

July 5, 1966

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3,259,198

METHOD AND APPARATUS FOR DRILLING UNDERWATER WELLS

Filed May 28, 1963

6 Sheets-Sheet 1

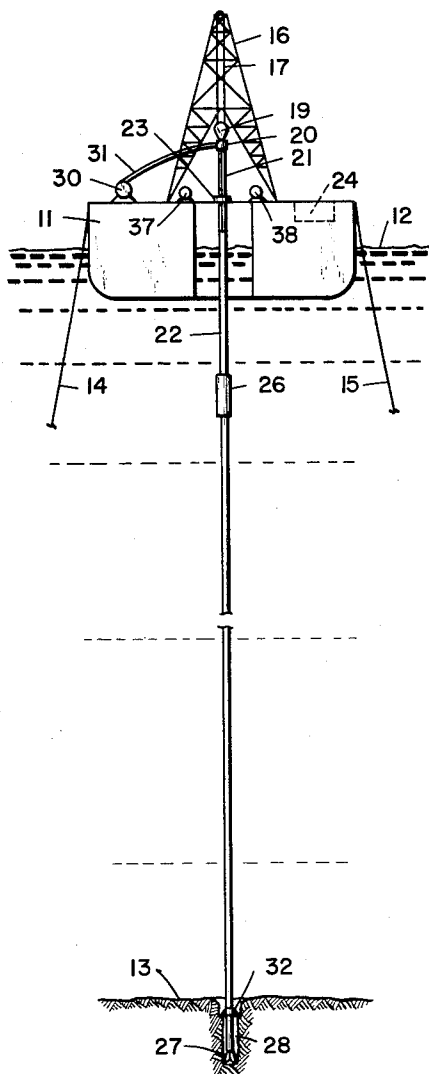


FIG. 1

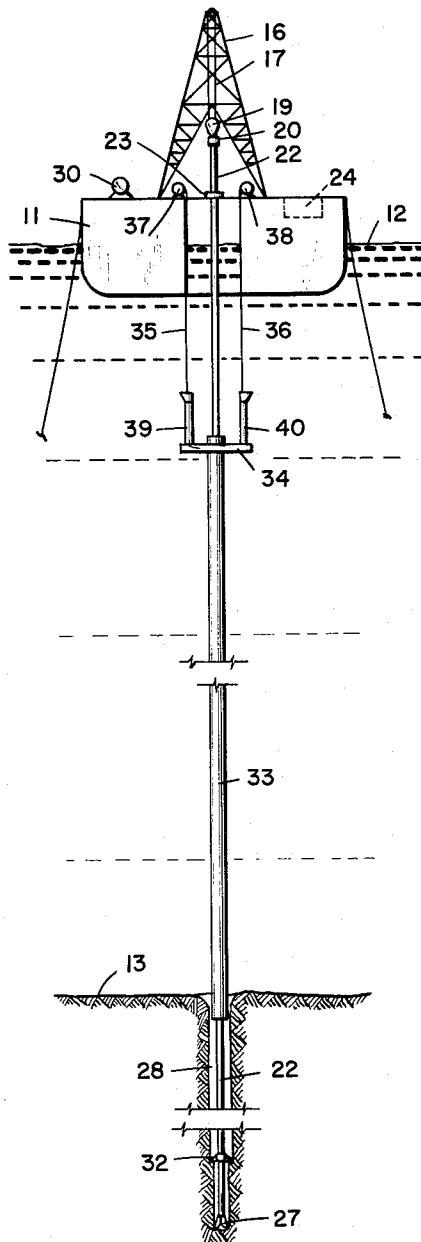


FIG. 2

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6 Sheets-Sheet 2

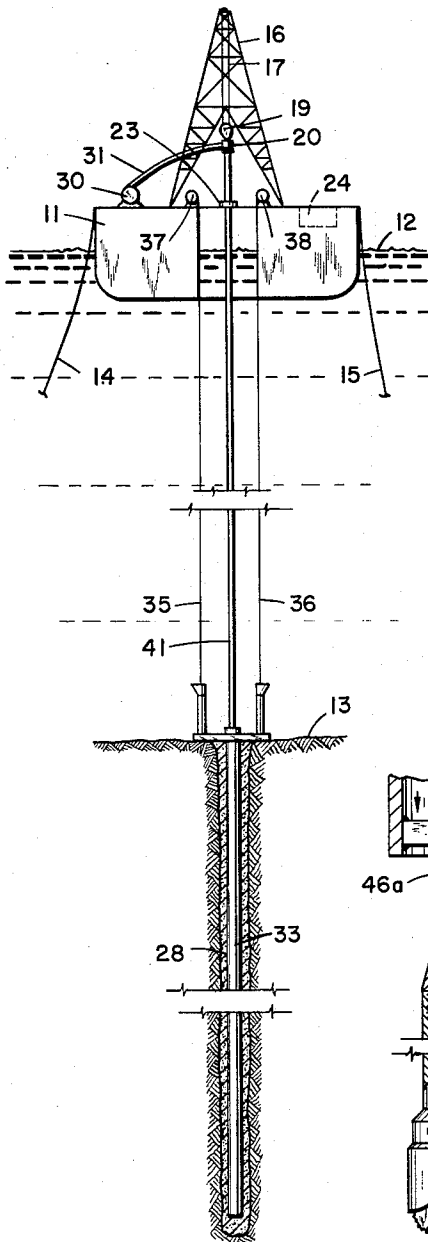


FIG. 3

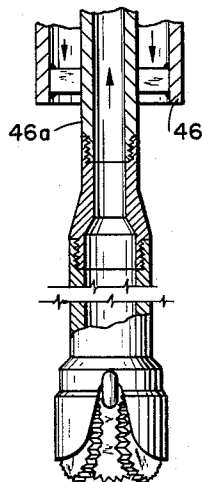


FIG. 17

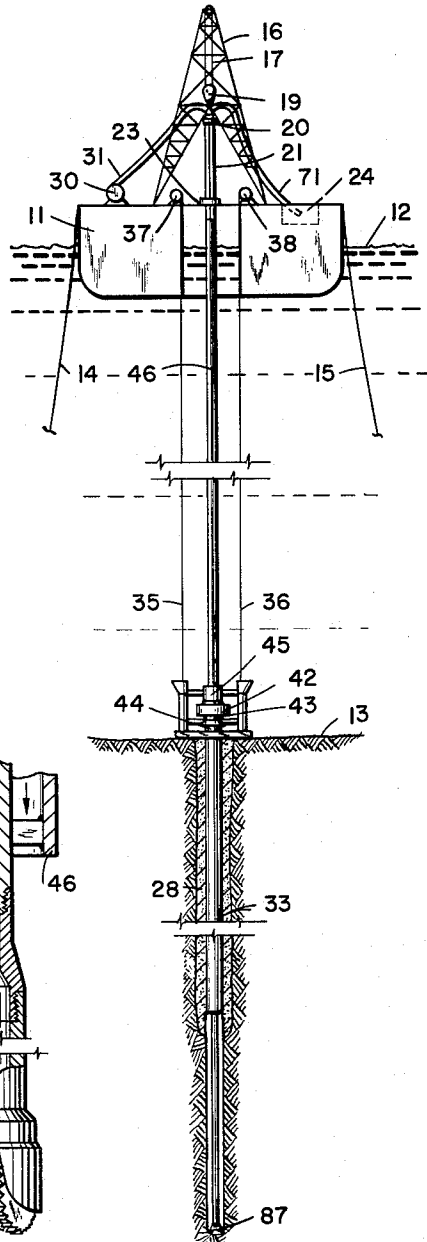


FIG. 4

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6 Sheets-Sheet 3

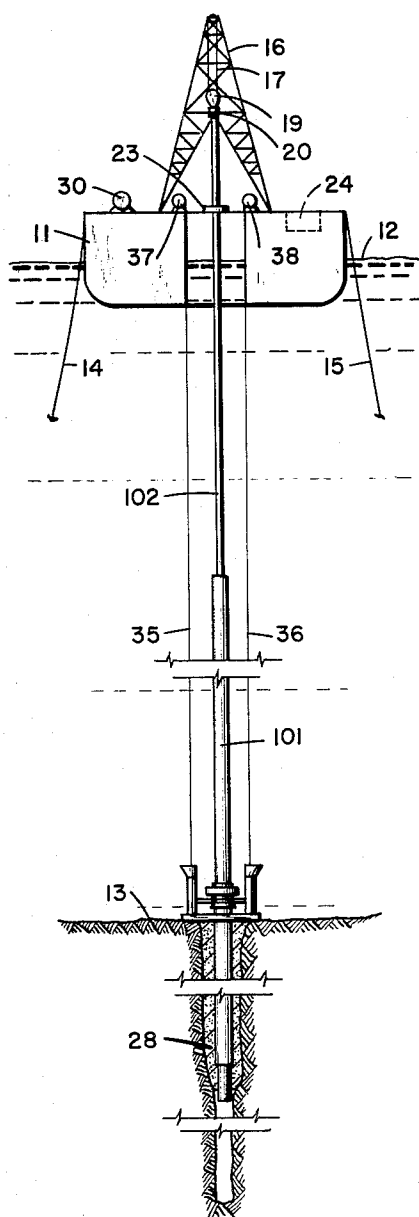


FIG. 5

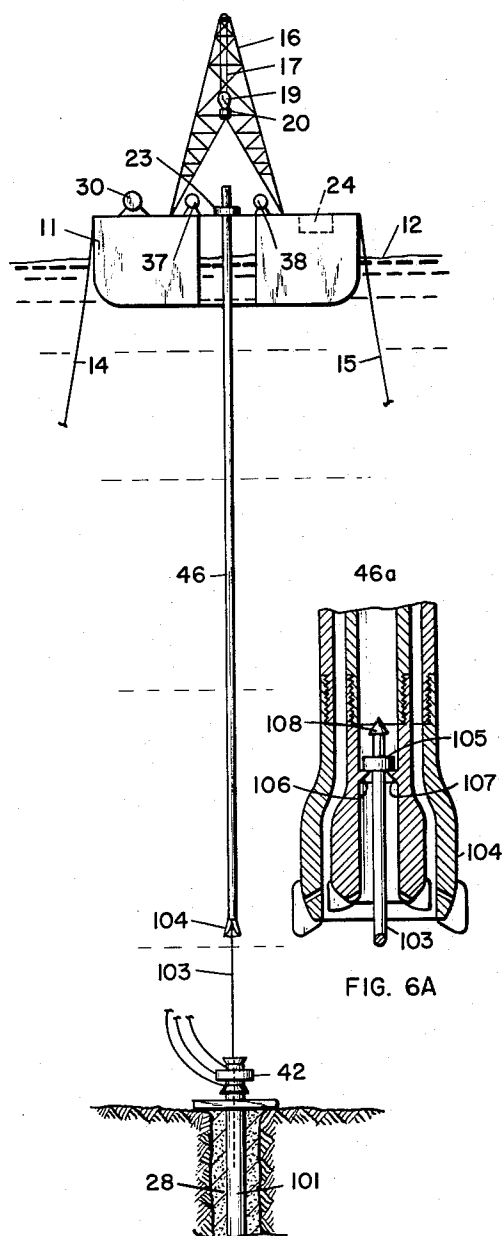


FIG. 6

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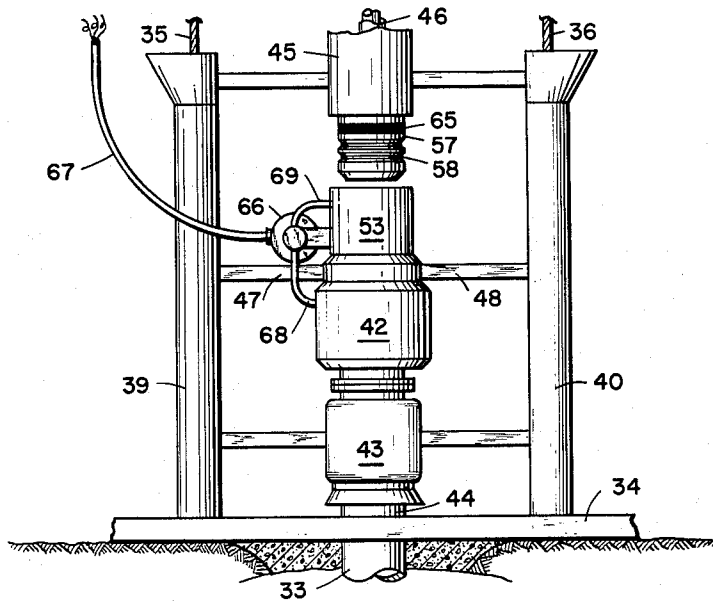


FIG. 9

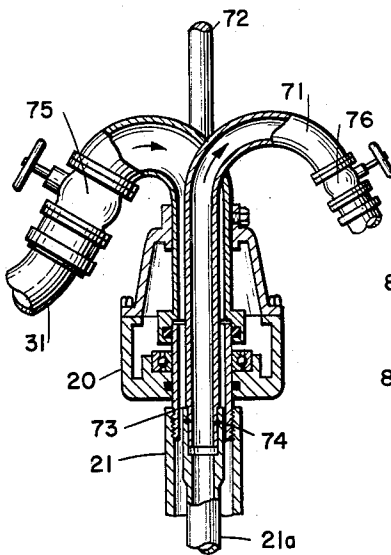


FIG. 10

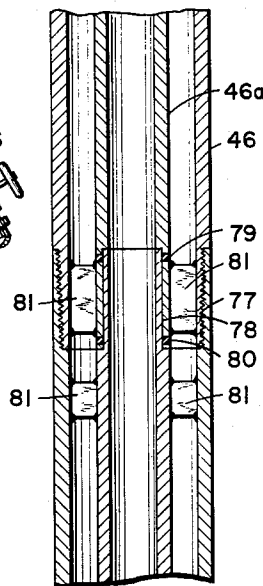


FIG. 11

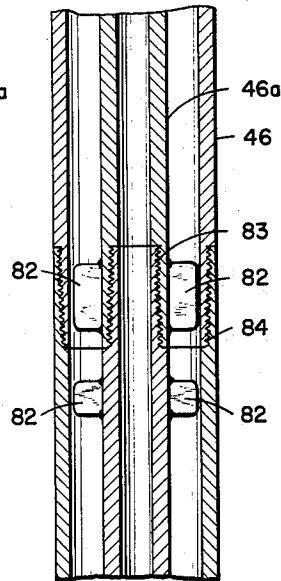


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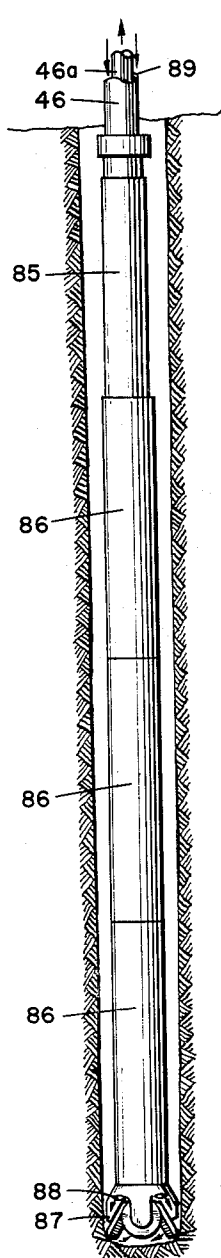


FIG. 13

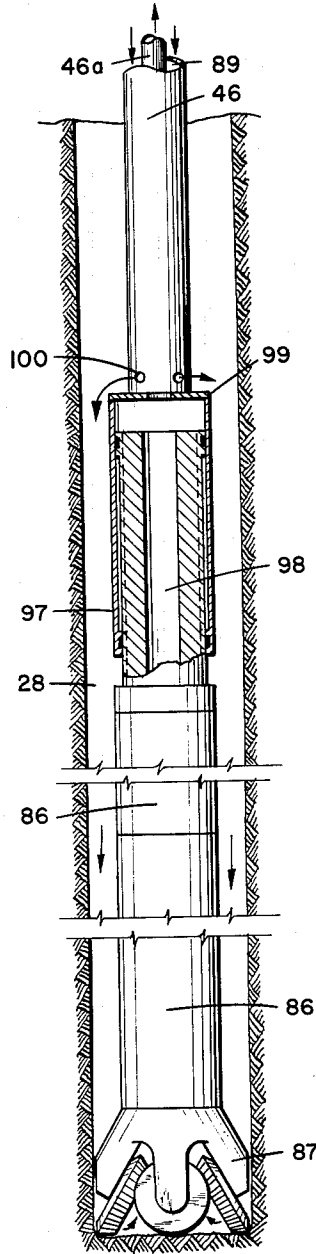


FIG. 14

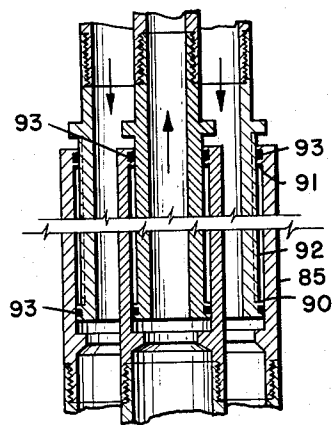


FIG. 15

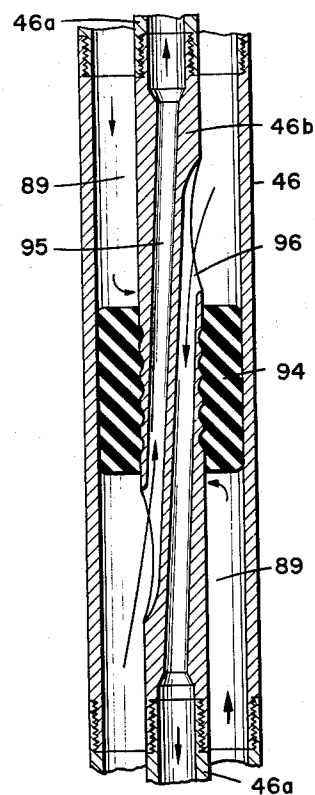


FIG. 16

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METHOD AND APPARATUS FOR DRILLING UNDERWATER WELLS

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Filed May 28, 1963, Ser. No. 283,844
13 Claims. (Cl. 175-7)

This invention relates to the underwater drilling of oil and gas wells and pertains more particularly to methods and apparatus for drilling underwater wells at deep-water locations from a floating vessel wherein it is essential that a drilling fluid be circulated down through a drill string to the bottom of the well and return to the vessel during 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 600 feet in depth. In these locations it is customary to position a wellhead at a considerable distance below the surface of the water, preferably on the ocean floor, so that it is not a hazard to navigation of ships in the area.

During the drilling of a well it is generally necessary to employ a drilling fluid which is circulated down through a rotating drill string and through the drill bit at the bottom thereof in order to flush the earth-formation cuttings away from the bit and transport them up the outside of the drill string and out of the well. In starting to drill a well in the ocean floor, the drilling fluid employed is normally salt water and no attempt is made to circulate the salt water into and out of the well and back to the vessel. Instead, as the salt water drilling fluid comes out of the well it is allowed to mix with the ocean. However, after drilling operations have continued for some time, it is necessary to change the drilling water composition from plain salt water to one containing clay and various chemical additives in order to give the drilling fluid the desired characteristics required at the particular location. In drilling through formations where gas or oil pressure may be encountered in a substantial amount, it is generally necessary to weight the drilling fluid by adding barites to the fluid.

Since drilling fluids may often be quite expensive and cost many thousands of dollars for a single well, it is essential that drilling fluid loss be reduced to a minimum. Previously, in drilling underwater wells from a floating vessel on the surface of the water, drilling fluid has been returned to the vessel in one of two manners.

In one system, in addition to the drill string extending between the vessel at the surface of the water and a wellhead on the ocean floor, a flexible hose is connected to the wellhead, preferably to one side thereof, so that when drilling fluid comes up the well outside the drill string to the wellhead it flows into the flexible hose and is forced up the hose to the vessel. While this method of drilling is satisfactory in shallow water locations at most offshore areas, in some areas where strong underwater currents exist, the flexible drilling fluid return hose is whipped back and forth and often against either the rotating drill string or the wellhead structure in a manner such that it wears out quickly and ruptures. When using this system in deep water location, one is faced with the problem of providing a hose having sufficient strength so that it will not pull apart when a considerable length of it, say 500 feet, is suspended from the vessel at the surface of the water. The hose must be fairly large and have a bore sufficient so that earth cuttings can be circulated up through the hose without clogging it. It is realized that any hose of this type can be strengthened by putting steel wire in its structure but this complicates the handling of the hose

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on the vessel or on hose reels because of the stiffness of the hose. Another disadvantage of using hoses for returning drilling fluid and earth cuttings to the surface is that the hose may temporarily kink in a manner such that the cuttings in the hose would form a plug at the kink which could not readily be circulated out when the hose was straight.

In order to overcome many of these problems in water depths over 100 feet, a second well drilling system was adopted which made use of a marine conductor pipe which is a large-diameter pipe, say 16 inches or more in diameter which extends from an underwater wellhead to a vessel on the surface of the water. The lower end of the marine conductor pipe is normally releasably latched to the top of the wellhead while the upper end of the marine conductor pipe is secured to the vessel at the surface, preferably by means of constant tension hoists so as to compensate for the rise and fall of the vessel relative to the underwater wellhead. In carrying out drilling operations with this apparatus utilizing a marine conductor pipe, after the wellhead was positioned on the ocean floor the marine conductor pipe was either stripped down over the drill string extending from the wellhead to the vessel, or the marine conductor pipe was lowered with the aid of suitable guide means into the latching position on the wellhead and a drill string was subsequently run down through the marine conductor pipe, the wellhead and into the well.

A marine conductor pipe of several hundred feet of large diameter pipe possessed considerable weight and it is a problem to support the weight of this pipe during drilling operations. It has been found undesirable to attempt to support the weight of this pipe on the underwater wellhead structure so all or most of the weight of the marine conductor pipe is either supported by means of constant tension hoists secured to its upper end or by means of buoyancy tanks secured to the outside of the marine conductor pipe, or a combination of the two solutions. The use of a marine conductor pipe possesses certain disadvantages. Because of the large diameter of the pipe its flexibility is much less than that of a drill pipe and hence the drilling vessel on the surface of the water to which the top of the marine conductor pipe is connected must be maintained in a relatively stationary manner against movement caused by wind and wave forces. If the vessel was allowed to move off position too far, that is, to an extent that the marine conductor pipe is not in a substantially vertical position between the vessel and the underwater wellhead, the marine conductor pipe may be permanently bent or ruptured.

Another drawback in using large diameter marine conductor pipes is that they contain substantially more drilling fluid than say a drill pipe. Thus, in drilling in 300 feet of water, a 20-inch diameter marine conductor pipe extended from the wellhead to the vessel at the surface would have a 20-inch column of drilling mud contained inside the pipe. When drilling in high pressure formations, this drilling mud may be weighted to as much as 17 or 18 pounds per gallon or 127 to 135 pounds per cubic foot. In the event that the top of a marine conductor pipe containing a heavy mud of this type starts to bend near the surface of the water, the action of gravity causes it to bend further thus endangering the pipe in the drilling operation. While these disadvantages have been overcome to date by the use of larger hoses from the vessel or larger buoyancy tanks on the marine conductor pipe in order to keep the latter in a substantially vertical position during drilling operations, these remedies are not practical when drilling in deep water locations where the water is from 1000 to 5000 feet deep.

In deep water locations it would be necessary to increase the size of the buoyancy tanks on the marine conductor tanks to an extent that they become quite enormous, thus possessing large areas against which wave forces and underwater currents could act in a manner causing the marine conductor pipe to deflect from its normally vertical position within the water. At the same time if constant tension hoists were to be employed to apply tension to the top of the marine conductor pipe from the vessel, larger and more buoyant vessels would have to be employed as well as vessels having larger hoists.

It is therefore a primary object of the present invention to provide a method and apparatus for drilling underwater wells at deep-water locations where it is necessary to circulate a drilling fluid from a vessel on the surface of the water down into the well and back to the vessel.

A further object of the present invention is to provide apparatus for drilling underwater wells wherein the fluid circulation system between the vessel and the well is more flexible than a marine conductor pipe and has greater strength and rigidity than a flexible hose.

Another object of the present invention is to provide apparatus for drilling underwater wells in deep-water locations wherein the fluid circulation system between the vessel and the underwater well is lighter than a marine conductor pipe so that it is more readily supported during drilling operations with its upper end at the vessel.

Still another object of the present invention is to provide apparatus for drilling in deep-water locations wherein the circulation system extending between the vessel and the wellhead is of a small size so that a minimum area is exposed to wave forces and underwater currents tending to deflect the system from the vertical.

A further object of the present invention is to provide apparatus for drilling deep-water wells from a vessel with a circulation system to an underwater wellhead which extends into and is slidably movable in the top of the wellhead so as to eliminate the need for a telescoping section of marine conductor pipe adjacent the vessel.

It is also an object of the present invention to provide apparatus for drilling underwater wells in deep-water locations wherein the circulation pipe system extending between the vessel and the wellhead passes entirely through the wellhead and depends within the well so that the weight of the circulation system in the well applies a tension to that portion of the circulation pipe system between the wellhead and the vessel which tends to maintain the circulation pipe system in a substantially straight line between the wellhead and the vessel.

A further object of the present invention is to provide apparatus for drilling underwater wells at deep-water locations wherein the circulation pipe system extending between the vessel and the underwater wellhead possesses a relatively small volume of drilling mud at any time thus minimizing any tendency for the circulation pipe system to be deflected from the vertical.

Still another object of the present invention is to provide apparatus for drilling an underwater well at deep-water locations when it is desired to continuously core the earth formation being penetrated by the drill bit during the drilling of the well.

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

FIGURES 1 through 6 are diagrammatic views taken in partial longitudinal cross section illustrating a floating vessel positioned over a drilling location during the sequential steps of starting to drill an underwater well, installing a foundation pile or a casing in the well, cementing the foundation casing in the well, continuing drilling the well through deeper formations, running another string of casing into the well, and applying one form of a guide element to maintain contact with the well.

FIGURE 6A on page 3 of the drawing is a longitudinal view taken in partial cross section illustrating one form of a drill bit in accordance with the present invention adapted to support the upper end of a guide element therefrom;

FIGURES 7, 8 and 9 are three longitudinal views taken in partial cross section illustrating three different forms of an underwater drilling wellhead together with guide means for positioning various wellhead components and/or the lower end of a drill string or casing string in axial alignment with the foundation casing in the well;

FIGURE 10 is a longitudinal view taken in partial cross section illustrating a fluid circulation swivel head mounted at the top of a dual conduit kelly for use in accordance with the present invention;

FIGURES 11 and 12 are longitudinal views taken in partial cross section of two forms of pipe couplings to be employed in a dual conduit drill string of the present invention;

FIGURE 13 is a longitudinal view of the lower end of a drill string in accordance with the present invention illustrating the circulation path of drilling fluid;

FIGURE 14 is a longitudinal view taken in partial cross section, illustrating another arrangement of drill collars at the lower end of the dual conduit drill string with fluid discharge pores being positioned above a telescoping section in the drill string;

FIGURE 15 is a longitudinal view taken in cross section of a dual conduit telescoping section of drill string;

FIGURE 16 is a longitudinal view taken in cross section of a cross over sub adapted for use in a dual concentric type drill string; and

FIGURE 17 on page 2 of the drawings is a longitudinal view of another form of concentric drill string and bit.

Referring to FIGURE 1 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 preselected 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 on well drilling operations or well workover operations in water varying from 100 to 5000 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 (not shown), traveling block 19, and a suitable hook and swivel or other connector means 20 adapted to be connected to the top of a kelly 21 at the upper end of a drill pipe 22 during well-drilling operations and being adapted to circulate a drilling fluid therethrough in a manner well known to the art. The vessel 11 is also provided with other auxiliary equipment needed during well-drilling operations, such, for example, as a rotary table 23 positioned on the operating deck, a mud pit or tank 24, etc. The derrick 16 is positioned over a drilling slot or well 25 which extends vertically through the barge in a conventional manner. When using drilling equipment of the present invention, a slot 25 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 the 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 22 preferably includes a conventional telescoping joint 26 in its length to compensate for the rise and fall of the vessel 11 relative to the drill string 22. The drill string 22 also includes a drill bit 27 at its lower end which is provided with one or more openings for circulating fluid such as drilling mud therethrough. At least one opening in the bit is positioned therein so that drilling mud can be circulated through the bit.

The length of the telescoping joint or bumper sub 26 is selected to be preferably slightly greater than the expected

rise and fall of the vessel so that the drill bit 27 will remain in drilling contact with the bottom of the well or hole 28 regardless of weather conditions at the surface. The telescoping joint 26 may be positioned 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 bit 27 or drill 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, or more than one bumper sub may be employed if desired. When using a number of drill collars at the bottom of the drill string and above the drill bit, it is often desirable to put the bumper sub 26 in the drill string below at least one of the drill collars so that the weight of the drill collar above the telescoping joint or bumper sub 26 may be utilized to telescope the sub toward its contracted position rather than letting the weight of the drill string set down on the sub from above. Although for ease of illustration the drill string 22 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.

FIGURE 1 illustrates the start of a method by which an underwater well is drilled from a floating vessel 11 positioned at the surface of the water 12. In starting a well, the drilling vessel 11 is first positioned at a selected drilling location. The drill string 22 having a bit 27 at the lower end thereof 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 22 may be thick-walled in the form of drill collars, if desired. The drill string 22 includes a kelly section 21, of square, hexagonal, or other non-round cross section, which is slidably positioned in the bushing of the rotary table 23 in a manner well known to the art. Drilling is commenced by the rotary table being driven by suitable motor means to rotate the kelly section 21 and the drill string 22 connected to its lower end. As the drill bit 27 is drilled into the ocean floor, the kelly section 21 slides down through the bushing in the center of the rotary table 23 until the upper end of the kelly reaches the table 23. During the drilling operation a drilling fluid is circulated, by means of a pump 30, through hose 31 and into the top of the kelly 21 through swivel 20. From there the drilling fluid is forced down through the drill string 22 and out discharge ports in the bit 27. After being discharged from the bit 27, drilling fluid moves up the borehole 28 and at the start of drilling operations is discharged to the ocean. Thus, at the start of drilling operations the drilling fluid is normally sea water which is sufficient to flush the earth formation cuttings from the well 28. As drilling progresses, additional sections of drill pipe are added to the drill string 22 below the kelly section 21 in a manner well known to the art.

In starting a well, the drill string 22 is preferably provided with a hole opener or collapsible bit 32 (FIGURE 1) of a type well known to the art so that a hole 28 can be drilled in the ocean floor 13 large enough to receive a large-diameter foundation casing 33 (FIGURE 2) while at the same time being adapted to be pulled up through the casing 33. In FIGURE 2 a well foundation casing 33, preferably having a wellhead base 34 secured near the top thereof, is lowered into the well 28 by sliding or stripping it down over the drill pipe 22. The foundation casing 33 and the wellhead base 34 may be lowered into position by means of a plurality of cables 35 and 36 running off of hoists 37 and 38. The lower ends of the cables 35 and 36 may be secured within vertically extending guide columns 39 and 40 secured to the wellhead base 34. Thus, the lowering cables 35 and 36 form guide lines for lowering other equipment to the ocean floor in axial alignment with the foundation casing 33. In order to maintain a predetermined tension from the guide lines

35 and 36, the hoists 37 and 38 are preferably constant tension winches. After the lower end of the foundation casing 33 has been inserted in the well 28, as illustrated in FIGURE 2, the drill string 22 can be withdrawn from the well and the remaining length of the foundation casing 33 can be lowered into the well without any guide apparatus.

If desired, the drill string 22 (FIGURE 2) can be left in the well until the foundation casing 33 is in place so that cementing operations can be carried out through the drill string. If it is not desired to cement through the drill string, a cementing pipe string 41 (FIGURE 3) may be run down into the foundation casing 33 so that cementing operations can be carried out in the normal manner by pumping cement down through the pipe string 41 and foundation casing 33 and thence upwardly in the annular space between the outside of the foundation casing 33 and the inner wall of the borehole 28.

It is understood that the underwater well may be started by other methods well known to the art. Thus, in another method a large-diameter (say 30 inch) pipe is driven or forced and/or jetted into the ocean floor from a floating vessel at the surface. Guide lines are secured to the upper end of the pipe for guiding a drill bit and its carrier into the pipe for drilling a hole in the ocean floor. Subsequently a wellhead foundation pile or casing and a casinghead are lowered along the guide lines into position in the well after the drill string and bit have been withdrawn.

Prior to continuing well-drilling operations, a blowout preventer 42 connected to a wellhead connector 43 is run down suitable guide equipment, such as guide lines 35 and 36 (FIGURE 4), and positioned on top of the foundation casing 33. The upper end of the foundation casing 33 is generally formed in a manner to provide a casinghead 44. The blowout preventer 42 and the wellhead connector 43 are remotely actuatable from the vessel 11 in a manner well known to the art while a removable sealing unit 45 is provided at the top of the blowout preventer 42 for sealing around the drill string 46. At this stage of the operation, the drilling fluid being used may have expensive chemicals or other additives contained therein so that it is essential that drilling fluid being circulated down to the well be returned to the vessel afterwards. In order to do this the drill string 46 employed is one having multiple conduits through its entire length.

Typical drilling wellhead assemblies are illustrated in more detail in FIGURES 7, 8 and 9. Preferably, each component such as blowout preventer 42, wellhead connector 43 or sealing unit 45 to be lowered from the vessel 11 at the surface down into an aligned and seated position on top of the casinghead 44, is provided with suitable guide means, such as guide arms 47 and 48 which are fixedly secured to blowout preventer 42. The outer ends of the guide arms 47 and 48 are provided with a guide element, such as 49, which is latched onto the guide line 36 at the vessel so as to surround guide line 36 and be mounted in sliding engagement therewith. The guide arm 48 moves down a slot 50 extending through the wall of the guide column 40 in a direction extending radially from the axis of the foundation casing 33. The blowout preventer 42 is provided with hoses 51 and 52 whereby hydraulic pressure fluid can be pumped from the vessel at the surface to open or close the blowout preventer 42. In the event that a bag-type blowout preventer is employed, only one pressure hose 51 may be needed. A nipple or short pipe section 53 at the top of the blowout preventer 42 is of a size to be received within the bore 54 of the sealing unit 45. Additionally the throughbore extending axially within the nipple 53 and the blowout preventer 42 is of a size to permit passage of the drill bit 55 at the lower end of the drill string 46. A resilient annular seal 56 within the sealing unit 45 seals against the drill string 46 in a fluidtight manner so as to prevent the escape of drilling fluid therefrom. Any suitable type of

seal may be employed. While a hydraulically-actuated seal 56 may be preferable in some situations, in general, a static seal of proper design will be satisfactory. The bore through the sealing unit 45 is small enough at one portion thereof so that when the drill bit is picked up out of the well and pulled up to the vessel it will pull the sealing unit 45 along with it up the guide line 35 and 36.

In FIGURE 7 the weight of the sealing unit 45, or weighting elements added thereto, holds the unit on the landing nipple 53 at the upper end of the blowout preventer, while in FIGURE 8 the sealing unit 45 is positively locked to the blowout preventer 42. It is realized that the unit of FIGURE 7 could also be provided with locking dogs as in FIGURE 8. In the arrangement shown in FIGURE 8 the sealing unit 45 is provided with a downwardly-extending mandrel 57 having latching grooves 58 formed in the outer surface thereof. The mandrel 57 is of a diameter to fit within the bore 59 of a latch-down unit 60 which is formed on or bolted to the blowout preventer 42. The latching unit 60 may be of any suitable design such as one being provided with a series of latching dogs 61 adapted to be moved inwardly so that they extend into the bore 59 of the latching unit and engage the grooves 58 of the mandrel 57 when the latter is positioned in the latching unit 60. The latching dogs 61 may be actuated by a vertically movable piston 62 which is moved up or down into unlocking or locking position by the application of a pressure fluid through pressure hoses 63 and 64 which run to the vessel. A seal 65 may be provided on the mandrel 57 to form a fluidtight seal between the mandrel 57 and the latch-down unit 60. It is to be understood that the drill string 46 is adapted to be rotated and moved axially within the seal 56 of the sealing unit 45 while at the same time the seal 56 forms a substantially fluid-tight seal around the outside of the drill string 46.

The drilling wellhead assembly of FIGURE 9 is similar to that described with regard to FIGURE 8 except that instead of having hydraulic hoses 51, 52, 63 and 64 (FIGURE 8) running down to the wellhead to actuate the latch-down unit 60 and the blowout preventer 42, the wellhead assembly is provided with a self-contained actuator unit 66. This actuator unit 66 may be an electrical or electro-hydraulic unit being supplied by the necessary signals and current from the vessel at the surface through conductor cable 67. The actuator unit is then either electrically or hydraulically connected through power transmission conduits 68 and 69 to the latch-down unit 60 and the blowout preventer 42, respectively.

Since the present invention utilizes a dual conductor drill string, the swivel 20 (FIGURE 10) must be provided with dual conduits 31 and 71 which are in communication with dual conduits 21 and 21a respectively of the kelly section at the top of the drill string. The swivel head 20 is provided with the usual type of bail 72 by which it is supported from the traveling block 19 (FIGURE 1). The outer section of kelly 21 may be connected to the swivel 20 by screw threads, as at 73 while the inner pipe 21a of the kelly section may be provided with a slip joint and seal, as at 74. The mud hoses 31 and 71 may be provided with valves 75 and 76 at some point in their length as desired.

Methods of connecting adjacent sections of concentric pipes 46 and 46a, to form the drill string of the present invention, may incorporate the use of threads 77 on the outer pipe string 46 while the inner pipe string 46a employs a stab-type coupling or slip joint, as at 78 or vice versa. In the event that a stab-type coupling is employed, suitable seals such as O-ring seals 79 and 80 are used. In order to insure proper spacing between the outer and inner pipe strings 46 and 46a, as well as to give additional strength to the drill string structure so that thinner wall pipe may be used, a plurality of thin spacer lugs 81 are positioned between the two pipes 46 and 46a and welded to at least one of them. As shown in FIGURE 11, the

lugs 81 are welded to both the inner and outer pipe strings 46a and 46, respectively. In FIGURE 12 the lugs 82 are welded only to the inner pipe string 46a since the sections of this type string are coupled together by means of screw threads, as at 83, while the outer string 46 is threaded as at 84.

The lower end of a dual concentric dual string in accordance with the present invention is shown in FIGURE 13 as employing a dual-conduit telescoping joint or bumper sub 85 and a plurality of dual-conduit drill collars 86. The bit 87 at the lower end thereof is provided with one or more fluid circulation ports 88 in communication with the annular space 89 between concentric pipe 46 and 46a forming the drill string, which annular space extends down through the bumper sub 85 and the drill collars 86. Drilling fluid is then circulated up through the central opening (not shown) in the bottom of the bit 87 and up the inner pipe string 46a.

One form of a dual-conduit telescoping joint or bumper sub 85 is shown in FIGURE 15. The outwardly and inwardly-extending flanges 90 and 91, respectively, form stop means to limit the maximum extension of the telescoping joint 85. At least one of the telescoping pipes is provided with a splined section or is formed in a non-round configuration, as at 92 so that the lower end of the telescoping joint will rotate when torque is applied to the upper portion of the telescoping joint. It is to be understood that suitable seals 93 are provided between the telescoping pipe sections, as needed. Returning to FIGURE 4 of the drawing, drilling operations are resumed by lowering into the well the dual conduit drill string 46 having bit 87 at the lower end thereof. During drilling the drilling mud is circulated by means of pump 30 through hose 31 and swivel 20 down through kelly section 21 and preferably down through the annular space between the two pipe sections 46 and 46a (FIGURES 11 and 12) and out the drill bit 87 at the bottom of the hole 28. The drilling fluid, together with the earth-formation cuttings formed by the drill bit, would be forced up the inner pipe string 46a, through the inner kelly pipe 21a (FIGURE 10) and out the discharge hose 71 and into the mud settling tank 24. While this is the preferred method of circulation it is to be understood that drilling operations can be carried out readily, especially in soft formations, by circulating the drilling mud down the center pipe 46a and up the annular space between the inner and outer pipes 56a and 46, respectively.

In the event that it is desired to change the flow within the two conduits forming the drill string 46, a fluid flow crossover device may be employed as shown in FIGURE 16. In this device a packer 94 is set in the pipe string 46 around a special section of inner pipe string 46b which is provided with flow passageways 95 and 96 which causes fluid in the annular space 89 above the packer 94 to be channeled into the inner pipe string 46a with similar action being taken place in handling the flow coming up the annular space 89 below the packer.

In order to obviate the use of a dual-conductor telescoping joint or bumper sub as shown in FIGURE 15, a telescoping joint or bumper sub 97 (FIGURE 14) having a single central conduit 98 in communication with the inner pipe string 46a is preferably used. Thus, the annular space 89 between the pipe strings 46 and 46a would be blanked off in any suitable manner as by a plate 99 while one or more fluid discharge ports 100 are provided in the outer pipe string 46 so that fluid circulating down the annular space 89 would be discharged through the ports 100 and flow downwardly around the telescoping joints 98 and drill collars 86 to wash across the cutting face of the bit 87, removing cuttings from the bottom of the hole and washing them up through the inner pipe string 46a.

While it is realized that the drilling of an underwater well may be started with a dual conduit drill string rather than a single conduit drill string as described with regard to FIGURE 1, the dual conduit would have to be pulled

out of the well before cementing operations were carried out therein as it would be too dangerous to attempt to circulate cement down through one of the two conduits of a dual conduit pipe string. If such an operation was to be carried out in an emergency, the other conduit would be maintained full of fluid so that no cement could be circulated up it.

Thus, after drilling the necessary amount of hole in accordance with FIGURE 4, prior to setting the next string of casing 101 (FIGURE 5) the dual-conduit drill string would be pulled back to the vessel 11. The casing 101 would then be run down into the well being guided originally into place by removable sealing unit 45 running along guide lines 35 and 36 and being lowered into the well by means of a running or lowering pipe string 102 of small diameter which can be readily detached from the top of the casing 101 when the latter is seated in the casinghead 44. Alternatively, the lower end of the casing 101 could be run in the well in a manner shown and described in patent application Serial No. 223,335, filed September 13, 1962. The running pipe string 102 could then be utilized as a cementing pipe string for circulating cement down into the well to cement the casing 101 therein.

While the method and apparatus of the present invention have been described hereinabove with regard to utilizing guide lines 35 and 36 which extend between the vessel 11 and the drilling wellhead in order to guide pipe into the well, it is to be understood that any other suitable guide means could be employed. For example, in FIGURE 6 a guide rod 103 is employed which is made up of sections of rod or small diameter pipe connected together and adapted to extend down through the bit 104 and into the well. As shown in FIGURE 6A, prior to pulling the bit 104 (FIGURE 6) out of the well, the guide rod 103 is dropped down through drill string 46 and out the bit 104 except for a stop member 105 adapted to seat itself on a pair of lugs 106 and 107 extending in from the inner wall of the inner pipe string 46a the guide rod 103 is also provided with a fishing head 108. The length of the guide rod 103 must be slightly greater than the depth of the water between the vessel 11 and the wellhead on the ocean floor.

After dropping the guide rod down the pipe string 46 and having it land on the bottom of the hole or seat on the landing lugs 106 and 107, the drill string 46 would then be withdrawn to the surface while the guide rod 103 would be drawn upwardly along with it. The lower end of the guide rod 103 would always maintain contact with the well. Thus, after removing the stop member 105 at the vessel the drill bit 104 could be removed and a new bit installed on the top of the guide rod 103, being removably secured thereto by reattaching the stop member 105 to the top of the guide rod 103. The new bit and drill string 46 would then be lowered into the well with the guide rod 103 moving down into the well. A wire-line fishing tool of any well known type would then be run down through the inner pipe string 46a to engage the fishing head 108 at the top of the guide rod 103 so that the guide rod 103 could be pulled up through the drill string 46 to the vessel prior to carrying out further drilling operations.

It may be seen that a method and apparatus have been provided for drilling at deep-water locations where it would be otherwise impossible to support the necessary length of marine conductor pipe or flexible mud hoses. At the same time, there has been provided a circulating mud system which is relatively more flexible than any presently known while at the same time having a minimum area exposed to underwater currents and wave forces at the surface. At the same time the weight of the drill string in the well provides the tension necessary to maintain the circulating mud and drill pipe in a substantially straight line between the vessel and the well rather than the need for providing this tension from the vessel at the surface.

Although the drilling operation has been described with regard to FIGURE 4 as employing a dual-conduit

drill string extending from the vessel to the bit at the bottom of the well, it is to be understood that at some locations, particularly when drilling through fairly well consolidated formations, the dual conduit string 46 may extend only from the vessel to a short distance below the sealing unit 45 and the wellhead assembly on the ocean floor. Drilling fluid would be circulated down the annular space between the inner and outer conduits 46 and 46a (FIGURE 11) which would terminate below the sealing unit 45 (FIGURE 4) and from there to the bottom of the well the drilling fluid would be circulated outside a single conduit drill string 46 (FIGURE 17) to be returned up the drill string along with the cuttings from the bottom of the well. In such an arrangement the single-conduit drill string extending below the dual-conduit drill string would be normal drill pipe while the pipes making up the dual conduit section of the drill string could be thinner walled pipe. In drilling with this combination of a single-conduit and dual-conduit drill string, every time a round trip was made to change a bit on the drill string, normal single conduit drill pipe would be run into the well with a new bit until the bit was off the bottom of the well a distance slightly greater than the depth of the water in which the drilling operations were being carried out. At this time dual-conduit drill pipe sections would be connected to the top of a single-conduit drill pipe and the entire drill string would continue to be lowered as made up until the lower end of the dual conduit drill string had passed through and was sealingly engaged by the sealing unit 45 at the wellhead. Thereafter, as drilling progressed additional sections of dual conduit drill pipe would be connected to the top of the drill string below the kelly.

We claim as our invention:

1. Apparatus for drilling an underwater well from a floating vessel positioned at an offshore location, said apparatus comprising:

- (a) a floating vessel;
- (b) a drilling wellhead structure positioned below the surface of the water beneath said vessel, said wellhead structure having a vertical throughbore aligned with a well in the ocean floor;
- (c) a drill string adapted to extend from said vessel and into the throughbore of said wellhead structure;
- (d) packer means adapted to be in operative sealing engagement between said wellhead structure and the outer surface of said drill string to seal the throughbore of said wellhead structure about said drill string and prevent all fluid from leaving the well except through said drill string;
- (e) said drill string having multiple conduit means at least extending from a point adjacent said vessel to a point below said packer means of said wellhead structure; and
- (f) said multiple conduit means being simultaneously rotatable together and axially slidable through said packer means while remaining in substantial sealing engagement therewith during drilling operations.

2. The apparatus of claim 1 wherein said dual conduit drill string includes a dual conduit telescoping section.

3. The apparatus of claim 1 wherein the length and weight of the drill string extending below the wellhead is sufficient to maintain adequate tension on said drill string to maintain it in a substantially vertical position beneath said vessel.

4. The apparatus of claim 1 wherein the conduit means of the drill string comprises two concentric pipe strings secured together in spaced relationship whereby a flow passage is formed between the two pipes and a drill bit is connected to the lower end of the drill string.

5. The apparatus of claim 4 wherein both of the concentric pipe strings extend to a bit at the bottom of the drill string, said bit being provided with at least one fluid port through the body thereof in communication with the space between said concentric pipe strings, and at least a second fluid port in communication between

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the bore of the inner pipe string and the space outside the bit.

6. The apparatus of claim 5 wherein said second fluid port is centrally located in said bit and is of a size to permit earth formation cuttings to enter the inner string of said concentric pipe strings.

7. The apparatus of claim 1 including a dual conduit kelly section coupled to the upper end of said dual conduit drill string.

8. The apparatus of claim 7 wherein the dual conduits of said kelly are arranged concentrically and extend longitudinally through said kelly.

9. The apparatus of claim 1 wherein said dual conduit drill string comprises dual conduit pipe extending from a point adjacent the vessel down to and being secured to a plurality of drill collars having a single conduit there-through adapted to communicate with only one of said conduits of said dual conduit pipe, there being outlet fluid port means through the wall of said pipe to the outside in communication with the other conduit of said dual conduit pipe above said drill collars, and a drill bit attached to the lowermost drill collar.

10. The apparatus of claim 9 including a telescoping section in said drill string with at least one drill collar of said drill string positioned above it.

11. The apparatus of claim 1 including guide means adapted to be in operative engagement between the lower end of the drill string and the wellhead structure.

12. The apparatus of claim 11 wherein said guide means includes guide lines extending from said vessel to said wellhead structure and means slidably mounted near the lower end of said drill string and slidably mounted on said guide lines for aligning the lower end of said drill string with the throughbore of said wellhead structure.

13. Apparatus for drilling an underwater well from a floating vessel positioned at an offshore location, said apparatus comprising:

- (a) a floating vessel;
- (b) a drilling wellhead structure positioned below the surface of the water beneath said vessel, said wellhead structure having a vertical throughbore aligned with a well in the ocean floor;

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- (c) a drill string adapted to extend from said vessel and into the throughbore of said wellhead structure;
- (d) packer means adapted to be in operative sealing engagement between said wellhead structure and the outer surface of said drill string to seal the throughbore of said wellhead structure about said drill string;
- (e) said drill string having multiple conduit means at least extending from a point adjacent said vessel to a point below said packer means of said wellhead structure; and
- (f) said multiple conduit means being simultaneously rotatable together and axially slidable through said packer means while remaining in substantial sealing engagement therewith during drilling operations,
- (g) the conduit means of the drill string comprises two concentric pipe strings secured together in spaced relationship whereby a flow passage is formed between the two pipes and a drill bit is connected to the lower end of the drill string,
- (h) the outer concentric pipe string extending from a point adjacent the vessel to a point just below the packer means at said wellhead structure and the inner pipe string only is provided with a drill bit at its lower end adapted to drill at least the upper portion of a well of a diameter greater than that of the outer pipe.

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