June 21, 1966 G. D. JOHNSON ETAL 3,256,936

DRILLING UNDERWATER WELLS

Filed June 22, 1961 9 Sheets-Sheet 1

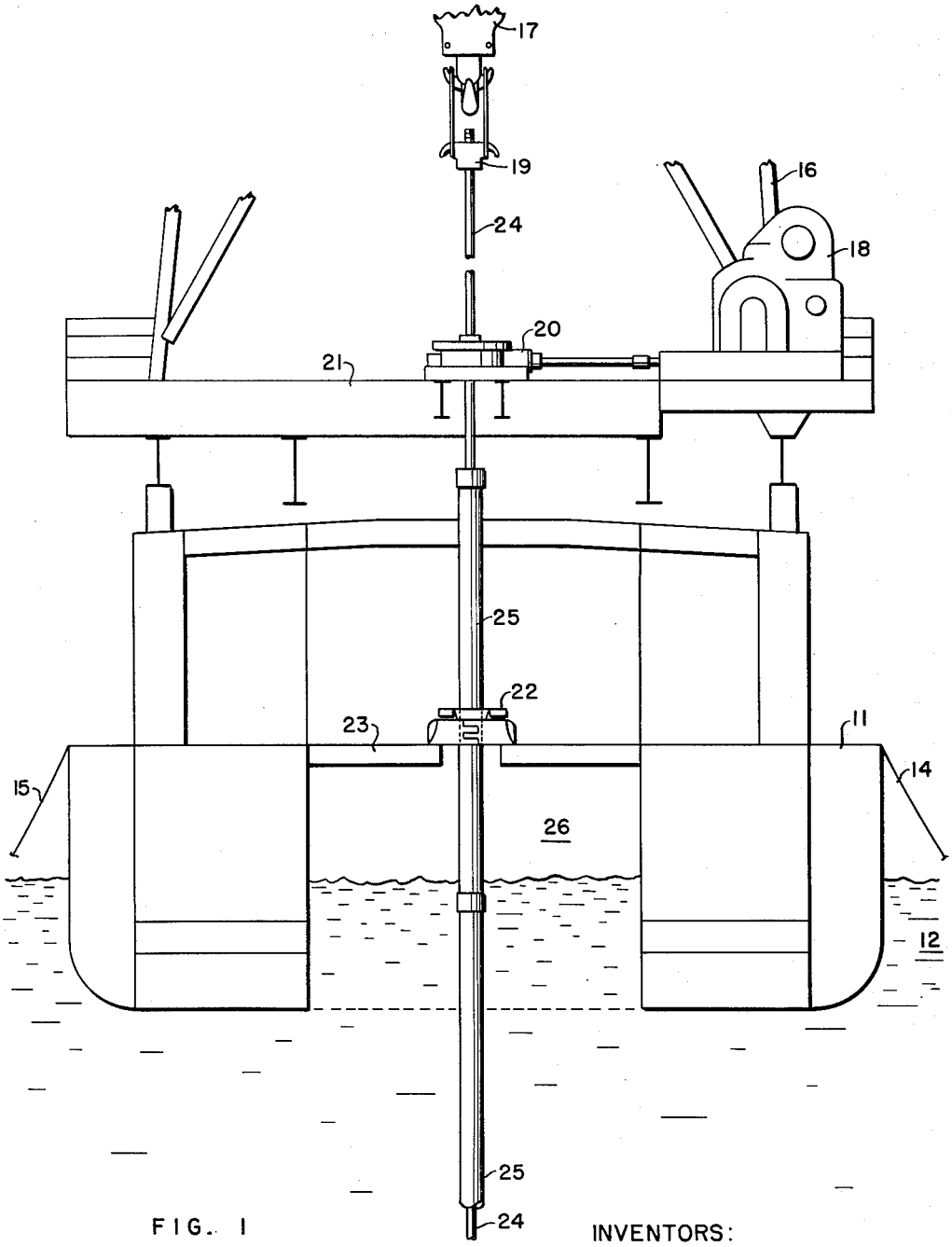


FIG. 1

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DRILLING UNDERWATER WELLS

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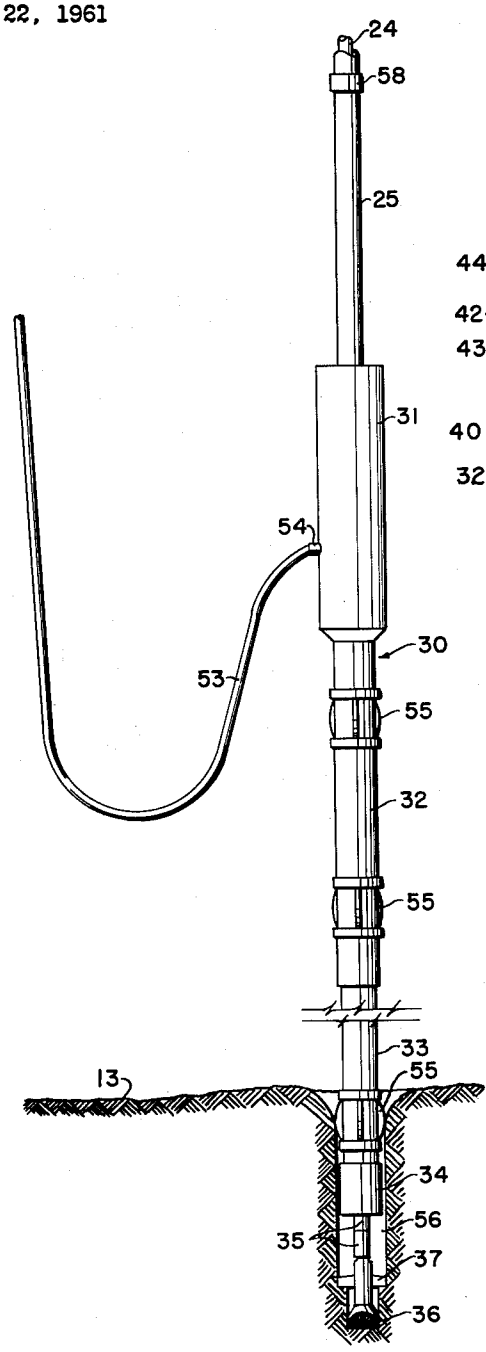


FIG. 2

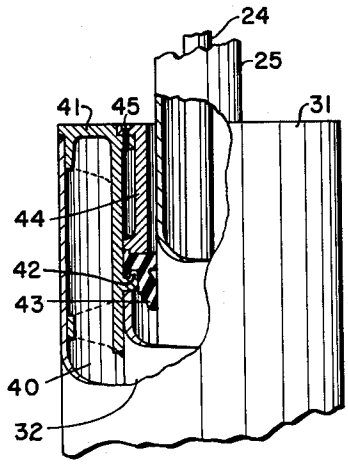


FIG. 2A

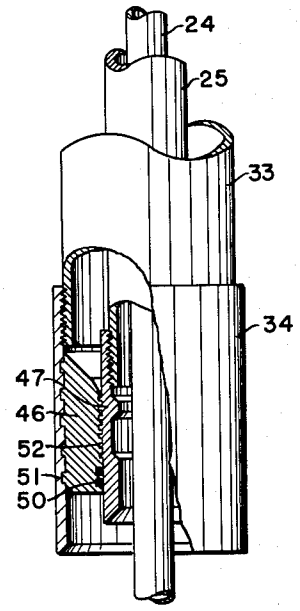


FIG. 2B

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DRILLING UNDERWATER WELLS

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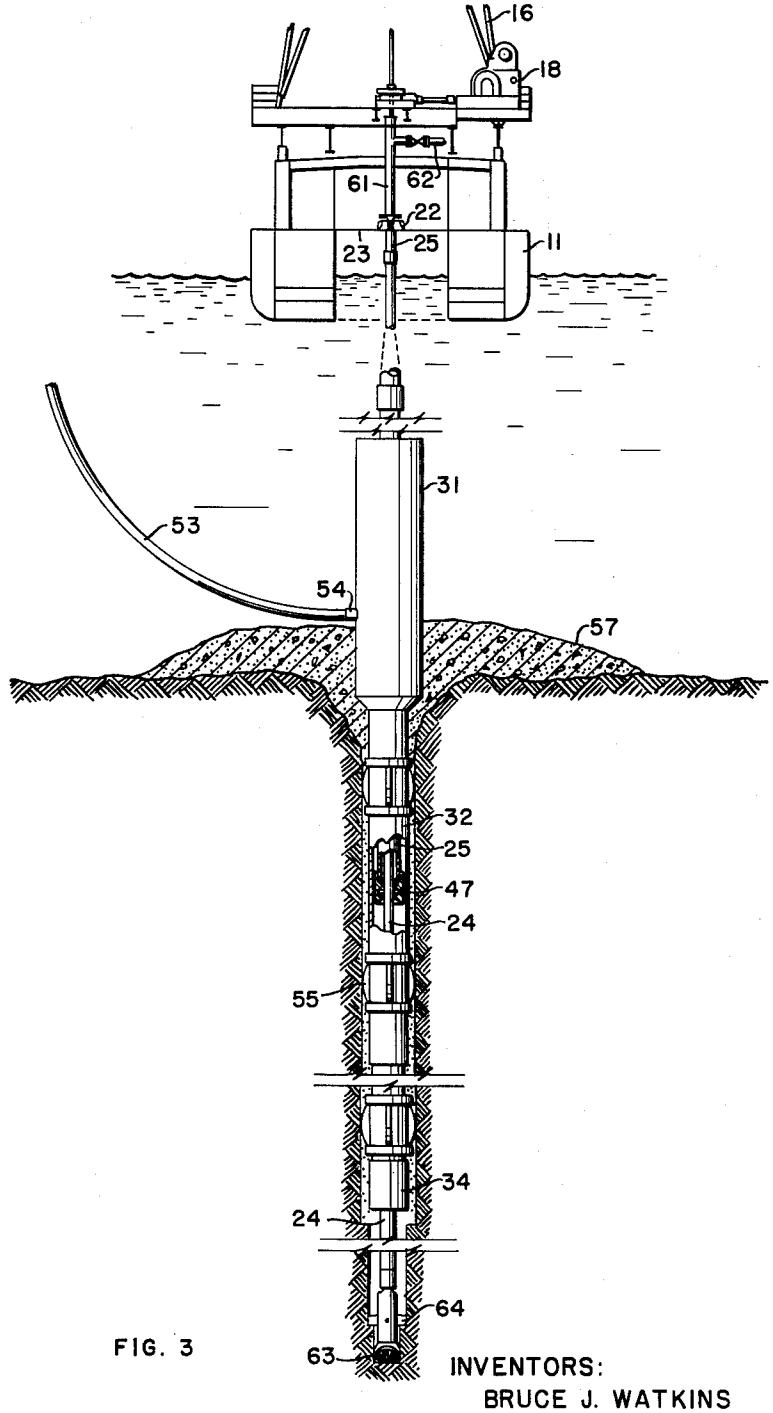


FIG. 3

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DRILLING UNDERWATER WELLS

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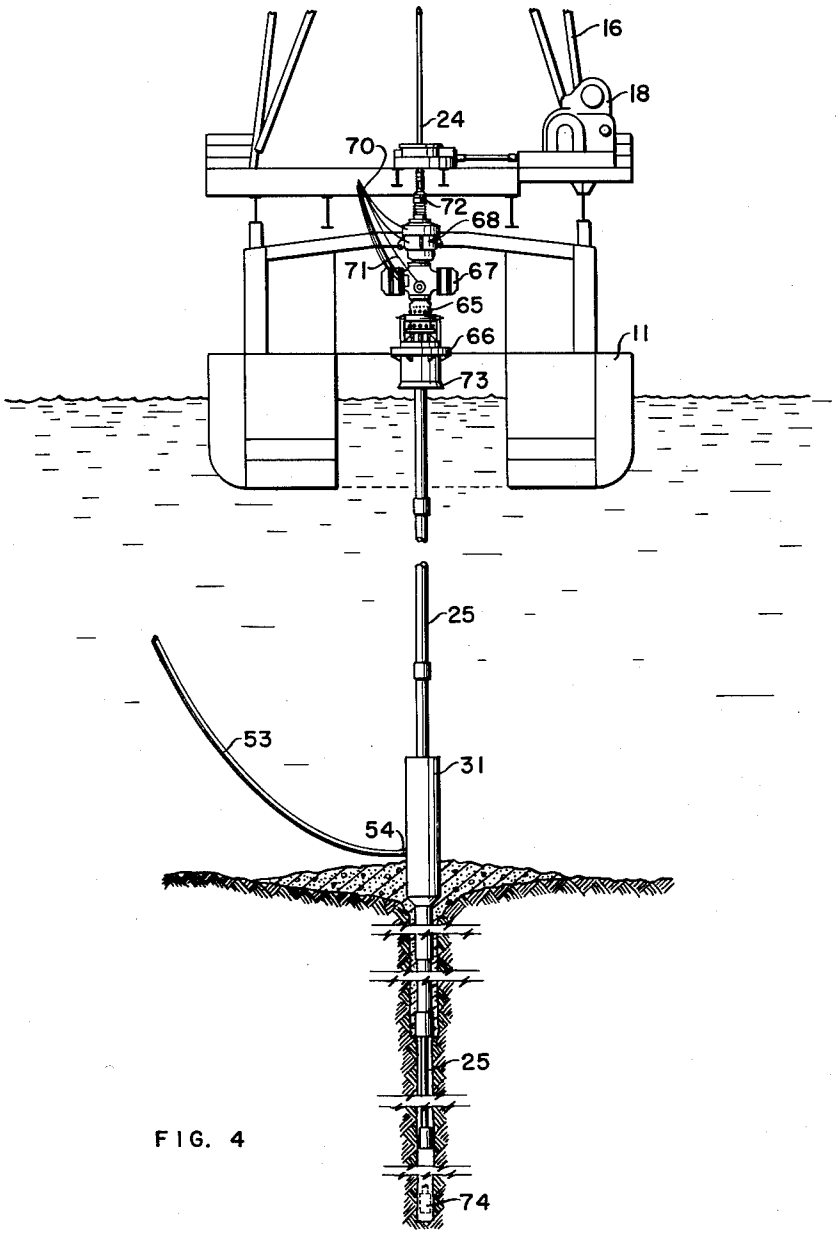


FIG. 4

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DRILLING UNDERWATER WELLS

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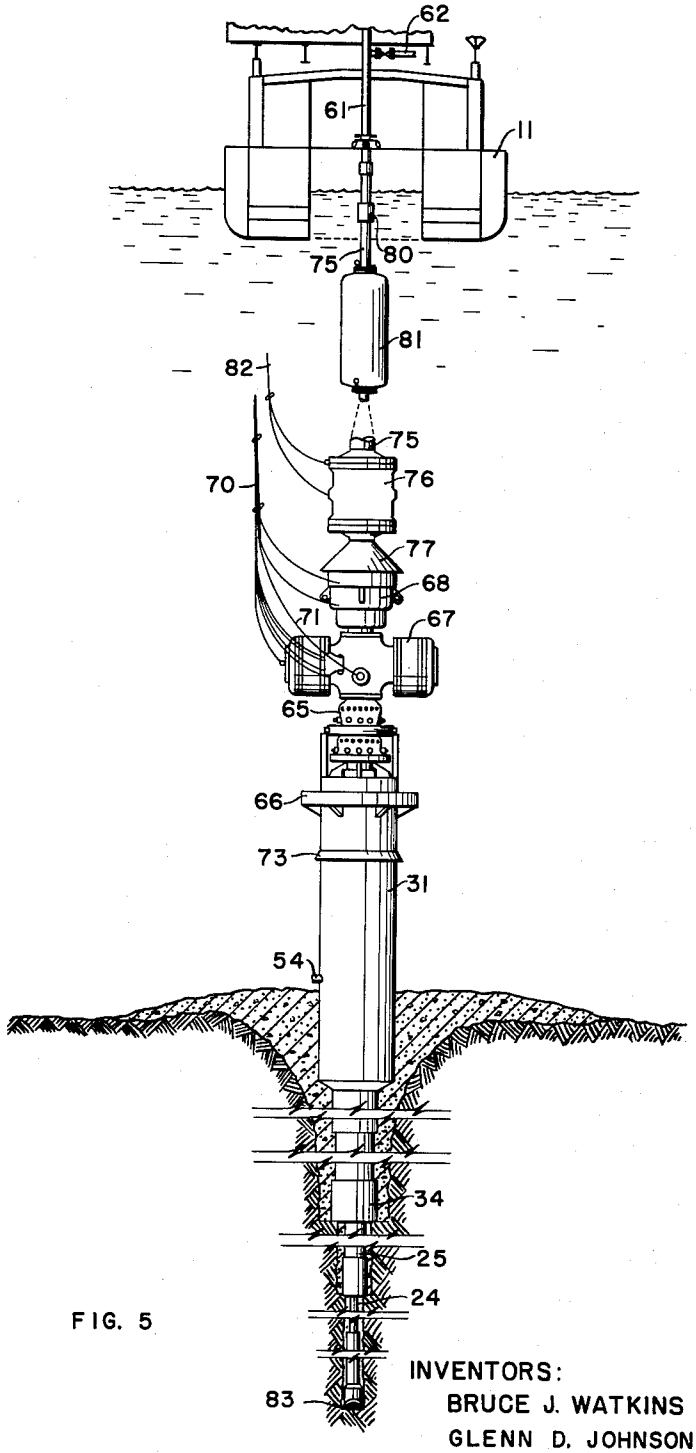


FIG. 5

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DRILLING UNDERWATER WELLS

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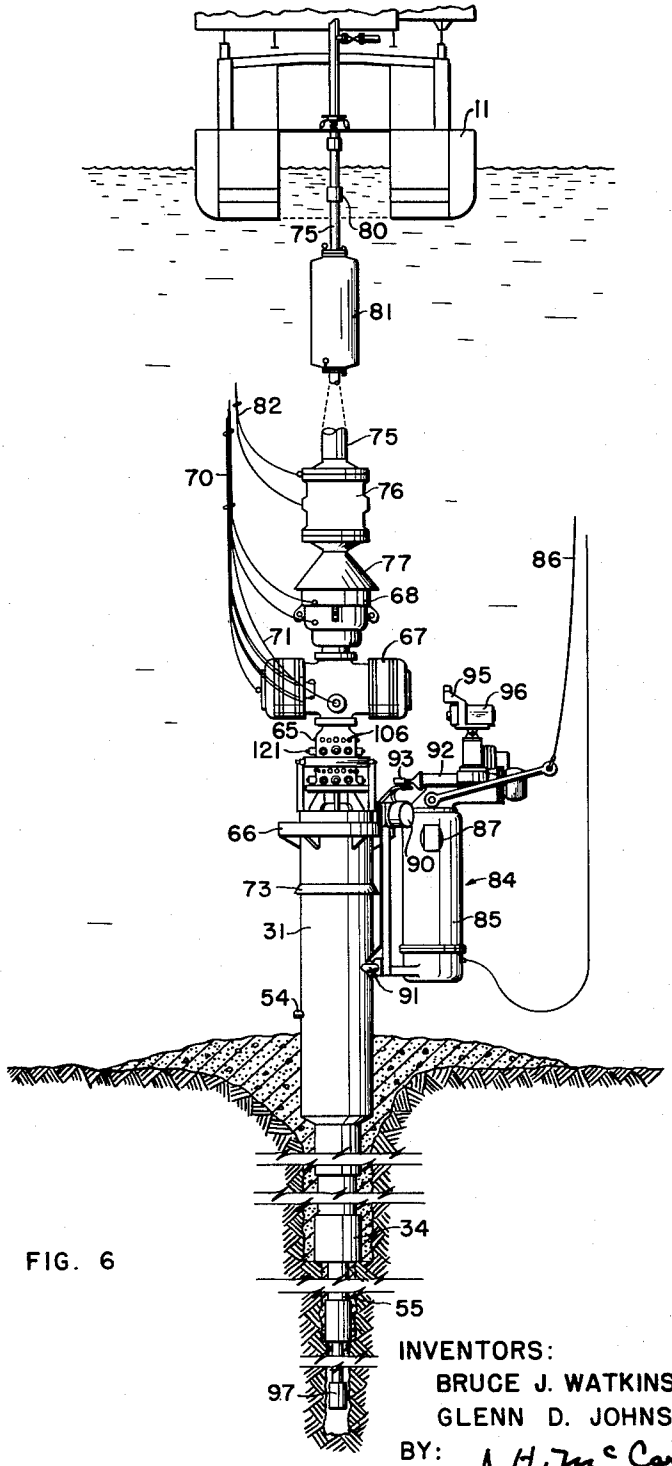


FIG. 6

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DRILLING UNDERWATER WELLS

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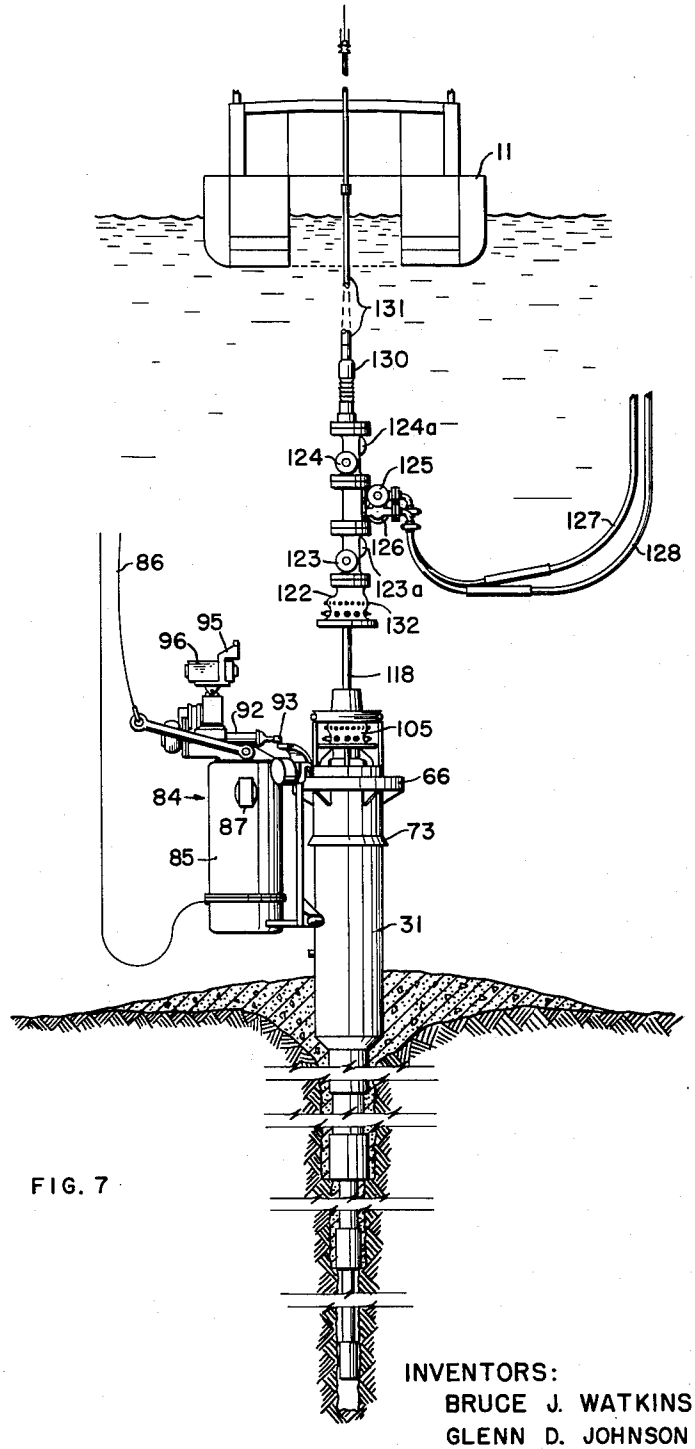


FIG. 7

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DRILLING UNDERWATER WELLS

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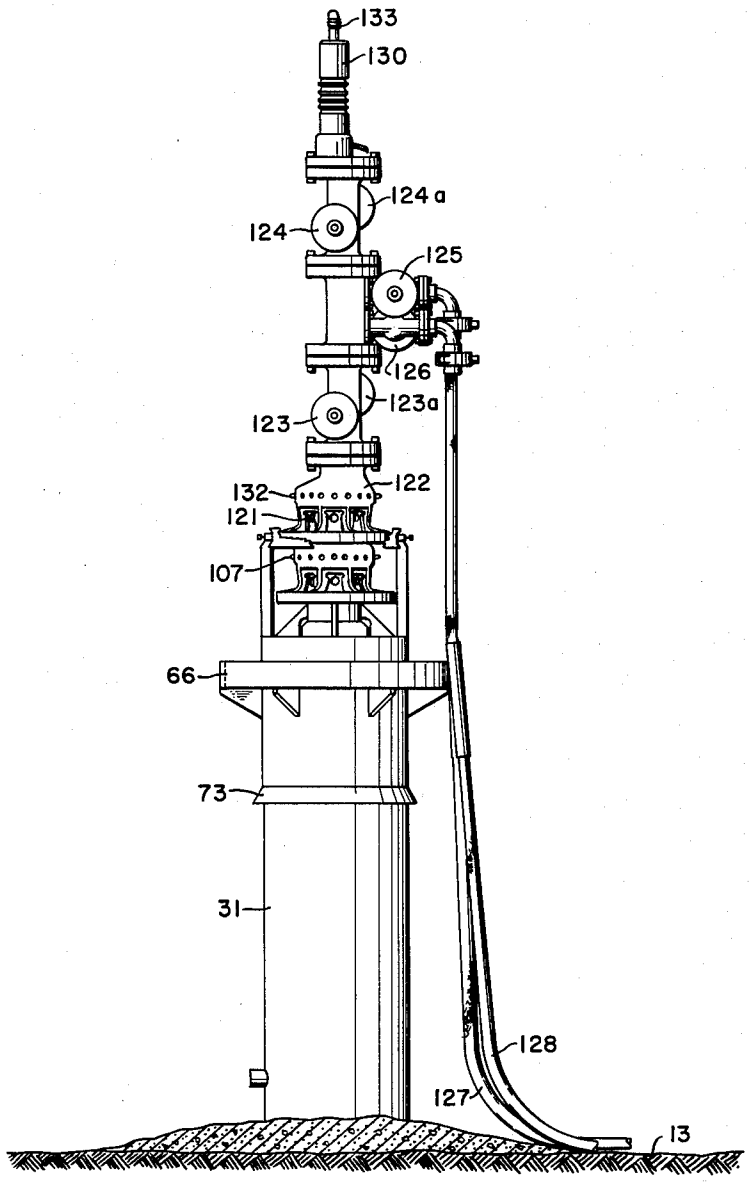


FIG. 8

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DRILLING UNDERWATER WELLS

Filed June 22, 1961 9 Sheets-Sheet 9

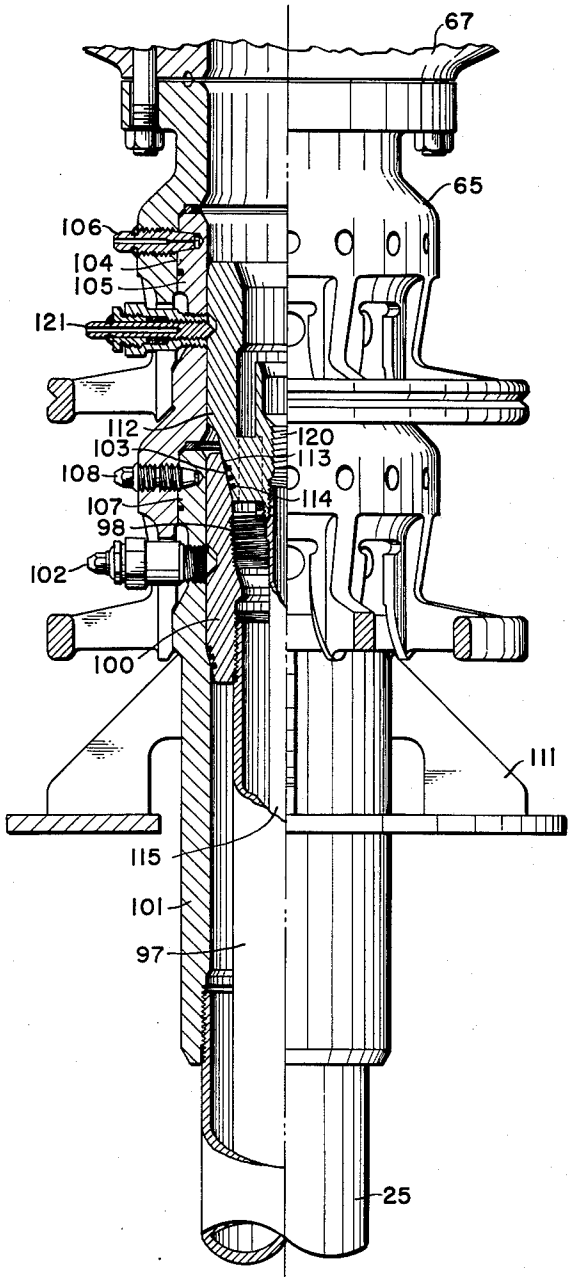


FIG. 9

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United States Patent Office 3,256,936 Patented June 21, 1966

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DRILLING UNDERWATER WELLS

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Filed June 22, 1961, Ser. No. 118,849
11 Claims. (Cl. 166—46)

This invention relates to the drilling of oil and gas wells, and pertains more particularly to a method and apparatus for the drilling of offshore wells wherein the wellhead assembly is positioned on the ocean floor or a considerable distance under the surface of a body of water.

In an attempt to locate new oil fields an increasing amount of well drilling has been conducted at offshore locations, such, for example, as off the coast of Louisiana, Texas, and California. As a general rule, the strings of casing in a well together with tubing string or strings, extend to a point well above the surface of the water where they are closed in a conventional manner that is used on land wells, with the conventional wellhead assembly being attached to the top of the casing. Due to the steeply dipping nature of the short line on the Pacific coast of the United States, there is a relatively narrow strip of ocean floor under less than 300 feet of water which might be developed economically from platforms employing legs which extend down to the ocean floor. The remainder of the offshore land, in water greater than 300 feet in depth, particularly the area off the southern California coast that includes deep basins potentially as productive as those on shore, can be developed economically only by drilling wells from floating vessels and by utilizing underwater well completion methods and apparatus wherein the wellhead assembly is located on or close to the ocean floor.

It is therefore a primary object of the present invention to provide a method and apparatus for drilling oil and gas wells from a floating, though preferably anchored, drilling barge in a manner such that the wellhead assembly is positioned on the ocean floor.

A further object of the present invention is to provide a method for drilling and completing an offshore well in a manner such wellhead is located below the surface of a body of water, and for example, near the ocean floor, so that deep draft vessels can pass safely overhead, thus eliminating the blow-out hazard present by the possibility of ships hitting the wellhead or a supporting platform therefore.

Another object of the present invention is to provide a method for drilling and completing an offshore well from a remote location without the aid of divers or without employing a rigid structure extending from the well to a point above the surface of the water.

Still another object of the present invention is to provide a method for maintaining control of an offshore well at all times during drilling completion and production operations.

A still further object of this invention is to provide a method of running and cementing multiple strings of pipe within a well drilled at an offshore location where the wellhead assembly is positioned near the ocean floor.

A further object of the present invention is to provide a method of drilling and completing a well wherein wellhead equipment is lowered through the water into place on the wellhead assembly without the use of a series of guide lines.

Another object of the present invention is to provide a method of drilling an offshore well which minimizes the number of trips necessary to lower into place various strings of pipe or equipment mounted on the wellhead.

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

FIGURE 1 is a diagrammatic view illustrating a floating drilling barge positioned over a drilling location and supporting concentric strings of pipe therefrom;

FIGURE 2 is a diagrammatic view of the foundation assembly used in accordance with the present invention with concentric pipe strings extending upwardly therefrom which are identical with the pipe strings that extend downwardly at the bottom of FIGURE 1;

FIGURE 2A is a view taken in partial longitudinal cross-section of the upper end of the foundation assembly of FIGURE 2;

FIGURE 2B is a view taken in partial longitudinal cross-section of the lower end of the foundation assembly of FIGURE 2 showing the connection between the conductor shoe and the lower end of the surface casing;

FIGURE 3 is a diagrammatic view illustrating the foundation assembly of FIGURE 2 positioned and cemented in a well borehole drilled in the ocean floor with a drilling barge positioned thereabove;

FIGURE 4 is a diagrammatic view illustrating the operation of lowering a drilling wellhead from a drilling barge onto the top of the foundation assembly on the ocean floor;

FIGURE 5 is a diagrammatic view showing the arrangement of equipment during the drilling of a well in accordance with the method of the present invention;

FIGURE 6 is a longitudinal diagrammatic view illustrating a manipulator device positioned on a drilling wellhead near the ocean floor for carrying out operations thereon;

FIGURE 7 is a longitudinal diagrammatic view illustrating the operation of lowering a production head and flow lines down to an underwater casinghead extending upwardly from the ocean floor;

FIGURE 8 is a longitudinal diagrammatic view of a completed wellhead assembly positioned on the ocean floor in accordance with the present invention; and,

FIGURE 9 is a view taken in partial longitudinal cross-section of the casinghead employed in the apparatus of the present invention.

Referring to FIGURES 1 and 2 of the drawing, a drilling barge **11**, of any suitable floating or floatable type is illustrated as floating on the surface of the water **12** and fixed positioned over a preselected drilling location 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 in water varying from about 100 feet to 1500 feet or more. The drilling barge is equipped with a suitable derrick **16** containing a fall-line system, including a traveling block **17**, a hoist **18**, and an elevator **19**. The barge **11** is also provided with other auxiliary equipment needed during the drilling of a well, such, for example as a rotary table **20** positioned on the operating deck **21**, a hinged slip and spider assembly **22** positioned on a lower deck **23**, etc. The elevator **19** is normally provided for suspending therefrom during drilling operations a drill string **24** or the kelly section at the top of the drill string, while the slip and spider assembly **22** is adapted to secure fixedly a string of pipe, for example, a string of surface casing **25**, against vertical movement relative to the barge **11**.

During some of the operations in accordance with the present invention, the surface casing **25** serves as a marine conductor pipe by which drilling mud may be circulated upwardly in the annulus formed between the surface casing **25** and the drill pipe **24**. The derrick **16** is positioned over a drilling slot, or well **26**, which extends vertically through the barge in a conventional manner. When using the equipment of the present invention, the

slot 26 in the barge 11 may be either centrally located or extend in from one edge, however, drilling operations may be carried out over the side of the barge without use of a slot. It is also to be understood that in some areas the apparatus and the method of the present invention may be utilized when operating from either a permanently fixed platform, or a temporarily fixed and normally floatable platform. However, for purposes of illustration, the present invention will be described with regard to its use when drilling and completing a well from a floating barge which is preferably anchored, but not necessarily so. In many drilling operations, the floating barge may be maintained in a relatively fixed position on the surface of the ocean by means of two or more outboard motors or other marine propulsion units arranged to act in opposition.

In FIGURE 2, a foundation assembly 30 is illustrated as comprising a section of large diameter pipe or conductor pipe 31, say 36 inches in diameter, which is fixedly secured as by welding, to intermediate and small sections of conductor pipe 32 and 33, respectively, with a conductor shoe 34 secured, as by screw threads, to the lower end of the conductor pipe 33. Although the foundation assembly has been described with regard to being made up of conductor pipe of varying diameters, it is to be understood that conductor pipe of a single diameter may be employed. Preferably, the portion of the conductor pipe, in this case, section 32 (FIGURE 3) in contact with the ground at the surface thereof is preferably a heavy-walled type in order to withstand the bending stresses during drilling. The upper portion of conductor pipe 31 is preferably of large diameter in order to serve as a base around which a manipulator device can rotate, as will be described herein below. A drill pipe 24 extends down through the conductor pipe of the foundation assembly, and drill collars 35 are normally secured to the lower end of the drill string above a drill bit 36 and a hole opener 37.

As shown in FIGURE 2A, the intermediate section of conductor pipe 32 extends up through the larger diameter conductor pipe 31 with the annular space 40 between the two pipes being closed by any suitable closure means 41. The closure means 41 is provided with a lip or shoulder 42 around the inner wall thereof for seating annular stripper rubber 43. A retaining ring 44 is positioned above the stripper rubber 43 for holding it on the shoulder 42. The retaining ring is secured in any suitable manner, as by screws 45, to the closure means 41. The internal diameter of the stripper rubber 43 is slightly less than the normal outside diameter of the surface casing 25 so as to provide a fluid tight seal therearound while allowing axial movement of the surface casing 25 relative to conductor pipe 31.

During the time when the well is being spudded and prior to the time when the foundation assembly 30 is cemented in the well, the conductor shoe at the bottom of the foundation asesmbly 30 is releasably secured to the lower end of the surface casing 25, as illustrated in FIGURE 2B. A rigid drillable closure member 46 is positioned between the conductor shoe 34 and a surface casing shoe 47. The closure member 46 is made of a drillable material, preferably cement, plastic or a soft or readily drillable metal, and may be provided with O-ring seals 50, if desired. The inner surface of the conductor shoe is preferably provided with a series of grooves 51 so that the closure member can be cast inside the shoe and will not move axially when a force is applied to it. Suitable connection means are provided between the closure member 46 and the surface casing shoe 47, such for example, as a J-slot connection or releasable left-hand thread 52. Although the present invention has been described as having the surface casing 25 and conductor pipe 33 being connected together at their lower ends, as by shoes 34 and 47 with closure member 46, it is to be understood that it is easier to connect the lower ends of casing 25 and conductor 33 together but that they could be connected at any joint above the end.

Prior to running any of the foundation assembly into the water and down to the ocean floor, the lowermost section of the surface casing would be inserted in the lowermost section of conductor pipe and the surface casing shoe 47 connected to the closure member 46. Thereafter, successive sections of pipe would be added to both the surface casing and the conductor pipe or foundation assembly 30 until the foundation assembly 30 had reached desired length. The foundation pipe would hang, by means of the closure member 46, from the lower end of the surface casing 25 as additional sections of surface casing were added to the top thereof to lower it to the ocean floor by means of the derrick hoist system. Prior to lowering the foundation assembly underwater a mud line 53 having a pull-off connection 54 would be attached to the conductor pipe 31 and would be in fluid communication with the conductor pipe 32 so as to serve as a mud return hose during future drilling operations.

With the equipment assembled in a manner illustrated in FIGURES 1 and 2, the lower section of the surface casing 25 is used in lowering and suspending the foundation assembly until the conductor shoe 34 thereof is positioned slightly above the ocean floor. The upper end the surface casing would be supported by the slip and spider assembly 22 from the lower deck of the drilling vessel 11. Well spudding operations are now carried out by installing the drill bit 36, hole opener 37, drill collar 35 and drill pipe 24 in the surface casing 25 and lowering it through the surface casing to the position shown in FIGURE 2. If desired, the conductor pipes 32 and 33 may be provided with centralizers 55. The drill bit and drill string is lowered to the ocean floor and drilling operations are commenced to drill the well. After a few feet of the hole 56 have been drilled, as illustrated in FIGURE 2, drilling is stopped and the foundation assembly and surface casing is lowered slightly so that the lower end of the foundation assembly is in the well bore, thus stabilizing the foundation assembly while the balance of the hole is being drilled for the conductor pipe. The hole for the conductor is preferably drilled using sea water as a circulating fluid which is pumped down through the drill string 24 and comes up outside the conductor pipe 32 and 33.

After the hole for the conductor pipe has been drilled, the drill pipe 24 and bit 36 are removed. The foundation assembly is then lowered by adding sections of surface casings 25 at the top thereof until the foundation assembly 30 is supported either by the conductor shoe 34 at the bottom of the well, or from the large conductor section 31 at the top of the wellbore.

As shown in FIGURE 3, cementing operations can be carried out either through the drill pipe 24 prior to its removal, or through the surface casing 25, depending on the conditions and the operator's preference, using an excessive amount of cement in order that conductor pipe be securely cemented to the ocean floor. The conductor pipe and foundation assembly then become the main structural member that supports the wellhead against any static or dynamic forces applied during such an operation.

In FIGURE 3, the foundation pipe as illustrated is cemented in place with a pad of cement 57 being formed around the top of the borehole. Prior to commencing further drilling operations, the surface casing 25, and its shoe 47 are released from the conductor shoe 34 by rotating the surface casing 25 until the left-hand threads become disengaged. The surface casing string 25 is then raised slightly to a position where the stripper rubber 43 (FIGURE 2A) is positioned between two collars 58 on the surface casing 25, thus permitting sliding axial movement of the surface casing string 25 within the stripper rubber 43, a distance equal to the length of a section of surface casing, normally 30 feet. The use of a stripper

rubber in this manner eliminates the need of a buoyancy chamber or a slip joint attached to the surface casing. In the position shown in FIGURE 3, the surface casing **25** is suspended from the slip and spider assembly **22**. A flow nipple **61** and a mud return line **62** are connected to the top of the surface casing **25**. Drilling operations may now be resumed using a drilling fluid in a conventional manner, pumping the fluid down the drill string **24**, through the small size bit **63**. Flow of mud would then proceed up the annulus between the surface casing **25** and the drill string **24** to the flow nipple and mud line **61** and **62** respectively, from whence, the mud could be discharged into a settling pit (not shown) on the barge, or could be discarded, as desired. A drill string **24** with the small size bit **63** and a hole opener **64** would be lowered through the surface pipe **25** as drilling progressed. Sufficient hole is then drilled and the well is otherwise conditioned to receive a surface casing **25**.

At any time during the drilling operation, the depth of the well is known. After drilling the borehole for the sufficient length of surface casing **25** desired, a length of surface casing is run into the well by adding additional sections to the top of the surface casing string until the surface casing shoe **47** is positioned at a distance above its final cemented position which is equal to the distance between the lower deck **23**, of the barge **11** and the upper end of the large diameter conductor pipe **31**. As is shown in FIGURE 4, a drilling wellhead assembly **65**, having a manipulator track **66** and blow-out preventers **67** and **68** secured thereto, is attached to the upper end of the surface casing, as by a threaded connection. The blow-out preventer is provided with a series of electrical or hydraulic conduits **70**, as well as a choke and kill line **71**. A riser mandrel **72** (FIGURE 4) is provided at the top of the blow-out preventer **68** to which a string of drill pipe **24** may be connected for purposes of lowering the assembled apparatus down into position on top of the large diameter conductor pipe **31**. A guide skirt **73** on the bottom of the assembly helps to guide the drilling wellhead assembly **65** and its manipulator track **66** into position over the upper end of the conductor pipe **31**, as shown in FIGURE 5. The surface casing is then cemented in place by pumping cement down the drill pipe **24** used for lowering (FIGURE 4) and surface casing, up the outside of the surface casing **25** until a cement plug **74** (FIGURE 4) has been discharged from the bottom thereof in a conventional manner. The fluid in the well druing the cementing operation is forced up the outside of the surface casing **25** and up through the return mud line **53**. At the termination of the cementing operation, the mud line **53** is pulled loose at its pullout connection **54**.

Prior to or subsequent to the cementing of the surface casing **25** a large diameter pipe string known as a drilling riser or marine conductor **75** is lowered or stripped down over the drill pipe **24** in a manner described in co-pending patent application Serial No. 118,989, filed June 22, 1961. The lower end of the drilling riser **75** is provided with a Regan Forge and Engineering Company type "K" preventer **76** which is of the contractable bag-type and may be provided with a guide skirt **77** at the lower end. Additionally, the drilling riser **75** may be provided with a telescopic joint **80** immediately below the drilling vessel and, if desired, a buoyancy tank **81**. A nipple **61** and return line **62** are also connected to the top of the drilling riser **75** for handling mud returns therefrom. The Regan preventer **76**, which serves as a flexible joint for the riser **75**, is provided with control hoses **82** prior to lowering it into position. When in engagement with the riser mandrel **72** (FIGURE 4) at the top of the blow-out preventer **68**, the preventer is secured in a fluid-tight manner by applying pressure fluid through a control hose **82**. Alternatively, instead of employing a preventer **76** at the lower end of the drilling riser **75** and using a drill pipe **24** to land the drilling head **65** and blowout preventers **67** and **68** in the top of conductor pipe **31**, the preventer **76** may be omitted and the top of the blowout preventer **68** may be connected to the bottom of the drilling riser **75** which would be used to run the blowout preventers **67** and **68** into place with the drilling head assembly **65**.

A drill bit **83** of suitable size is run down through the apparatus assembled in FIGURE 5 on a drill string **24** and drilling operations are continued until the bore hole has been drilled deep enough to receive a production casing. Prior to running a string of production casing in the well, the drill pipe **24** and bit **83** are withdrawn therefrom and an under-water manipulator device **84** is landed on the track **66**. The underwater manipulator device **84** is of a type described on co-pending application Serial No. 24,558, filed April 25, 1960, and comprises a housing **85** adapted to be lowered by means of a cable **86**, swum into position by means of propellers in housings **87** and hung by means of a pair of wheels **90** on the track **66** to move thereabout while a pair of idler wheels **91** contact the outer surface of the larger diameter conductor pipe **31**. The manipulator device **84**, is provided with at least one arm **92** preferably horizontally-positioned, as illustrated, and adapted to move in and out, up and down, or to rotate at the discretion of an operator at a remote location on the drilling barge **11**. In this particular application the moveable arm **92** would be provided with the wrench **93** of the outwardly extending in thereof for contacting the bolts **94** on the drilling wallhead assembly **65**. Lights **95** and a television camera **96** are provided on the manipulator device and are movable in any direction, normally being used to observe the operation carried out by the wrench **93**, or to aline it on one of the bolts **94**.

In FIGURE 6, the production casing **97** is shown as having been lowered to its desired position in the well at which point it is cemented. The production casing **97**, is lowered by means of a drill pipe (not shown) which would be attached to a left-hand thread release **98** formed on the inner wall of the production casing hanger **100**, as shown in FIGURE 9. After being landed, the production casing **97** is locked to the casinghead **101** by the lower control screws **102**. These screws would be run into place by means of the wrench **93** of the manipulator device **84** (FIGURE 6). The production casing **97** is cemented in place by use of a Baker Company "J" cementing collar (not shown) which would be installed on the lower end of the cementing pipe string or on the drill pipe, and inserted in the upper end of the production casing **97** in a manner well known to the art. The cement is circulated down through the drill pipe or cementing string with return of fluid passing through the cementing collar and up through the choke and kill line **71** of the blow-out preventer **67**. Subsequent to cementing the production casing, the lower end of the drill pipe or cementing string would be released from the left-hand thread **98** in the casing hanger **100** and the pipe would be withdrawn to barge **11**. The well is now ready for additional drilling operations or for receiving production tubing. If further drilling is to be performed, a combination tool guide and seat protector (not shown) may be installed, if desired, in the casing hanger **100** to serve as a guide for tools and to protect the tubing hanger seat **103**.

As shown in FIGURE 9, the wellhead assembly used during drilling operations comprises the drilling wellhead portion **65** which seats on a landing surface **104** of an intermediate section or upper casinghead section **105**, and is secured thereto by a series of upper lock screws **106**, only one lock screw being shown. The upper casinghead section **105** in turn is seated on a landing surface **107** formed at the top of the casinghead **101** on the outer surface thereof, with a series of lower lock screws securing casinghead sections **101** and **105** together. The casinghead **101** is preferably provided with a support base **111** which is fixedly secured thereto, as by welding. This support base **111** in turn may rest on top of the foundation pipe assembly section **31** (FIGURE 2). While it is preferred in the present invention to employ a wellhead having

upper and lower casinghead sections, **105** and **101**, respectively, on which a drillinghead **65** can be secured, it is quite apparent that the upper and lower sections of the casinghead, **105** and **101**, respectively, could be formed as a single element, in which case the lower lock screws **108** could be eliminated. However, as a safety precaution in underwater wellhead structures, the housing employs upper and lower casing heads, section **105** and **101**, respectively, secured together by a means of the lower locking screws **108** which are preferably made of an alloy carbon steel or of a suitable material so that they can be drilled out in the event that the upper lock screws **106** become wedged or corroded in a manner so that they cannot be withdrawn from their seating position in order to remove the drilling head **65**, or a production head, therefrom.

A tubing hanger **112** is illustrated as being seated on the landing surface **103** formed in the top of the casing hanger **100**. The tubing string **115**, depending from the tubing hanger **112**, is concentrically arranged within the surface casing string **25**. The outer surface of the tubing hanger **112** at the lower end thereof is provided with a tapered seating surface **113**, preferably provided with seal means **114**, such for example as any suitable type of packing, or O-rings. The tubing hanger **112** is adapted to be secured at its lower end to the top of a string of tubing **115**, for example, by screw threads. One or more fluid flow passageways **116** extend vertically through the tubing hanger **112** in communication between the annulus **117**, formed between the outer wall of the tubing string **115** and the inter wall of the production casing **97**, and the space above the tubing hanger **112**.

The interior wall of the tubing hanger **112** is provided with suitable means, for example, a left-hand thread **120** by which the tubing hanger **112** can be attached to the lower end of a pipe string (not shown) for lowering the tubing hanger **112** and its depending tubing string into the well from the barge **11**. After landing the tubing, the tubing hanger **112** is locked down by tightening the upper set of control screws **121** by means of the wrench **93** carried by the manipulator device **84**. The tubing string **115** is run with any conventional downhole equipment that prevents communication between the formation and the tubing or casing string. Prior to running the tubing string, or subsequent thereto, the well casing could have been perforated in any suitable manner well known to the art.

After the tubing string **115** has been positioned in the well, and the well is otherwise conditioned to receive the Christmas tree, the underwater manipulator device **84** is employed to unscrew the upper lock screw **106** which hold the drilling head **65** into the upper section **105** of the casinghead. The drilling riser **75** and the equipment associated therewith, that is, the connector device **76**, the blow-out preventers **67** and **68**, and the drilling head **65** are raised or stripped out of the water over the pipe string employed to run the tubing hanger into place. This stripping operation is carried out in a manner described in co-pending patent application Serial No. 118,989, filed June 22, 1961.

In order to produce oil from the well, a production head **122** (FIGURE 7) is lowered or stripped down over the tubing running string **118** which extends from the top of the tubing within the casinghead to the barge **11**. The production head is preferably of the type described in co-pending patent application Serial No. 72,168, filed November 28, 1960, which alters the two concentric pipe strings in a well to two parallel flow passageways in which control valves may be located. The production head is provided with control valves **123** and **124** and side outlet valves **125** and **126** which control fluid flow through flow lines **127** and **128**, respectively. Normally, only one flow line would be employed to produce fluid from the oil or gas zone. However, in certain areas dual flow lines may be employed. After the normal flow of a well has decreased to an extent it no longer will produce out of a flow line, the other flow line can be employed to inject gas into the well to gas life production fluid therefrom.

The top of the Christmas tree, made up of valves **123** through **126**, may be closed in any suitable manner, as by a wellhead closure member or a lubricator mandrel **130** which is releasably secured to the lower end of a running pipe string **131** used to lower the production and Christmas tree down over the tubing landing string **118**. The tubing landing string **118** is a small-diameter pipe and may have a wire line or cable (not shown) running therethrough, the cable being made up in sections as long as each pipe and being secured at its lower end to the lowermost tool joint at the bottom of the tubing string of each section. Thus, in the event that the tubing landing string should break, the cable would be sufficient to support the weight of the equipment.

When the production head **122** has been seated on the upper portion **105** of the casing head, the lock screws **132** carried by the production head **122** are run into place by the wrench **93** on the underwater munipulator **84**. The tubing landing string **118** (FIGURE 7) is then disconnected from a tubing hanger by rotation and it is then pulled up to the barge through the running string **131** secured to the lubricator mandrel **130**. A closure **133** is then run through the lubricator pipe string **131** and secured in a fluidtight manner in the top of the lubricator mandrel **130**. The lubricator mandrel is preferably of the type having at least two concentric vertical flow passages therethrough with a cross-over chamber at the bottom of the outermost flow passage in communication, through one flow passageway in the Christmas tree, with the tubing-casing annulus of the well.

The manipulator device **84** (FIGURE 7) may then be lifted off the track **66** by means of cable **86** and raised to the surface. This leaves the wellhead assembly on the ocean floor with its two flow lines **127** and **128** extending down from the Christmas tree and running along the ocean floor **13**. The master valves **123** and **123A** as well as valves **124** and **124A** are of a normally-closed type, preferably, whereas the side arm valve **125** and **126** are preferable of a normally-open type. All of the valves are operated by means of gas pressure supplied through one of the flowlines **127** or **128** from a suitable source. Under operating conditions, master valves **123** and **123***a* are held open by the pressure in the high pressure gas line **128** while production fluid leaves the well through flow line **127**.

If it becomes necessary to open the well and re-enter it with tools, the manipulator device **84** (FIGURE 7) is lowered on its cable together with a guide line (not shown) which is attached by the manipulator device to the top of the lubricator mandrel **130** or its closure plug **133**. Using this guide line which would extend up to the barge **11** at the surface, drilling riser **75** (FIGURE 5) similar to the pipe string **131** of FIGURE 7, and carrying a Regan connector at its lower end similar to element **76** of FIGURE 5, would be lowered down onto and attached to the top of the lubricator mandrel **130**. The drilling riser used in re-entry and work-over operation on the well may be much smaller in diameter than the riser used in drill operations. After the work-over riser is attached to the lubricator mandrel **130**, the mandrel cap can be removed by means of a wire line tool or a retrieving tool positioned at the lower end of a pipe string. The upper end of the riser at the vessel would be provided with suitable means for connecting it to a source of hydraulic fluid whereby a pressure fluid could be applied to the riser mandrel to open control valves **124** and **124A**. The well would then be completely connected to the barge **11** and would be in a condition to be entered, with wire line tools, or could be filled with drilling mud for more extensive work-over operations. The well can also be filled by circulating mud through the flexible flow lines **127** and **128**. After the well is filled and otherwise

plugged, the Christmas tree and production head can be removed by having the wrench **93** carried by the manipulator device **84** unscrew the upper lock screws **132** (FIGURE 8). However, if difficulty is encountered in disconnecting the Christmas tree at this point, the upper control screw **121** and the lower lock screws **107** can be backed off by the manipulator device **84** and the tree, production head **122**, and upper portion of casing head **105** can be removed. After the production tree has been removed the drilling riser and blow-out preventers can be reattached to the well by reversing the steps in the operation described herein above. It may be seen from the assembly method and equipment described that all parts of the wellhead equipment subject to possible damage can be removed, repaired and reinstalled at any time during the productive life of the well.

We claim as our invention:

1. A method of drilling an offshore well from an operational platform positioned above the surface of a body of water, said method comprising assembling a foundation assembly, having a vertical opening therethrough, inserting a string of surface casing into the vertical opening of the foundation assembly, releasably connecting together the lower end of said surface casing and said foundation assembly, suspending said surface casing from said operational platform, inserting a drill string and bit through said surface casing, rotating said drill string and bit to drill a hole in the ocean floor of a diameter and length to receive at least the lower portion of said foundation assembly, lowering said foundation assembly supported by said surface casing and connected thereto along said drill string and into the hole in the ocean floor, and cementing the foundation assembly in the hole in the ocean floor.

2. The method of claim **1** including the step of releasing the lower end of the surface casing from the lower end of the cemented foundation assembly by manipulating the upper end of the surface casing from the vessel.

3. The method of claim **2** including the steps of subsequently installing a drill string and bit through said surface casing and resuming drilling operations.

4. A method of drilling an offshore well from an operational platform positioned above the surface of a body of water, said method comprising assembling a foundation assembly having a vertical opening therethrough, inserting a string of surface casing into the vertical opening of the foundation assembly, sealing the space between said surface casing and said foundation assembly near the top thereof in axial sliding arrangement, releasably connecting together the lower end of said surface casing and said foundation assembly, suspending said surface casing from said operational platform, inserting a drill string and bit through said surface casing, rotating said drill string and bit to drill a hole in the ocean floor of a diameter and length to receive at least the lower portion of said foundation assembly, lowering said foundation assembly and said surface casing connected thereto along said drill string and into the hole in the ocean floor, and cementing the foundation assembly in the hole in the ocean floor.

5. A method of drilling an offshore well from an operational platform positioned above the surface of a body of water, said method comprising assembling a foundation assembly having a vertical opening therethrough including a conductor pipe with a mud return line intermediate the ends thereof and a conductor shoe at the lower end thereof, inserting a string of surface casing into the vertical opening of the foundation assembly, sealing the space between said surface casing and said foundation assembly near the top thereof in axial sliding arrangement, releasably connecting together the lower end of said surface casing and said foundation assembly, suspending said surface casing from said operational platform, inserting a drill string and bit and hole opener through said surface casing, rotating said drill string and bit to drill a hole in the ocean floor of a diameter and length to receive the major portion of said foundation assembly, lowering said foundation assembly and said surface casing connected thereto along said drill string and into the hole in the ocean floor, cementing the foundation assembly in the hole in the ocean floor, releasing the lower end of the surface casing from the lower end of the foundation assembly by manipulating the upper end of the surface casing from the vessel, raising the surface casing sufficient to place the sealed zone at the top of said foundation assembly in a position intermediate the end of a section of surface casing, and resuming drilling operations.

6. A method of drilling an offshore well from an operational platform positioned above the surface of a body of water on a floating barge, said method comprising assembling a foundation assembly having a vertical opening therethrough including a conductor pipe with a mud return line intermediate the ends thereof and a conductor shoe at the lower end thereof, inserting a string of surface casing into the vertical opening of the foundation assembly, sealing the space between said surface casing and said foundation assembly near the top thereof in axial sliding arrangement, releasably connecting together the lower end of said surface casing and said foundation assembly, suspending said surface casing from said operational platform of said floating barge, inserting a drill string and bit and hole opener through said surface casing, rotating said drill string and bit to drill a hole in the ocean floor of a diameter and length to receive the major portion of said foundation assembly, lowering said foundation assembly and said surface casing connected thereto along said drill string and into the hole in the ocean floor, removing the drill string, cementing the foundation assembly in the hole in the ocean floor, releasing the lower end of the surface casing from the lower end of the foundation assembly by manipulating the upper end of the surface casing from the vessel, raising the surface casing sufficient to place the sealed zone at the top of said foundation assembly in a position intermediate the ends of a section of surface casing, installing a drill string and drill bit through said surface casing and resuming drilling operations.

7. Apparatus for use at an offshore well drilled from an operational platform positioned above the surface of a body of water, said apparatus comprising a large-diameter conductor pipe adapted to be lowered from an operational platform into a well drilled in the ocean floor, a string of surface casing pipe positioned concentrically within said conductor pipe, releasable weight-supporting connector means securing together said lower portion of said surface casing pipe and said conductor pipe intermediate the ends thereof, said connector means being of a material drillable by a well drill bit, there being an annular space formed above said connector means between said surface casing pipe and said conductor pipe and means for guiding the concentric pipes from the platform into the well.

8. Apparatus for use at an offshore well drilled from an operational platform positioned above the surface of a body of water, said apparatus comprising a large-diameter conductor pipe adapted to be lowered from an operational platform into a well drilled in the ocean floor, a string of surface casing pipe positioned concentrically within said conductor pipe, releasable weight-supporting connector means securing together said lower portion of said surface casing pipe and said conductor pipe intermediate the ends thereof, said connector means being of a material drillable by a well drill bit, there being an annular space formed above said connector means between said surface casing pipe and said conductor pipe, resilient seal means carried by said conductor pipe near the top thereof for closing said annular space and means for guiding the concentric pipes from the platform into the well.

9. The apparatus of claim **8** including conduit means extending from said operational platform and through the wall of said conductor pipe below the seal means

thereof for allowing fluid to flow from said conductor pipe to said operational platform.

10. Apparatus for use at an offshore well drilled from an operational platform positioned above the surface of a body of water, said apparatus comprising a large-diameter conductor pipe adapted to be lowered from an operational platform into a well drilled in the ocean floor, a string of surface casing pipe positioned concentrically within said conductor pipe, releasable weight-supporting connector means securing together the lower ends of said surface casing pipe and said conductor pipe, said connector means being of a material drillable by a well drill bit, there being an annular space formed above said connector means between said surface casing pipe and said conductor pipe, resilient seal means carried by said conductor pipe near the top thereof for closing said annular space, said seal means forming substantially fluidtight seal arranged for sliding engagement with the outer surface of said surface casing pipe when the lower ends of said surface casing pipe and said conductor pipe are disconnected one from the other and means for guiding the concentric pipes from the platform into the well.

11. Apparatus for use at an offshore well drilled from an operational platform positioned above the surface of a body of water, said apparatus comprising a large-diameter conductor pipe adapted to be lowered from an operational platform on a floating drilling barge into a well drilled in the ocean floor, a shoe carried at the lower end of said conductor pipe, a string of surface casing pipe positioned concentrically within said conductor pipe, a shoe carried at the lower end of said surface casing pipe, releasable weight-supporting connector means securing together the shoes at the lower ends of said surface casing pipe and said conductor pipe, said connector means being of a material drillable by a well drill bit, there being an annular space formed above said connector means between said surface casing pipe and said conductor pipe, resilient seal means carried by said conductor pipe near the top thereof for closing said annular space, said seal means forming a substantially fluidtight seal arranged for sliding engagement with the outer surface of said surface casing pipe when the shoes at the lower ends of said surface casing pipe and said conductor pipe are disconnected one from the other and means for guiding the concentric pipes from the platform into the well.

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