelly section and connecting the upper Kelly section to said drill pipe section, and

(*k*) again operatively engaging the upper kelly section in the rotary table and rotating the drill string to drill more hole.

5. The method of claim 4 including the preliminary step of making up a drill string having two Kelly sections in it that are temporarily fixedly secured together.

6. In a method of drilling an underwater well from a floating drilling vessel equipped with a rotary table for engaging a Kelly section of a drill string having a telescoping section in its length, the steps of the method comprising

(*a*) drilling a hole in the ocean floor while the Kelly section is in engagement with the rotary table,

(*b*) subsequently adding a second Kelly section to the top of the original Kelly section,

(*c*) continuing drilling operations with the second Kelly section in engagement with the rotary table,

(*d*) stopping drilling operations and securing the drill string to the vessel at a point below the second kelly section,

(*e*) disconnecting the two Kelly sections and threadedly connecting another section of drill pipe between them, and

(*f*) lowering the drill string to the bottom of the drilled hole and continuing drilling operations with the second Kelly section in the rotary table.

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BENJAMIN HERSH, *Primary Examiner.*