

Feb. 11, 1969

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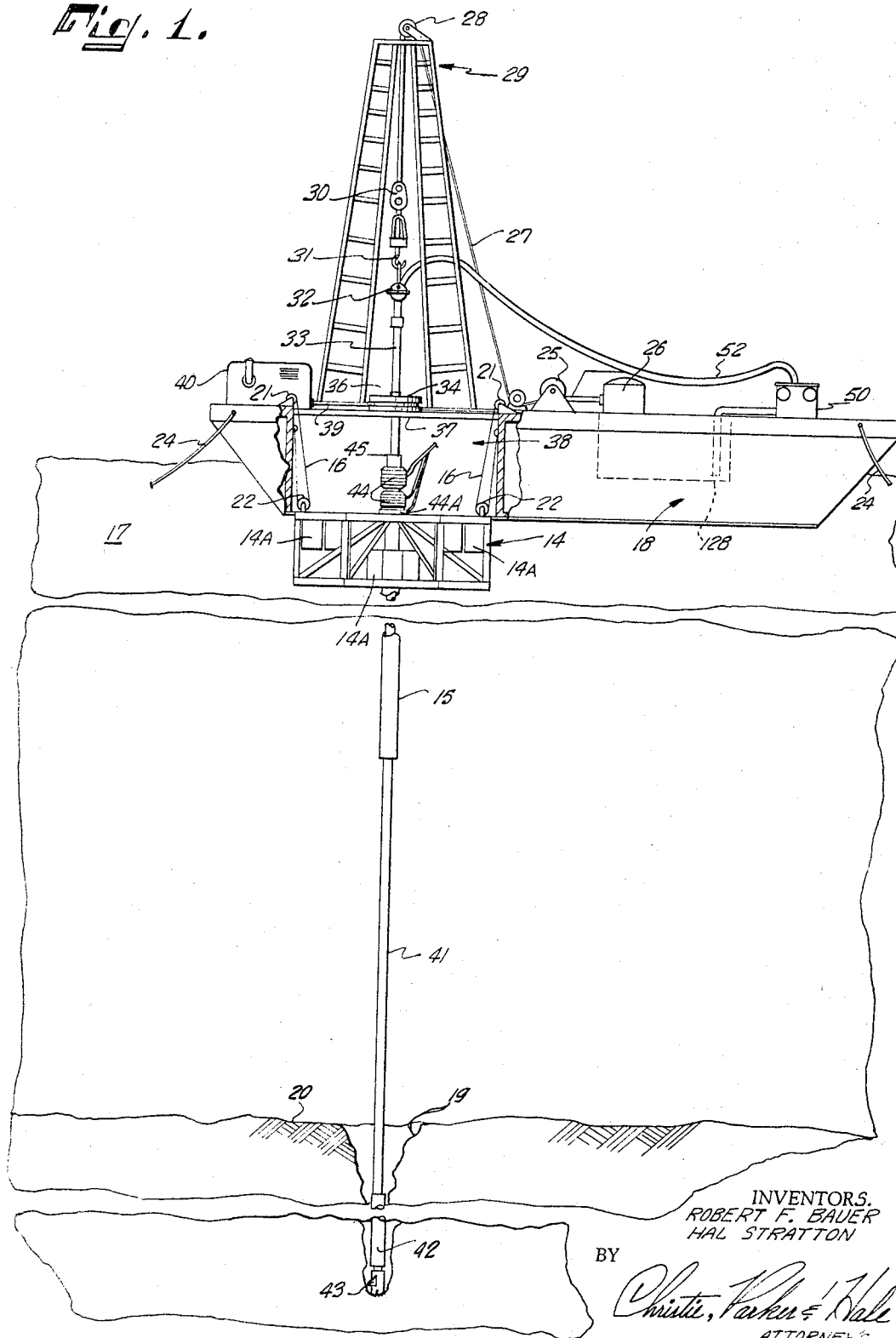
3,426,858

DRILLING

Filed July 12, 1957

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Fig. 1.



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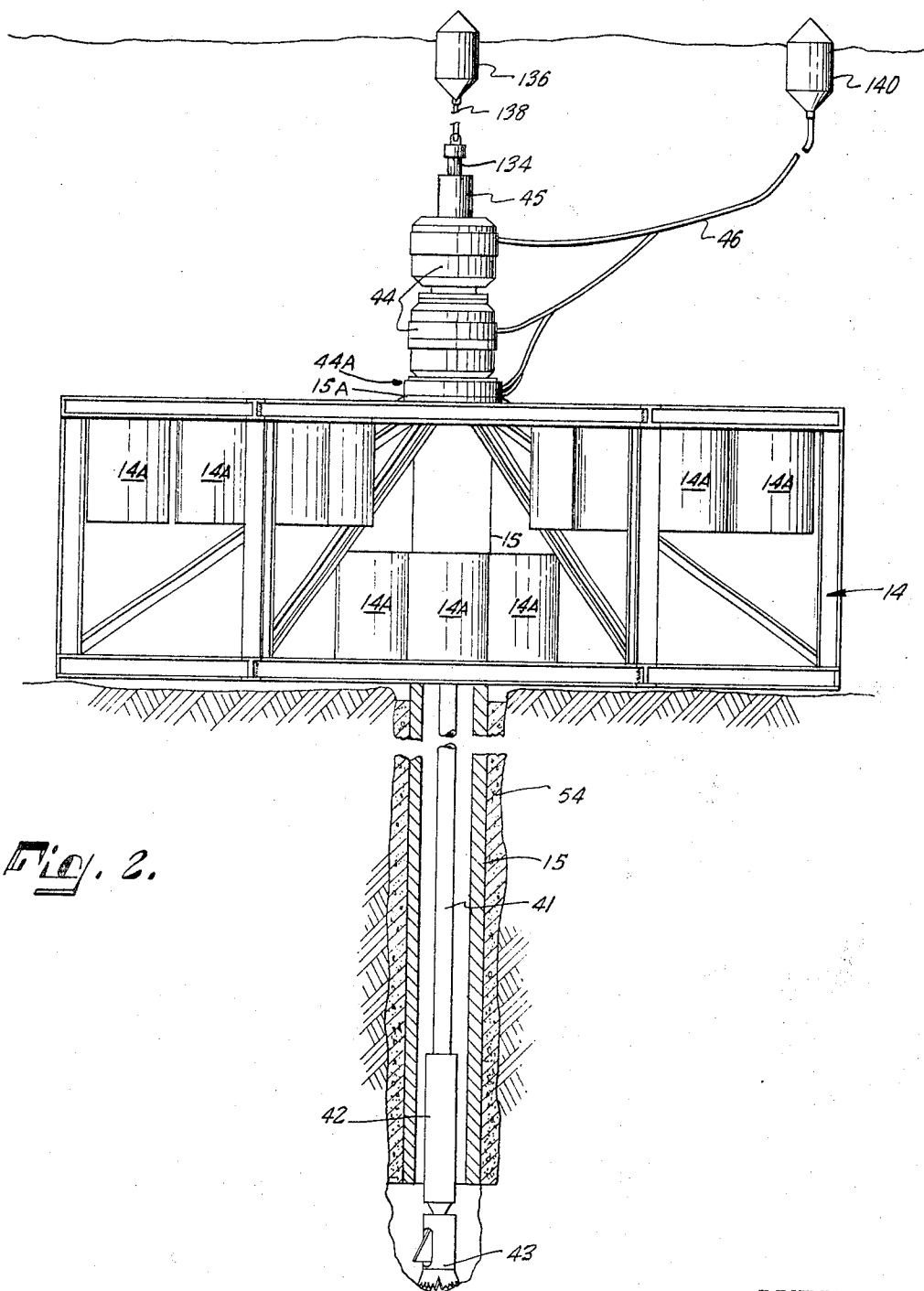
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Fig. 8.

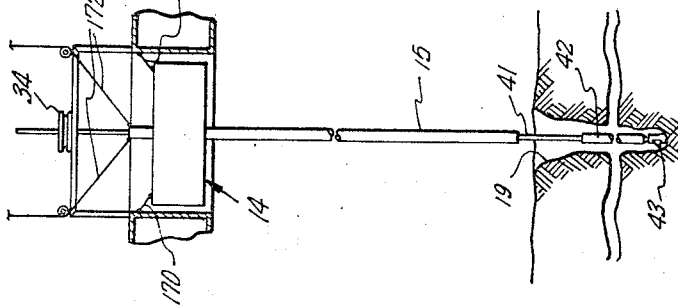


Fig. 9.

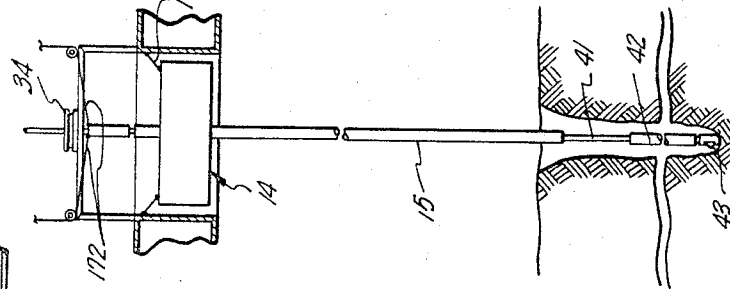


Fig. 10.

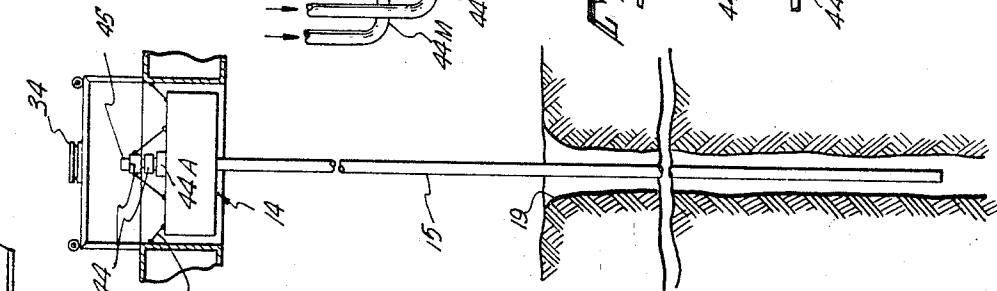


Fig. 3.

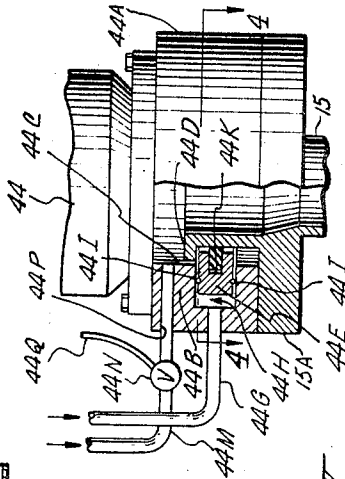
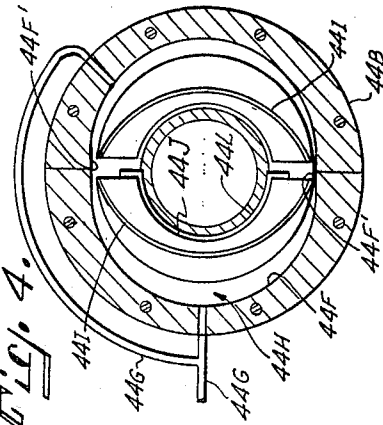


Fig. 4.



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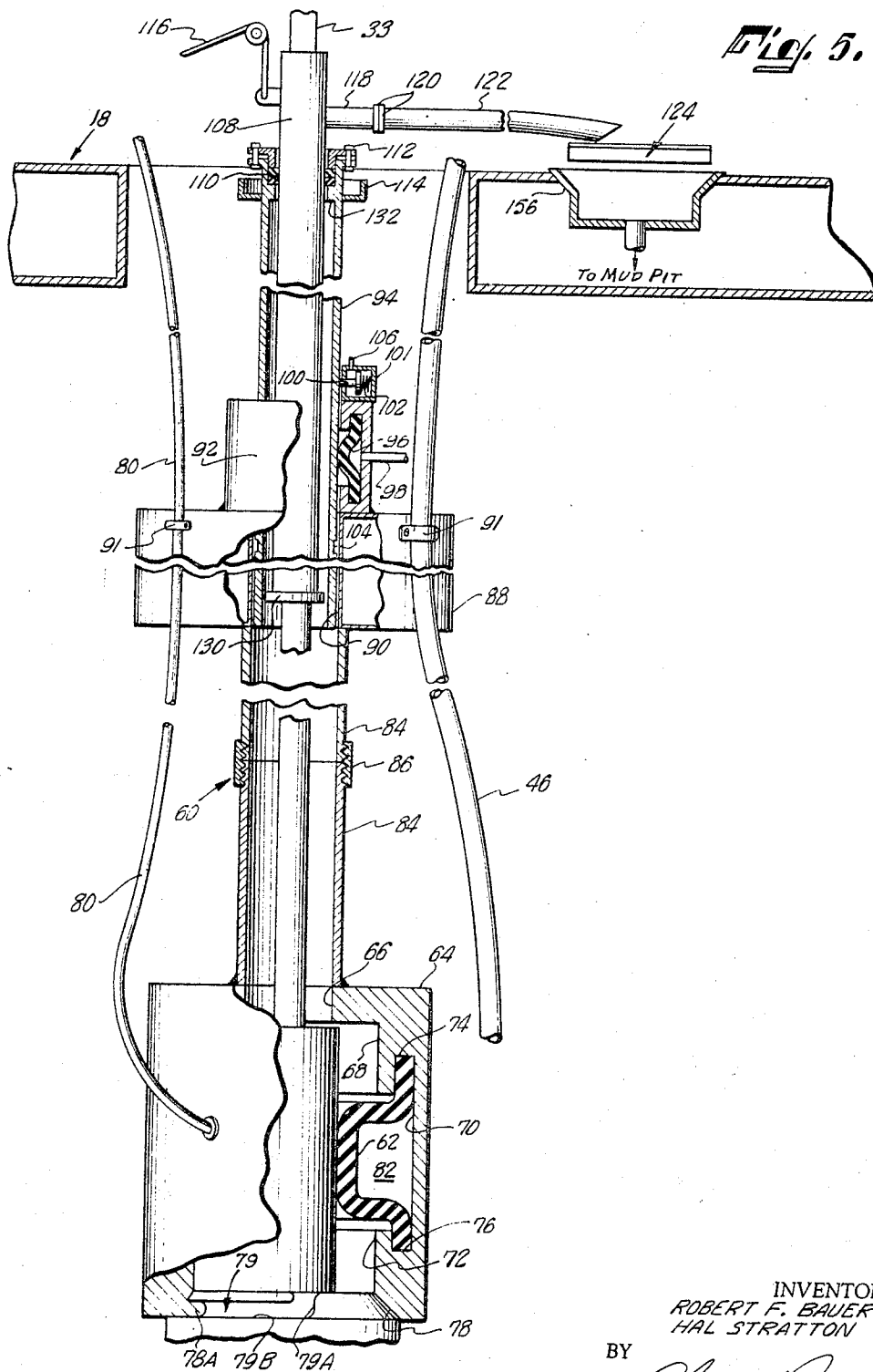
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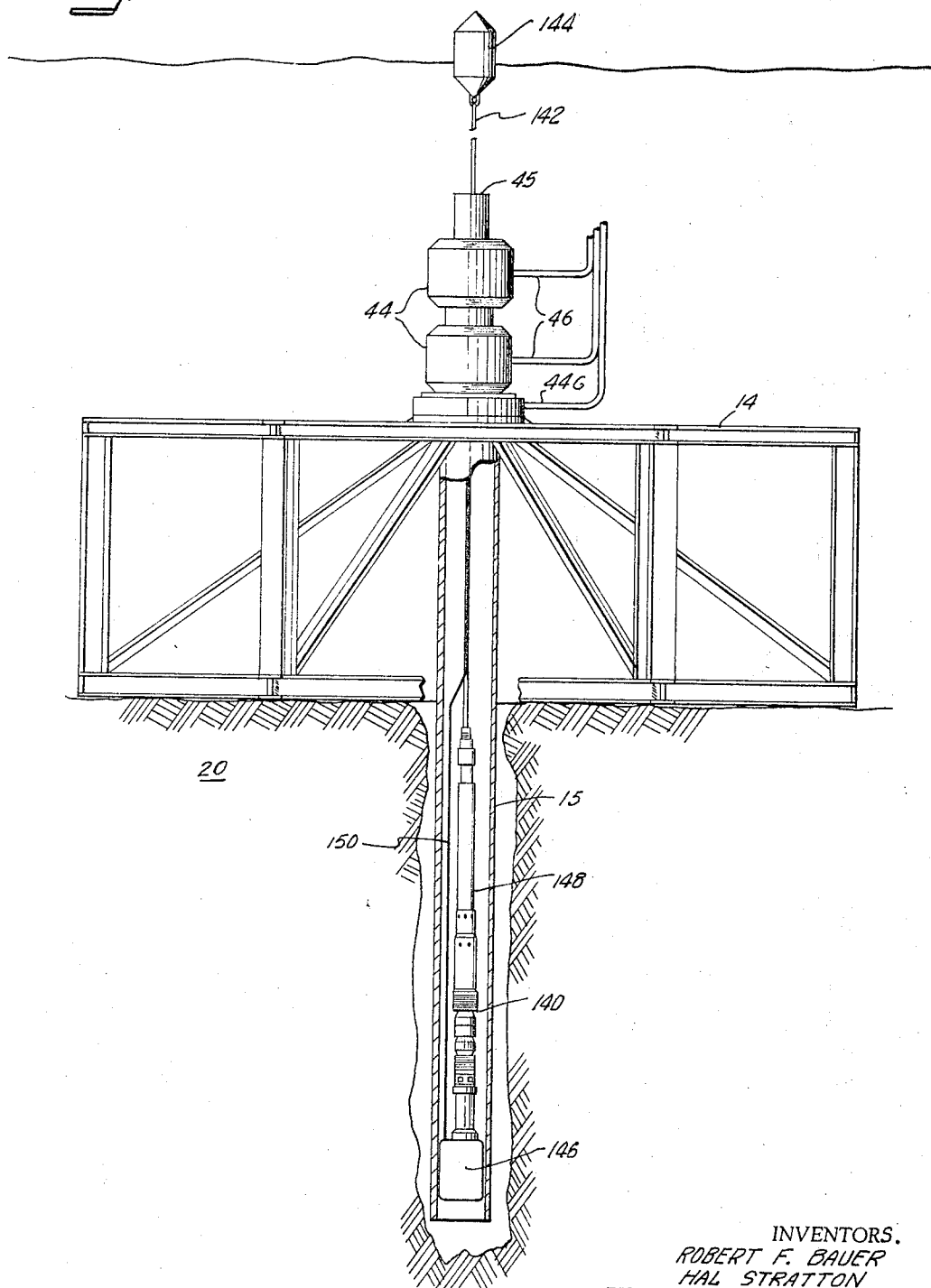
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Fig. 6.



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Fig. 7.

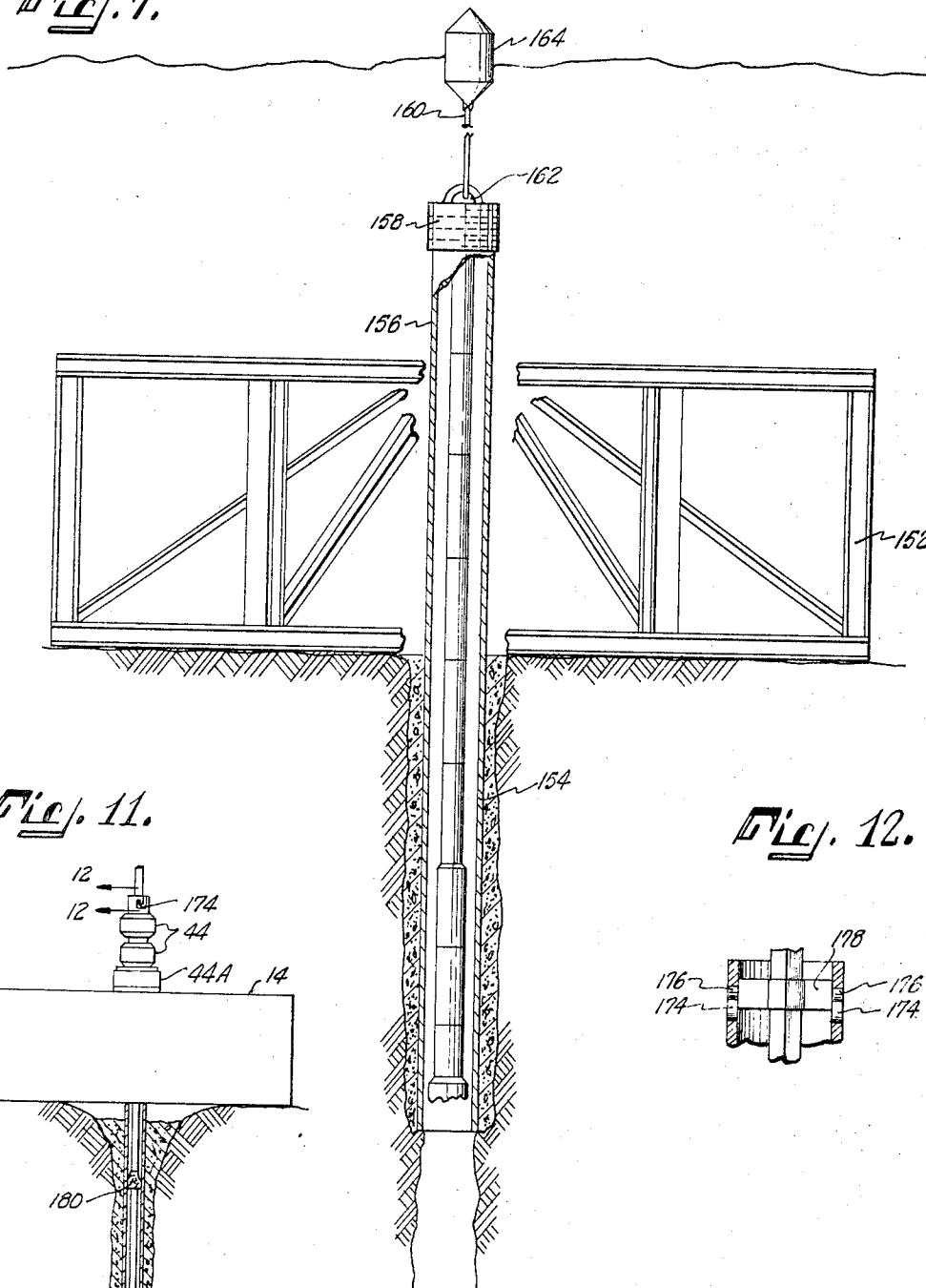


Fig. 11.

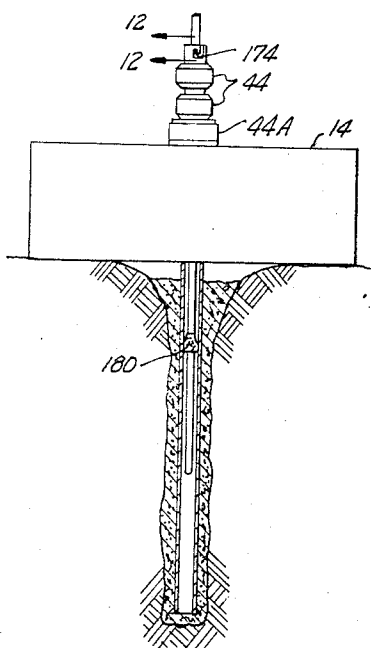
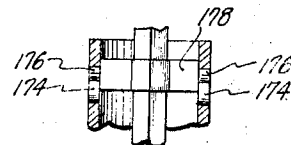


Fig. 12.



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3,426,858
DRILLING

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U.S. Cl. 175—7

7 Claims

Int. Cl. E21b 15/02, 7/12, 33/035

This invention provides apparatus and methods for drilling and working on underwater wells.

The invention may be practiced in connection with wells under any kind of water, whether marine or fresh, but for simplification of explanation of the invention, the apparatus is described as being used in an ocean.

At the present time, there is considerable activity in exploring and drilling for oil and gas at offshore locations. Currently, much of the drilling is done from stationary structures rigidly anchored to the underwater formation. These structures provide static bases for the drilling equipment and are satisfactory for relatively shallow water. However, for deeper water, say depths of several hundred feet, stationary structures are not always economically practical. Furthermore, the stationary structures are usually permanent installations which may be navigation hazards.

Recently there has been described in U.S. Patents Re. 24,083, 2,476,309, and co-pending application Ser. No. 468,214, filed Nov. 12, 1954, now Patent No. 3,380,652, apparatus and method for drilling underwater wells from a floating vessel. Drilling from a floating vessel has the advantage over drilling from a stationary structure that the floating vessel may be readily moved from one location to another, is less expensive to set up, and may be quickly removed in the event of a storm. However, one of the difficulties in drilling or working on an underwater well from a floating vessel is guiding drilling and other equipment such as tubing, casing, etc., to the well from the vessel. The movement of the floating vessel due to wind, current and wave action, which is almost invariably present, makes it difficult to relocate the well once equipment is moved from it. This problem has been solved in the past by using guidelines anchored at their lower ends adjacent the well and extending to the floating vessel so that drilling and other equipment can be guided down them to the well. This arrangement is satisfactory under many circumstances, but under some operating conditions the lines have proved cumbersome and have tended to foul with each other and with drilling equipment.

Another problem presented by floating drilling is that of positively shutting in the well in the case of a threatened blow-off, or when the floating drilling rig is temporarily removed from the well site, say, due to rough weather.

This invention provides drilling techniques with which equipment may readily be guided from a floating vessel to and from an underwater well without the use of guidelines, and in effect, provides a means of underwater drilling whereby the well site and drilling operation can be quickly abandoned in case of storm, and easily resumed when the weather is more favorable.

The apparatus of the invention includes a floating vessel and means for anchoring the vessel over the hole or well site. A well head base adapted to be secured firmly to the formation is anchored at the well site. The base includes a receiver which overlies the upper end of the hole. An elongated conductor is sealed at its lower end to the receiver and extends to the floating vessel to provide a closed passageway from the receiver to the vessel. Blow-out preventer means are provided in the passageway for shutting in the well when required.

In the preferred form, the elongated conductor is pro-

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vided with buoyant support to maintain it in a substantially upright position, and the lower end of the conductor is adapted to make a quick seal to, and release from, the receiver by means which are controlled remotely from the floating vessel, so that the conductor may be either quickly sealed to or released from the receiver by remote control.

Also in the preferred embodiment, the receiver includes blow-out preventer means which include remote controls operable from the surface of the water, so the well can be safely shut in while drilling operations are temporarily suspended, and no structure is left at or near the surface of the water which would either be damaged by storm or present a navigation hazard.

Preferably, the conductor includes a slip joint which permits the upper portion of the conductor to slide longitudinally with respect to the remainder of the conductor. This feature permits the upper end of the conductor to be secured to the vessel and move up and down with it, and also permits the upper end of the conductor to be lowered to a safe distance below the water surface when the vessel is moved from the well site.

In terms of method, the invention contemplates drilling a hole in a formation underlying a body of water by anchoring a floating vessel over a well site and drilling a hole in the formation at the well site, say with a drill pipe supported from the vessel. A base, which includes a receiver or mandrel with an opening extending through it, is stripped down over the drill pipe, or other member supported on the vessel and extending to the well, so the base is guided to the hole and rests on the formation with the receiver opening overlying the upper end of the hole. An elongated conductor is slipped down over the drill pipe or other guide member, and the guide member is used to guide the lower end of the conductor into sealing relationship with the receiver. The lower portion of the conductor is sealed to the receiver so that the conductor registers with the upper end of the hole and extends from the receiver to the vessel.

These and other aspects of the invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic elevation of a well head base and receiver being lowered from a floating vessel into a hole which is being drilled in an underwater formation;

FIG. 2 is a view of the wellhead base in its final position on the ocean floor, the vessel being temporarily removed from the well site;

FIG. 3 is an enlarged fragmentary view, partly broken away and in section, of equipment shown in FIG. 2;

FIG. 4 is a view taken on line 4—4 of FIG. 3;

FIG. 5 is a fragmentary schematic elevation, partly in section, showing the presently preferred embodiment of the invention, in which the lower end of the conductor is sealed to the receiver, and the upper end of the conductor is secured to the floating vessel and provided with a slip joint to permit vertical displacement of the vessel with respect to the lower portion of the conductor;

FIG. 6 is a schematic elevation, partially broken away, showing an arrangement for anchoring a guide line in the well when the well is temporarily abandoned;

FIG. 7 is a schematic sectional view of an alternate arrangement in which the drill pipe is used to anchor a guide line in a well not having blow-out preventers;

FIG. 8 is a schematic elevation of an alternate arrangement for setting the wellhead base on the ocean floor without using support lines;

FIG. 9, 10 and 11 are schematic elevations of the arrangement shown in FIG. 7 at succeeding stages of the operation; and

FIG. 12 is a view taken on line 12—12 of FIG. 11.

Referring to the drawings, FIG. 1 shows a wellhead

base 14, including a plurality of buoyant compartments 14A and a downwardly extending casing 15 with an outwardly extending flange 15A at its upper end welded to the top of the base, being lowered by a pair of lines 16 in a body of water 17 from a floating drilling barge 18 toward a well 19 being drilled from the barge in an under-water formation 20. One end of each of the lines is attached to the barge, and the other end of each of the lines is wound on a respective winch 21 which is powered through a torque converter transmission (not shown) to keep the lines under a constant tension. Each line is looped through a respective pulley 22 mounted on the top of the wellhead base. The barge is anchored over the well by a plurality of suitable anchor lines 24 extending in opposite directions from the barge and connected to anchors (not shown).

A drawworks 25 and a power unit 26, which may be of conventional type, are mounted on the barge to operate a hoisting cable 27 carried over a crown block 28 located at the upper end of a derrick 29. The travelling end of the hoisting cable carries a travelling block 30 and a hook 31 which supports a swivel joint 32. A kelly joint 33 extends downwardly from the swivel through a kelly bushing 34 in the center of a rotary table 36 mounted on gimbals in a manner similar to that described in U.S. Reissue Patent Re. 24,083. The rotary table is supported on a platform 37 directly over a cellar 38 which may be located in the center of the barge as illustrated. Power is supplied to the rotary table through a shaft 39 turned by a rotary table power unit 40.

A string of drill pipe 41 is connected to the lower end of the kelly and extends down through the cellar, the casing, the water and into the well. Drill collars 42 and an underreamer drill bit 43 are attached to the lower end of the drill pipe for boring the well to a diameter slightly larger than the outside diameter of the casing welded to the wellhead base. One or more blow-out preventers 44 are attached to the upper end of the casing by a locking head 44A, and extend above the top of the wellhead base. Referring to FIG. 3, the locking head includes an annular body 44B having a vertical bore 44C through it, which is of a diameter slightly larger than an outwardly extending lid 44D on the upper end of the casing. The body 44B rests on the upper surface of flange 15A. A pair of semi-circular locking plates 44E are disposed in an internal annular groove 44F in the locking head body, and are adapted to be moved inwardly and outwardly through fluid pressure, applied through a line 44G to the annular space 44H between the plates and the body interior. Arcuate gaskets 44I in the upper and lower surfaces of the plates make a sliding seal in the groove 44F, and the outer sides of the plates makes a sliding seal against a pair of diametrically opposed straight sections 44F' in the groove 44F. The central portion of the inner edge of each plate has a semi-circular cutaway portion 44J to match the outside diameter of the casing (see FIG. 4), and also has an internal groove 44K in which is disposed a semi-circular sealing gasket 44L that makes a fluid-tight seal around the casing when fluid pressure is applied through line 44G. The plates make a close sliding fit within the groove in the locking head body and make a similar fit under the casing lip so that the plates form a positive lock for the blow-out preventers to the casing. A "kill" line 44M is connected through valve 44N to the interior of the locking head body through a conduit 44P for a purpose which is explained below. The valve 44N is actuated through a line 44Q, which extends to the barge.

A receiver or mandrel 45 in the form of a relatively short section of pipe approximately the same diameter as the casing is attached at its lower end to the top of the blow-out preventers, which are of conventional type so that the well may be closed off with drill pipe either in or out of it. The drill pipe extends through the receiver, the blow-out preventers, and the locking head. The blow-out preventers are actuated through control lines 46 which

extend from the blow-out preventers to the floating vessel.

Although the base is shown as a platform structure, it may also take other forms. For example, it can simply be a reinforced section of pipe with sufficient rigidity to support the equipment attached to it and resist the lateral forces applied to it.

A drilling operation as illustrated in FIG. 1 is commenced with the wellhead base as follows:

The wellhead base is either towed or carried on the barge to the desired location, and the barge is firmly anchored over the well site. The supporting lines are run through the pulleys on the wellhead base, and it is launched into the ocean, if carried on the barge.

The upper ends of the support lines being controlled from the barge, the wellhead base compartments are flooded, say by puncturing the walls of some of the buoyant compartments, until the base has a slight negative buoyancy. The base is then pulled to the position shown in FIG. 1, i.e., under the cellar in the barge, where it is held by the lines at a shallow depth below the cellar. The ends of the supporting lines are then connected to the barge and the winches as shown in FIG. 1. The underreamer drill bit, drill collar and drill pipe are then made up on the barge and lowered through the receiver, the blow-out preventers, which are open, the locking head and the casing. Drilling is begun, sea water being circulated by a pump 50 through a mud hose 52 connected to the swivel, and out the bit to wash cuttings up out of the hole, no attempt being made to obtain return circulation of drilling fluid at this time. Drilling continues in this fashion until a sufficient depth is reached to permit the casing to be lowered into the well and allow the bottom of the wellhead base to rest on the ocean floor.

For operation in areas where the water depth is less than the overall length of the desired amount of casing and the wellhead base, a slightly different procedure is used. The base is maneuvered into the position shown in FIG. 1 without the casing, locking head, blow-out preventers, and receiver. A joint of casing is inserted in the opening of the base and supported by suitable means from the barge so that the lower end of the casing is flush with the bottom of the base. The casing and base are lowered simultaneously, successive joints of casing being added as required, until the base is resting on the bottom, and the upper end of the casing extends up into the barge above the water level.

Using a salt water without return circulation, sufficient hole is drilled with the bit and underreamer to receive the desired amount of casing. Salt water is then displaced with drilling mud to keep the hole open, and the bottom of the casing is lowered a few feet into the upper end of the hole. The drill pipe is withdrawn from the hole and casing, and the remainder of the casing is then run down into the hole, additional joints of casing being added as required. The locking head, blow-out preventers and receiver are connected to the upper end of the casing, and the lower end of the drill pipe is disposed within the upper end of the casing so that it extends down below the blow-out preventers. The blow out preventers are then closed around the drill pipe, and the upper end of the casing is lowered by means of the drill pipe so that the blow-out preventers rest on the top of the wellhead base.

The casing is cemented in place by pumping cement down through the drill pipe and forcing the cement into the annular space between the casing and the hole. The cement is followed by drilling mud which displaces the cement from the upper portion of the casing to a point below the drill bit. The cement is then allowed to set. The drill bit may then be either removed immediately or drilling may proceed to such a depth that it is necessary to replace the bit or provide for return circulation of drilling mud to support the walls of the well bore. At this point it is necessary to have apparatus which permits equipment to be guided accurately to and from the well bore. Such apparatus is shown in FIG. 5.

Referring to FIG. 5, the lower end of an elongated conductor **60**, which extends from the wellhead base to the barge, is adapted to be sealed releasably to the receiver by a heavy-wall rubber sleeve **62** mounted within a conductor seal housing **64**, the top of which is welded to the lower end of the conductor. A first central bore **66**, collinear with and of the same diameter as the internal diameter of the conductor, extends from the top of the conductor seal housing downwardly to terminate at the upper end of a second bore **68** of greater diameter. The lower end of the second bore terminates at the upper end of a third bore **70** of increased diameter, and the lower end of third bore **70** terminates at the upper end of a fourth bore **72** which is of the same diameter as the second bore, and which opens out the bottom of the conductor seal housing. The upper end of the sealing sleeve **62** is molded in an annular groove **74** formed in the shoulder between the second and third bores, and the lower end of the sleeve is molded in an annular groove **76** formed in the shoulder between the third and fourth bores. The lower end of the fourth bore has a section **78** which tapers downwardly and outwardly to match and seat on a similar surface on the upper end of the upper blow-out preventer. The tapered bore of the conductor seal housing has an inwardly extending lug **78A** which fits down into a J slot **79** formed in the tapered portion of the upper end of the blow-out preventer on which the housing seats. As the housing is lowered toward the position shown in FIG. 2, as described below, the lug rests on the tapered seat of the upper blow-out preventer. The conductor is slowly rotated in a clockwise direction (as viewed from above) until the lug drops into a vertical section **79A** of the J slot. The conductor is further rotated until it reaches the end of a horizontal section **79B** of the J slot. Thus, the lug and slot lock the conductor to the wellhead base. A conduit seal control line **80** forces the sleeve to extend inwardly and seal around the receiver, providing a closed path for the flow of drilling fluid back to the floating vessel.

The greater part of the conductor is made up of a plurality of casing sections **84** externally threaded at each end and held together by couplings **86**. A buoyant conductor chamber **88** having a central opening **90** of the same diameter as the internal diameter of the conductor is welded to the upper end of the uppermost section of conductor casing so that opening **90** is collinear with the conductor. The buoyant chamber for the conductor is located well below the surface of the water to provide necessary navigation clearance for vessels, and to be virtually unaffected by wave action.

The control lines **46** and **80** for the blow-out preventers and conductor seal housing, respectively, are secured by clamps **91** to the buoyant conductor chambers.

An annular extension conduit seal housing **92** is welded to the top of the buoyant chamber around the central opening in the chamber. The lower end of an upright extension conduit **94** extends down into the conduit seal housing and the opening in the buoyant chamber. The conduit seal housing is adapted to be sealed firmly to the extension conduit by an internal rubber sleeve **96** which is secured at each end to the housing interior and actuated by fluid pressure applied through a line **98** extending to the drilling barge. A horizontal locking piston **100** is disposed in a cylinder **101** on the upper end of the conduit seal housing and urged by a compression spring **102** inwardly against the extension conduit so the piston will engage an annular groove **104** near the lower end of the extension conduit when the conduit is raised, and thereby prevent the conduit from being pulled inadvertently up out of the conduit seal housing. Fluid pressure may be applied through a line **106** to hold the locking piston outwardly against the spring to permit the withdrawal of the extension conduit when desired.

A slidable tube **108** is disposed in, and projects upwardly from, the upper end of the extension conduit. A

packing gland **110** in the upper end of the extension conduit may be adjusted by bolts **112** to provide the desired sealing between the tube and the extension conduit, i.e., the gland is adjusted to permit the tube to slide freely with the vertical motion of the drilling barge, and yet be tight enough to prevent leakage of drilling mud. An external gutter **114** is on the extension conduit under the packing gland to catch any drilling mud which might leak through the gland. A suitable sump pump (not shown) has its intake disposed in the gutter to carry away any drilling mud which might be collected in the gutter.

The upper end of the sliding conduit is supported by a cable **116** which is secured by suitable means (not shown) to the barge. The drill pipe extends coaxially down through the tube, the extension conduit, the conductor, and into the well.

A mud return nipple **118** is on the upper end of the tube and is connected by flanges **120** to a mud return hose **122** which discharges on to a shaker and screens **124**, which are disposed above a collector **126** which returns mud to the mud pit.

The operation of the apparatus shown in FIG. 5 is relatively simple. With the wellhead base located on the ocean floor as shown in FIG. 2, and the drill pipe extending down from the floating vessel into the well as shown in FIG. 1, the blow-out preventers are closed around the drill pipe to lock it in place, and the upper end of the drill pipe is disconnected from the kelly joint. The rotary table is temporarily moved out of the way, and the conductor seal housing and conductor are lowered down over the drill pipe until the conductor seal housing rests on the upper blow-out preventer as shown in FIG. 5. If the depth of the water is so great that the overall length of the conductor is more than can be handled at one time by the drilling rig, the conductor is assembled on the vessel as it is lowered to the receiver.

After the conductor seal housing is disposed around the receiver as shown in FIG. 5, fluid pressure is applied through line **80** to force seal **62** into tight contact with the receiver.

The extension conduit at the upper end of the conductor is adjusted to a convenient height above the water surface so the packing gland **110** can readily be observed and adjusted, and the extension conduit seal housing is then sealed to the extension conduit by the application of fluid pressure through line **98**. The upper end of the slidable tube **108** is secured to the barge by line **116** so the tube moves up and down with the barge. The mud return nipple is connected to the mud return line, the rotary table is replaced, and the upper end of the drill pipe is again connected to the kelly joint. The bit is lowered to the bottom of the well and the drill pipe is turned by the rotary table. Drilling mud is circulated from a mud pit **128** through the pump, mud line, swivel, kelly joint, drill pipe, and out the bottom of the drill bit into the annular space between the drill pipe and the well bore. The drilling fluid returns up the annular space between the drill pipe and the well bore, up the annular space between the drill pipe and the conductor, and flows out the mud return nipple and mud return line to discharge on the shaker and screens, where cuttings are separated and drilling mud is returned to the mud pit for recirculation.

The packing gland for the slidable tube is set so that the tube moves freely up and down with the motion of the barge, yet prevents the leakage of drilling fluid. With this arrangement, the slidable tube and shakers and screens move up and down together so that there is always a constant elevation between the mud return nipple and the shaker and screens to provide for the steady and uninterrupted return of drilling mud. Drilling continues in this fashion until the required depth is reached, or until it becomes necessary to set additional casing and blow-out preventers, which may be done through the conductor.

At any time desired, the fluid pressure applied to the extension conduit seal housing can be released to permit the extension conduit to be adjusted to any required height, say due to change in tide, the locking piston 100 and annular groove in the lower portion of the extension conduit preventing the inadvertent removal of the extension conduit from its seal housing.

If it becomes necessary to leave the well site quickly, say due to a sudden storm, the drill pipe is either completely removed from the hole, or else a sufficient length is removed from its upper end to permit it to be plugged and lowered back into the well so that its upper end is well below the surface of the water. The blow-out preventers are closed to seal the well, and the mud return nipple is disconnected from the mud return hose. Pressure is released from the extension conduit seal housing and the extension conduit and tube are lowered from the barge until the gutter on the extension conduit rests on the upper surface of the cylinder 101, and the drilling mud nipple rests on the upper end of the extension conduit. The control lines for the blow-out preventers, the conductor seal housing, the extension conduit seal housing, the valve 44N, and the locking cylinder 101 are sealed, disconnected from the barge, buoyed and cast off. Supporting cable 116 for the slidable tube is disconnected from the barge, buoyed and cast off, and the barge is then moved from the location.

When drilling is to be resumed, the barge is returned to and anchored over the well site, being guided by the buoys. The control lines and the supporting line 116 are picked up and arranged on the barge as described previously. The slidable tube is then raised by line 116. An annular external lip 130 on the lower end of the slidable tube engages an internal annular lip 132 at the upper end of the extension conduit and raises the conduit to the desired position. Fluid pressure is again supplied through line 98 to seal the extension conduit seal housing to the conduit. The drill pipe, if left in the well, is retrieved by a conventional fishing operation, and drilling is then resumed as described above.

If desired, the extension conduit 94 and the slidable tube 108 can be removed from the conductor when the well is abandoned, pressure being applied through line 106 to retract the locking pin 100 and thereby permit the extension conduit to be withdrawn. The extension conduit is replaced in the conductor by a diver, or by sliding it down a line buoyed from the upper end of drill pipe left in the well as described below.

In some cases, particularly where shallower water is encountered, the buoyant chamber for the conductor may be eliminated. In such instance, the conductor may be supported during drilling operations by its own columnar strength or by guy lines to the vessel. When the vessel is cast off, the mud level in the conductor may be dropped, say to the region of the blow-out preventer assembly, and by capping the upper end of the conductor it then becomes its own buoyant support.

FIG. 2 shows the condition of the well after the conductor has been removed from the ocean floor equipment and the barge has left the well site. Under such circumstances, the drill pipe is disconnected from the kelly joint, and a sufficient length removed from its upper end to permit it to be lowered and sealed in the position shown in FIG. 2 by the blow-out preventer adapted to seal around the drill pipe so that its upper end is well below the surface of the water. A plug 134 is screwed onto the top of the drill pipe to close it, and a buoy 136 is connected by a line 138 to the drill pipe plug. Pressure is released from the conductor seal housing, and the conductor is rotated slowly in a counterclockwise direction to clear the lug from the J slot, lifted and stored on the drilling barge, the blow-out preventer control line is sealed, connected to a buoy 140, and cast off.

If the well is to be permanently abandoned, the well is filled with cement (not shown), or otherwise suitably

shut in, and the drill pipe withdrawn. Pressure is released from the blow-out preventer locking head through line 44G so that the conductor, blow-out preventers, and locking head can be lifted from the casing. As shown most clearly in FIG. 2, when the pressure in line 44G is reduced, the hydrostatic head of water pressure forces the locking plates outwardly so that the locking head can be lifted from the casing. In the event the hydrostatic head of water is not sufficient to retract the locking plates, additional pressure may be applied through the kill line 44M and valve 44N to the interior of the locking plates, the blow-out preventers being set to shut off communication with the conductor. The kill line has the additional function of permitting a heavy fluid to be pumped down into the well in the event of a threatened blow-out and when the well is shut in by the blow-out preventers.

If the well is not to be permanently abandoned, but the blow-out preventers require replacement or repair, the drill pipe or other suitable guide is left in the well, and the locking head is released from the casing so that the conductor, blow-out preventers, and locking head can be lifted to the barge over the drill pipe. After the necessary repairs or replacements have been made, the locking head, blow-out preventers, and conductor are stripped back down over the drill pipe and into the sealing position shown in FIG. 2.

When it is desired to return to the well left in the condition shown in FIG. 2, the drilling barge, being guided by the buoys, is again anchored over the well site. The blow-out preventer line is picked up and again connected to the barge as described previously. The blow-out preventers are opened, and the drill pipe is raised by line 138 to the barge. The conductor is then stripped down over the drill pipe and sealed to the receiver, and drilling operations are resumed as described previously.

Referring to FIG. 6, which shows an arrangement for temporarily abandoning the well without leaving drill pipe in the well, an anchoring tool 140 on the lower end of a guide line 142 is lowered into the well through the conductor after the drill pipe is removed from the well. A marker buoy 144 is secured to the upper end of the guide line. The anchoring tool may be of any suitable type which can be lowered on a guide line and actuated from the guide line. For example, the tool may be a conventional plug of a type which is known commercially as Baker Model E-3, Product No. 437, which is described in the "Composite Catalog of Oil Field and Pipe Line Equipment," 21st 1955-56 Edition, on page 562, published by World Oil. The tool includes a packer element or anchor 146 on its lower end, and a wire line pressure setting assembly 148 on its upper end. The guide line is a coaxial-type conductor, permitting an electric current to be passed down the guide line to fire a charge in the pressure setting assembly, which expands the anchor 146 against the walls of the casing in the well. In firing the charge, the conventional tool releases the wire line and setting assembly from the anchor so that they may be withdrawn from the well. For this particular application, an auxiliary lead 150 is spliced onto the guide line and attached at its lower end to the anchor so the guide line remains secure to the anchor after it is set. Thus, a guide line can be lowered down the conductor into the well and anchored without using drill pipe. When drilling is to be resumed, the conductor is slid down over the guide line down onto the receiver and sealed as described above. A suitable conventional cutting tool is slipped down the guide line to cut it and release it from the packer. The guide line and setting assembly are then withdrawn from the well and the anchor drilled out so drilling operations may be resumed as described previously.

FIG. 7 shows another arrangement for anchoring a guide line in the well when the well is to be temporarily abandoned. A well base 152 is anchored in the well by a casing 154 which has only a receiver 156 at its upper end projecting a short distance above the top of the

base, no blow-out preventers being used at this stage of the operation. When it is desired to leave the well temporarily, the drill pipe is raised from the well until the drill bit is above the lower end of the casing by a distance slightly greater than the water depth. A plug 158 is screwed onto the upper end of the drill pipe remaining in the well, and the lower end of a guide line 160 is connected in an eye 162 in the plug 158. The upper end of the guide line is attached to a marker buoy 164. The drill pipe is then lowered back into the well by the guide line until the plug rests on the upper edge of the receiver and the buoy is floating in the water. The conductor (not shown) is then released from the receiver and raised to the drilling barge (not shown) which may then be removed from location. Drilling operations are resumed by anchoring the barge over the well site again, slipping the conductor down over the guide line, and connecting the conductor to the mandrel as described previously. The drill pipe is then lifted by the guide line, and the plug and guide line removed so that drilling operations can be resumed as described above.

Referring to FIG. 8, which shows an alternate system for locating the wellhead base on the ocean floor without using support lines, the wellhead base is suspended in the cellar of the barge by supports 170. The casing is made up in sections and lowered by lines 172 down through the center of the wellhead base until the lower end of the casing is just above the ocean bottom and the upper end of the casing is just below the rotary table. The drill pipe, drill collars, underreamer and drill bit are lowered down the casing to drill the well in the formation, salt water being circulated down the drill pipe, and no effort being made to obtain return circulation at this time.

Referring to FIG. 9, after the well is drilled to the required depth, additional sections of casing are added from the barge and the casing is lowered so its lower end is guided by the drill pipe to enter the upper end of the well. If desired, the well may be filled with a suitable drilling fluid to prevent sloughing of formation into the well. The drill pipe is withdrawn from the well and the casing to facilitate the addition of more sections of casing and the lowering of the casing into the well. Once the upper end of the casing is reached, it is welded or otherwise suitably secured to the wellhead base and the locking head, blow-out preventer and receiver are added.

As shown most clearly in FIGS. 11 and 12, a pair of diametrically opposed J slots 174 are in the upper end of the receiver and are adapted to receive a pair of outwardly extending projections 176 on a J slot tool 178 made up on the drill string. Thus, the well head base 14 and its associated parts are supported from the barge by the drill pipe. The supports 170 are disconnected from the well head base and the entire assembly is lowered by the drill pipe until the wellhead base rests on the formation as shown in FIG. 11.

The lower end of the drill pipe extends a considerable distance into the casing and a swab cup 180 is attached to the drill pipe well above its lower end to seal the annular space between the drill pipe and the casing. Conveniently, the drill collars and drill bit are not attached to the lower end of the drill pipe during this stage of the operation. A cement slurry is pumped down into the casing through the drill pipe and is forced by the swab cup to flow into the annular space between the casing and the well. After the desired amount of cement is added, it is followed by mud to place the cement in the position shown in FIG. 10. The J slot tool is then rotated out of the J slot, and the drill pipe is raised until the swab cup clears the upper end of the receiver, additional mud or other fluid being added to the casing as the drill pipe is withdrawn. The hydrostatic head of the drilling mud in the casing is sufficient to hold the cement in the position shown in FIG. 11 as the cement sets.

With the swab cup out of the receiver, but the lower end of the drill pipe extending down below the blow-out

preventers, additional drilling mud or fluid is circulated out the drill pipe to wash the blow-out preventers clean of any cement or other unwanted material. The well is now ready for the conductor 60 (see FIG. 5) to be stripped down over the drill pipe and sealed to the receiver. Drilling operations are then conducted as described previously.

We claim:

1. 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 disposed beneath the vessel so the upper end of the conductor terminates at the vessel, an anchor including a casing secured to the formation and having an opening communicating with the upper end of the well, releasable coupling means for sealing the lower end of the conductor to the anchor to form a continuous conduit between the well and the vessel, an elongated guide member extending down from the vessel through the conductor and anchor opening and into the casing, means for supporting the guide member in a generally upright position, means for lowering or raising the conductor with respect to the anchor to move it into or out of sealing position with the anchor while the guide member is disposed in the anchor to constrain and guide the conductor, and remote control means external of the conductor for releasing the coupling means from the water surface to permit the conductor and anchor to be separated from each other so the conductor can be raised from the anchor while the guide member is in the anchor.

2. Apparatus according to claim 1 in which the guide member is a laterally flexible line anchored at its lower end below the anchor opening within the casing.

3. Apparatus according to claim 2 which includes buoyant means secured to the upper portion of the guide line.

4. A method for connecting an elongated hollow conduit to a hole in a formation underlying a body of water to facilitate working in the hole from a vessel floating in the water over the hole, the method comprising disposing an elongated guide member in the hole, maintaining an upper portion of the guide member in the vicinity of the vessel, suspending an anchoring base with a depending casing from the vessel with the casing disposed around the guide member, lowering the base and casing so the casing enters the hole and the base comes to rest firmly on the formation, disposing the conduit around the guide member at the vessel, lowering the conduit so it is constrained by the guide member and guided to the casing, and sealing the conduit to the casing.

5. A method for drilling, marking, leaving and returning to a hole in a formation underlying a body of water from a floating vessel anchored in the water over the formation, the method comprising supporting an elongated and depending drill member from the vessel, lowering the drill member from the vessel to contact the formation, forming a hole in the formation with the drill member, lowering the lower portion of the drill member into the hole, disposing an elongated conduit around the drill member, supporting the conduit from the vessel, lowering the conduit so it is constrained and guided to the hole by the drill member, connecting the lower end of the conduit to the hole, drilling the hole deeper, disconnecting the drill member from the floating vessel, leaving the drill member in the hole to mark its location, disconnecting the conduit from the hole, raising the conduit and storing it on the vessel, moving the vessel from over the hole, thereafter returning the vessel to a position over the hole, disposing the conduit around the drill member, lowering the conduit so it is constrained and guided to the hole by the drill member, connecting the lower end of the conduit to the hole, and drilling the hole deeper.

6. Apparatus to facilitate operations such as drilling and working in a well in a formation underlying a body of water comprising a floating vessel, means for keeping

the vessel over the vicinity of the well, a generally upright elongated hollow conductor disposed beneath the vessel so the upper end of the conductor terminates at the vessel, a casing in the upper end of the well, means securing the casing to the formation, releasable coupling means for sealing the lower end of the conductor to the casing to form a continuous conduit between the well and the vessel, an elongated guide member extending down from the vessel through the conductor and into the casing, means for supporting the guide member in a generally upright position, means for lowering or raising the conductor with respect to the casing to move it into or out of sealing position with the casing while the guide member is disposed in the casing to constrain and guide the conductor, and remote control means external of the conductor for releasing the coupling means from the water surface to permit the conductor and casing to be separated from each other so the conductor can be raised from the casing while the guide member is in the casing.

7. A method for connecting an elongated hollow conduit to a hole in a formation underlying a body of water to facilitate working in the hole from a vessel floating in the water over the hole, the method comprising forming a hole with the lower end of an elongated drill pipe, maintaining the vessel over the vicinity of the hole, maintaining a lower portion of the drill pipe in the hole and an upper portion of the drill pipe in the vicinity of the vessel, suspending a casing from the vessel with the casing dis-

posed around the drill pipe, lowering the casing so the casing enters the hole, sealing the casing to the formation, disposing the conduit around the drill pipe at the vessel, lowering the conduit so it is constrained by the drill pipe and guided to the casing, and sealing the conduit to the casing.

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