June 23, 1970 A. A. JERGINS 3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Filed Jan. 5, 1968 5 Sheets-Sheet 1

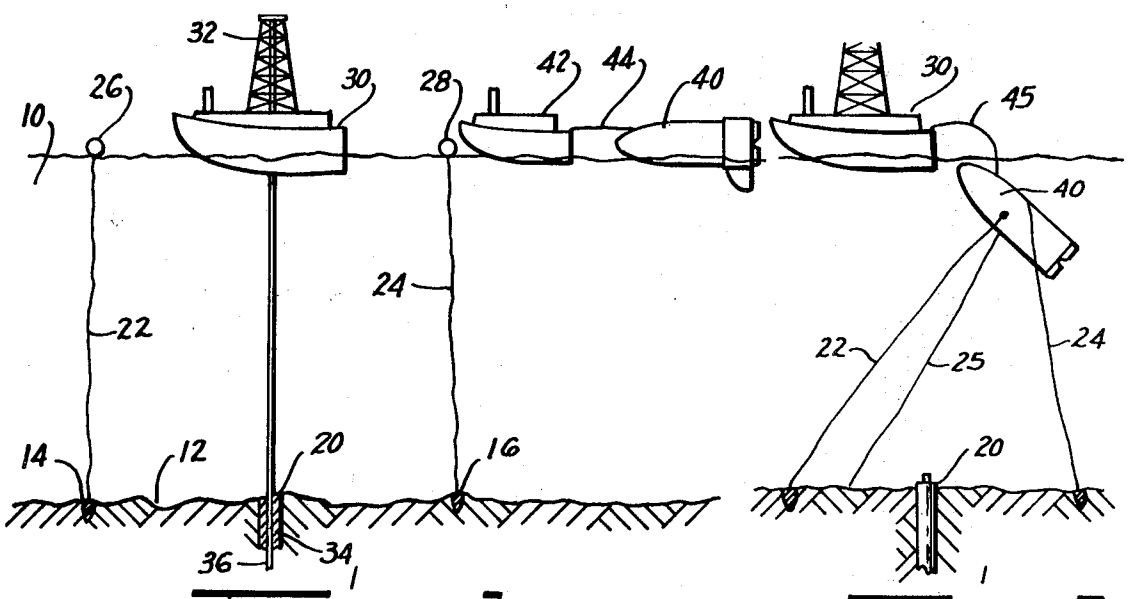


Fig 1

Fig 2

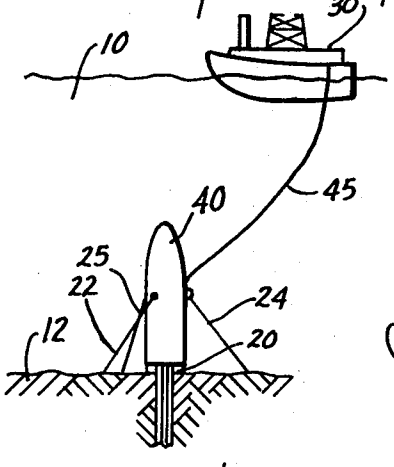


Fig 3

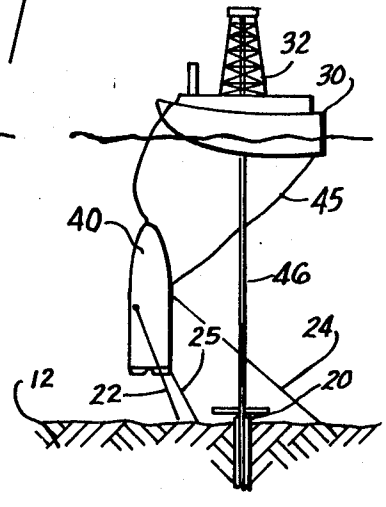


Fig 4

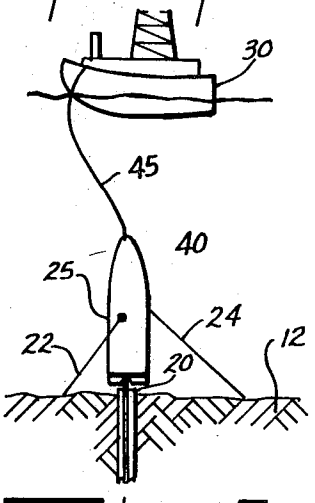


Fig 5

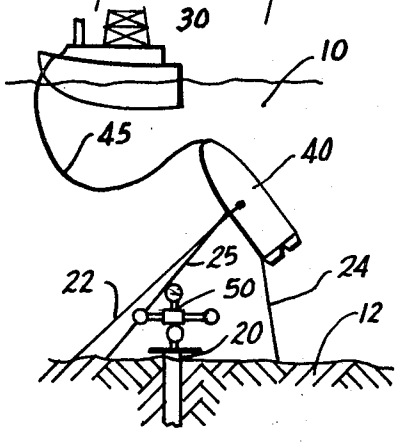


Fig 6

ALLEN A. JERGINS
INVENTOR.

BY James A. Bargfrede

ATTORNEY

June 23, 1970 A. A. JERGINS 3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Filed Jan. 5, 1968 5 Sheets-Sheet 2

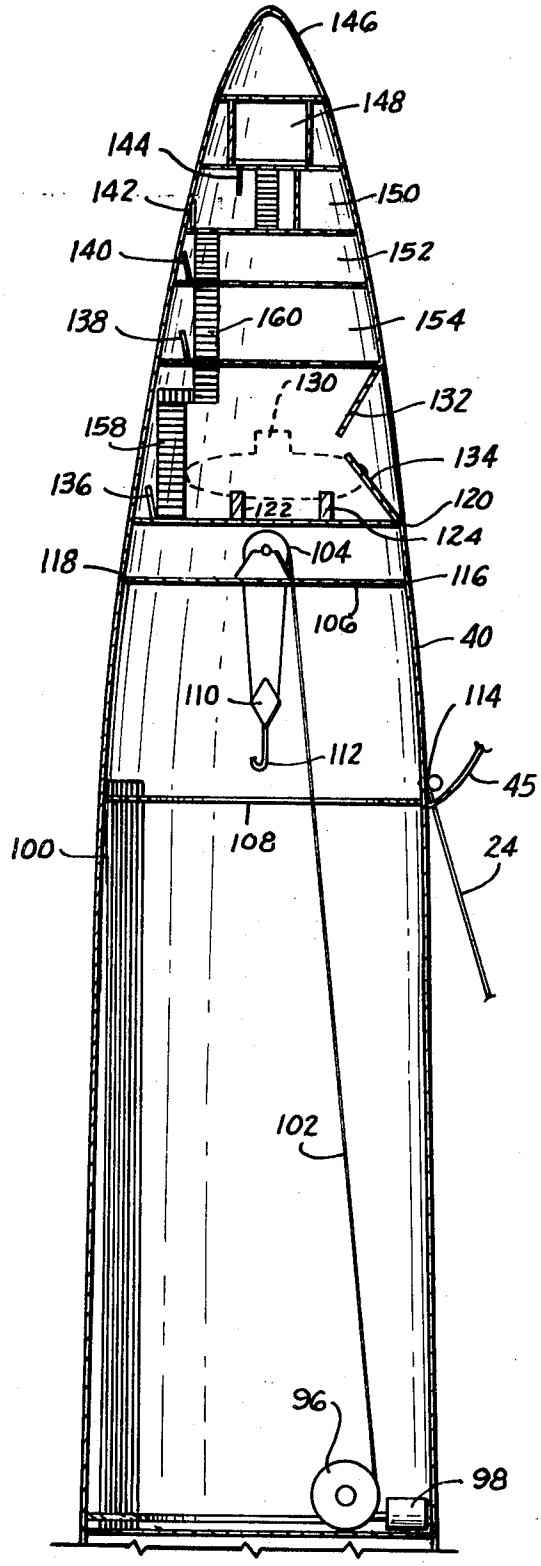


FIG. 7

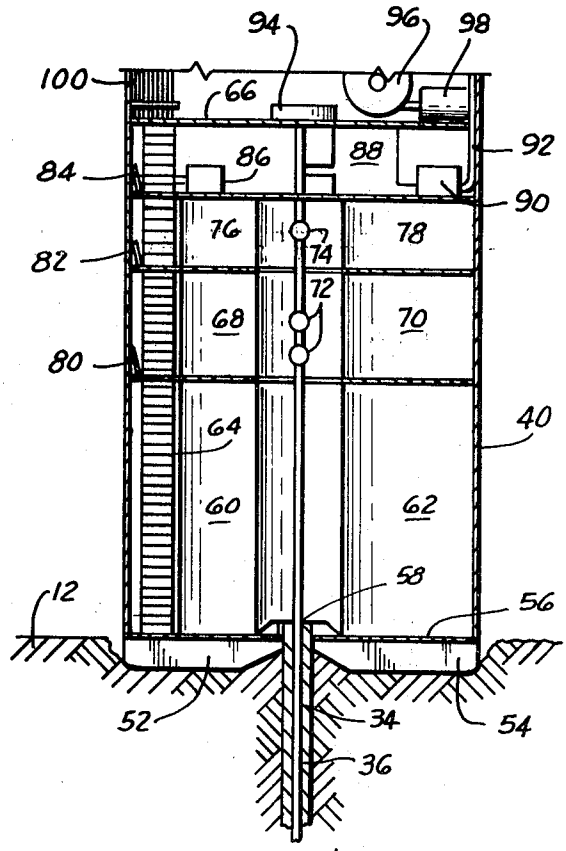
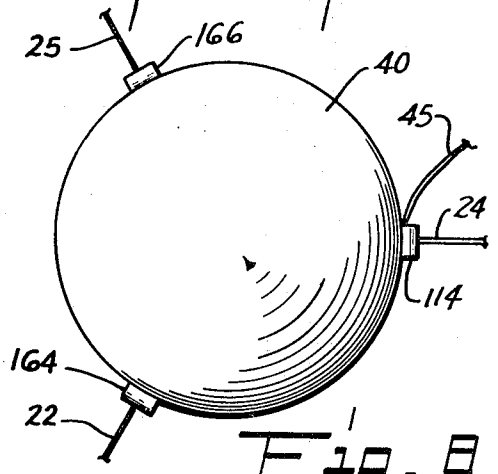


FIG. 8



INVENTOR.
ALLEN A. JERGINS
BY James A. Bargfrede
ATTORNEY

June 23, 1970 A. A. JERGINS 3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Filed Jan. 5, 1968 5 Sheets-Sheet 3

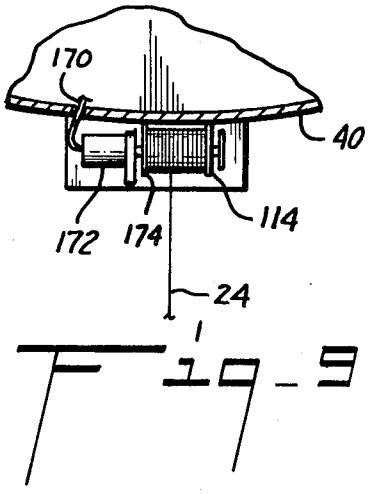


Fig. 9

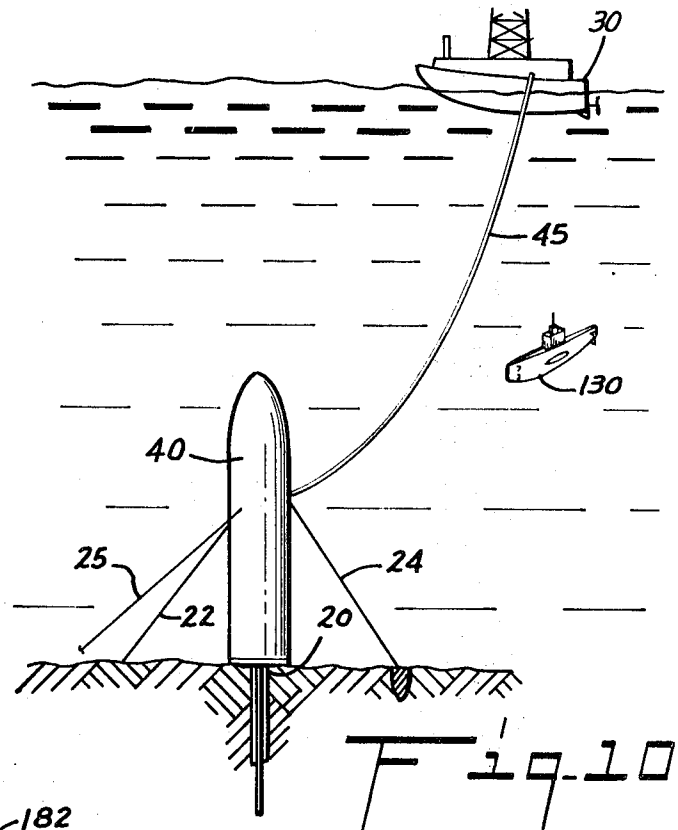


Fig. 10

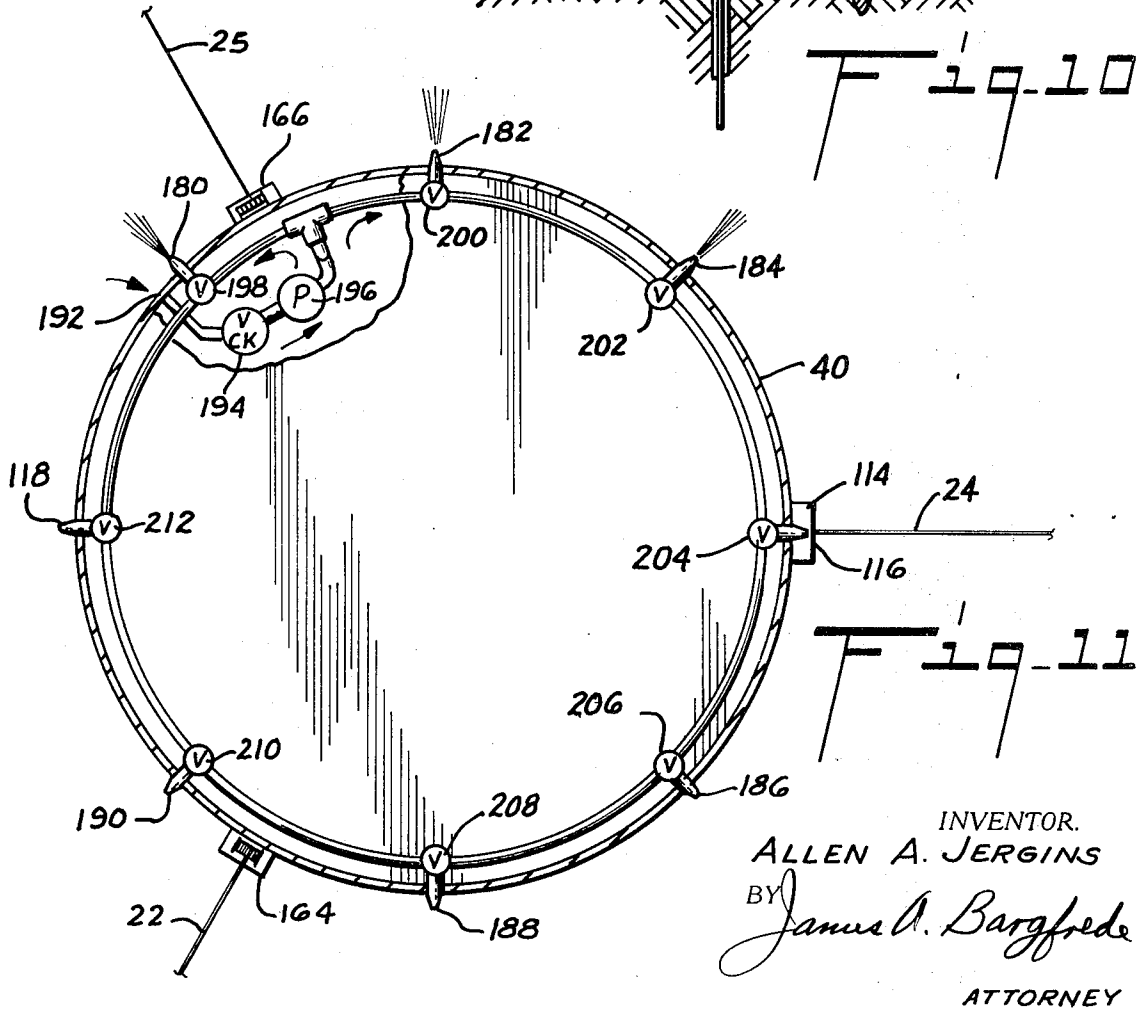


Fig. 11

INVENTOR.
ALLEN A. JERGINS
BY James A. Bargfrede
ATTORNEY

June 23, 1970 A. A. JERGINS 3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Filed Jan. 5, 1968 5 Sheets-Sheet 4

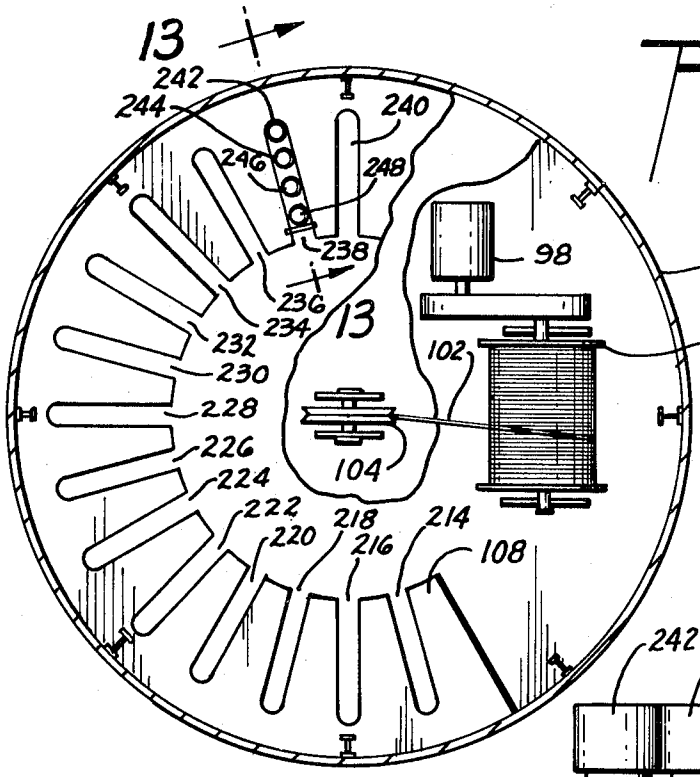
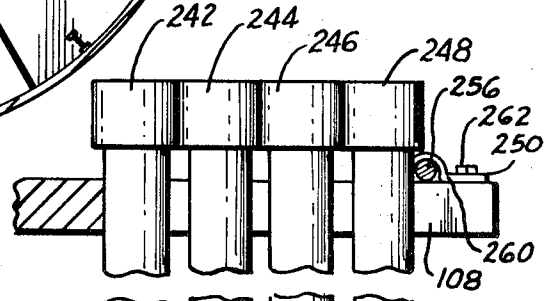


FIG. 12



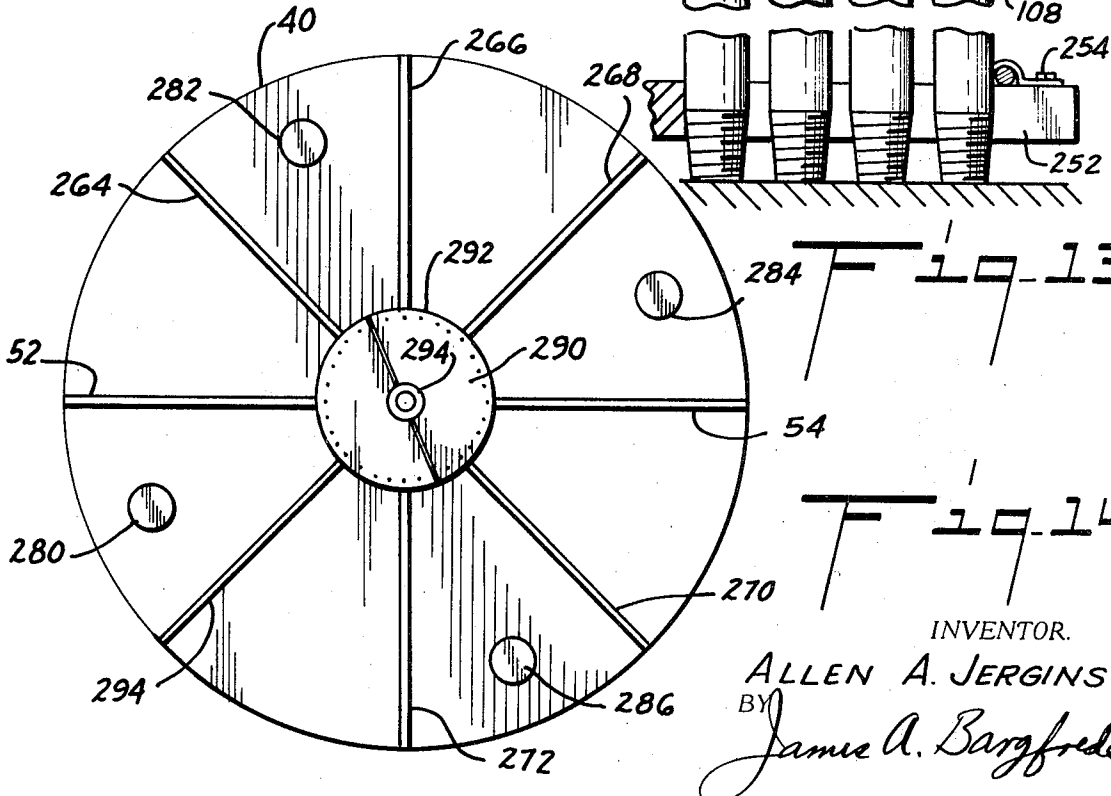


FIG. 13

FIG. 14

INVENTOR.
ALLEN A. JERGINS
BY James A. Bargfrede
ATTORNEY

June 23, 1970 A. A. JERGINS 3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Filed Jan. 5, 1968 5 Sheets-Sheet 5

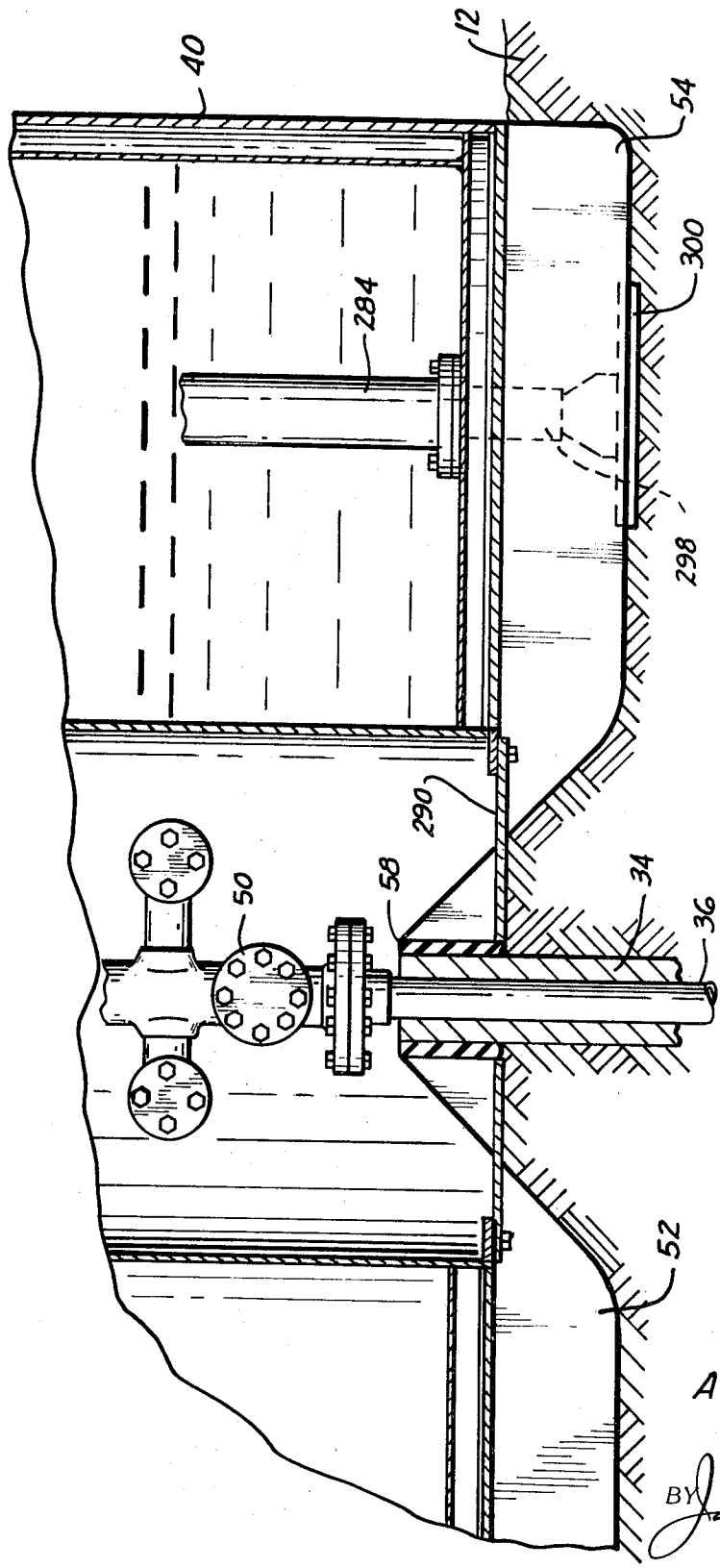


FIG. 15

ALLEN A. JERGINS
INVENTOR.

BY James A. Bargfrede

ATTORNEY

United States Patent Office 3,516,489
Patented June 23, 1970

3,516,489

OFFSHORE DRILLING AND WELL COMPLETION APPARATUS

Allen A. Jergins, 900 NE. Loop 410,
San Antonio, Tex. 78209

Filed Jan. 5, 1968, Ser. No. 696,047
Int. Cl. E21b 7/12, 33/035, 43/01
U.S. Cl. 166—.5 13 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus is provided for drilling and completing hydrocarbon production wells in substantial depths of water. Such apparatus includes a surface vessel and a submersible drilling vessel. After the surface vessel sets and cements at least one pipe in the formations below the floor of the body of water, the submersible drilling vessel is coupled in a watertight manner to the pipe and drilling of a well is performed from the interior of the submersible drilling vessel which houses well drilling equipment as well as logging and completion equipment. Such interior is at substantially atmospheric pressure and is in fluid communication with the surface vessel. If the drilled well is completed as a producing well, the submersible drilling vessel installs valves on a plate means which is left on the floor of the body of water when the submersible drilling vessel is moved to a new location.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to apparatus and methods utilized in drilling and completing wells on the floor of a body of water, particularly when such body of water has considerable depth.

Description of the prior art

During recent years considerable activity in the search for oil and gas in offshore areas has resulted in much sophistication of apparatus and methods which may be utilized in drilling and completing wells on the floor of a body of water. At the present time there are several types of drilling rigs which are utilized in drilling wells in a body of water but such drilling rigs generally require the use of divers who are limited in the water depths in which they can work and also the duration of time is limited for such divers to work at considerable depths. Known devices and methods also leave much to be desired in the way of completing a well drilled on the floor of a body of water.

Present apparatus and methods are very expensive, lack mobility, and are subject to wave, wind and other weather conditions which result in the rigs being inoperative for considerable lengths of time while drilling a well from the surface of a body of water.

Some of the known devices and methods utilized in offshore drilling operations are set forth in various U.S. patents which disclose surface drilling operations. Multiple well drilling operations are known as are surface drilling operations where pressure or weight on the drill bit is controlled.

One known U.S. patent discloses an underwater vessel of the submarine type which rests on the floor of a body of water and which is cumbersome and difficult to position and navigate. Such submarine type vessel provides only a "core hole" and not a production well. Completion of a producing well cannot be accomplished with such submarine type vessel because electric logs cannot be run and gun perforating cannot be performed. Also core samples cannot be take and examined on the floor of a body of water when using a submarine type vessel. The storage space is also limited so that not much drill pipe can be stored and the depth of the "core hole" is limited to relatively shallow depths.

SUMMARY OF THE INVENTION

The present invention is related to apparatus and methods for drilling and completing a well in a body of water. The apparatus includes a surface vessel and a submersible hull vessel which houses a complete drilling rig and accessories, such as electric logging equipment, and equipment for taking core samples, perforating, and performing other related work necessary for completing a well. Such submersible hull vessel includes positioning means for fixedly positioning such submersible hull vessel on the floor of the body of water. The submersible hull vessel is not subjected to wind and wave action and, therefore, may be utilized in drilling operations continuously from the time that the submersible hull vessel is properly positioned on the floor of a body of water. When the submersible hull vessel is submerged, the interior of such vessel utilizes air at approximately atmospheric pressure. The submersible hull vessel is coupled to anchoring devices which have been positioned by the surface vessel and the submersible hull vessel is lowered into position over stub means by filling the ballast tanks with water. The stub means include a conductor pipe and a surface pipe which has been positioned and cemented on the floor of the body of water at the location where the well is to be drilled. The submersible hull vessel includes hatch means which allow a small submarine to be positioned in the upper portion of said submersible hull vessel to allow small parts, such as drill bits, and personnel to enter and be removed from the submersible hull vessel. The submersible hull vessel includes water jet discharge means for vertical positioning of the submersible hull vessel and also means for controlling the buoyancy of the submersible hull vessel. After the well has been drilled, an electric log is run from either the submersible hull vessel or from the surface vessel prior to setting production pipe from the surface vessel after the submersible hull vessel is moved from the well site. After the production pipe has been run and cemented, the submersible hull vessel is positioned over the conductor pipe, clamps onto the conductor pipe, and completes the well by drilling out any cement that might be lodged in the production pipe. The submersible hull vessel will then gun perforate the production pipe, either run production tubing or leave the drill pipe in the hole as a substitute for the tubing, and install control valves (Christmas tree) in air at approximately atmospheric pressure to complete the well as an oil or gas producer. A bottom plate on the submersible hull vessel is then removed with the control valves being attached to such bottom plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 through 6 show a typical sequence of operations utilizing the apparatus and methods of the present invention;

FIG. 7 is a sectional, elevational view of the submersible hull vessel of the present invention showing such submersible hull vessel positioned on the floor of a body of water;

FIG. 8 is a top view of the submersible hull vessel of the present invention showing guy wires coupled to the submersible hull vessel for vertical positioning of such submersible hull vessel;

FIG. 9 is a sectional, top view showing the winch means positioned on the exterior of the submersible hull vessel for tightening the guy wires anchored to the floor of a body of water;

FIG. 10 is a side elevational view showing the surface vessel, a submarine, and the submersible hull vessel positioned on the floor of a body of water;

FIG. 11 is a sectional top view of the submersible hull vessel showing the guy wires coupled to the submersible hull vessel and further showing the typical radial jet system utilized in stabilizing the submersible hull vessel;

FIG. 12 is a top view through a section of the submersible hull vessel showing drill pipe and the draw works positioned inside such submersible hull vessel;

FIG. 13 is a broken sectional view taken along line 13—13 of FIG. 12 showing a typical installation of drill pipe in the finger board of the submersible hull vessel;

FIG. 14 is a bottom view showing the radial fins and the supports positioned on the bottom of the submersible hull vessel; and

FIG. 15 is a sectional, elevational view of the lower portion of the submersible hull vessel showing such submersible hull vessel in position at a well site on the floor of a body of water.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in detail, FIG. 1 is an elevational view showing a body of water **10** having a floor **12**. Anchor devices **14** and **16** have been positioned on the floor of the body of the water near the well site **20** and anchors **14** and **16** have cables **22** and **24** coupled respectively to anchor **14** and anchor **16**. A buoy **26** is coupled to cable **22** and a buoy **28** is coupled to cable **24**. Although only two anchors and two lines are shown in FIG. 1, the present invention contemplates the use of three anchors as will be shown and described in detail subsequently.

Also shown in FIG. 1 is a surface drilling vessel **30** equipped with a drilling rig **32**. The surface drilling vessel, in practicing the present invention, is utilized to drill, set and cement a conductor pipe **34** which may be about 200 feet in length and from 24 inches to 30 inches in diameter. After the conductor pipe has been set at the well location on the floor of the body of water **10** the surface drilling vessel drills and sets surface pipe **36** which may be from about 1,000 to 2,500 feet in depth. The surface pipe **36** is cemented to the conductor pipe **34**. Surface pipe **36** may be from 13 inches to 16 inches in diameter.

Generally, the surface drilling vessel will set the conductor pipe and surface pipe prior to installation of the anchors such as **14** and **16**. After the anchors and buoys have been set as shown in FIG. 1, a submersible hull vessel **40** is moved into position at the well site by a tug **42** coupled to the submersible hull vessel through suitable means such as a cable or line **44**.

FIG. 2 shows the submersible hull vessel **40** being lowered into position near the well site **20** after coupling lines **22**, **24**, and **25** to the submersible hull vessel **40**. Tug **42** tows the submersible hull vessel **40** to the drill site. Upon arrival at the drill site, and before the submersible hull vessel **40** is submerged, a flexible pipeline or hose **45** containing a supply of air, electric power or other power, drilling mud delivery and return, telephone communication and closed circuit television is attached to the submersible hull vessel **40** from the surface drilling vessel **30** or other suitable vessel which can fulfill the needs of the submersible hull vessel **40**. Surface drilling vessel **30** is shown for illustration purposes but it will be appreciated by those skilled in the well-drilling art that a more economical surface vessel might be provided when practicing the invention. The submersible hull vessel **40** is positioned over the well site **20** by winches located on the exterior of the submersible hull vessel **40** and such winches are coupled to the cables **22**, **24**, and **25** to draw the submersible hull vessel **40** into position. Also, the submersible hull vessel **40** contains ballast tanks, the operation of which will be explained in detail subsequently, and these ballast tanks are filled with water to allow the buoyancy of the submersible hull vessel **40** to be varied so that as the submersible hull vessel **40** is lowered into position, the submersible hull vessel **40** is partially filled with water to cause the submersible hull vessel **40** to sink in the body of water.

FIG. 3 shows the submersible hull vessel **40** positioned over the well site **20** which has stub means protruding from the floor **12**. Such stub means includes the conductor pipe and surface pipe which was set previously by the surface drilling vessel. FIG. 3 shows the submersible hull vessel **40** positioned over the well site **20** with the guy wires **22**, **24**, and **25** utilized for stabilizing the submersible hull vessel. As will be shown in detail subsequently, submersible hull vessel **40** includes hatch means whereby a small submarine may be positioned in the upper portion of the submersible hull vessel **40** to provide supplies and personnel to such submersible hull vessel **40**.

FIG. 4 shows the submersible hull vessel **40** removed from the well site **20** after drilling operations have been completed. Surface drilling vessel **30** having a derrick **32** is utilized for running production pipe **46** after the submersible hull vessel **40** has drilled the hole and run an electric log at the well site **40**. The submersible hull vessel **40** as shown in FIG. 4 is moved off of the surface of the conductor pipe to allow the production pipe **46** to be run and cemented from the surface vessel.

FIG. 5 shows the submersible hull vessel **40** repositioned over the well site **20**. The submersible hull vessel **40** is positioned over the well site **20** and clamps onto the conductor pipe and completes the well by drilling out any cement which might be lodged in the production pipe which was set by the surface drilling vessel **30**. When the cement has been drilled out, the casing opposite potentially productive sands is gun perforated in a manner well known in the drilling art. The submersible hull vessel **40** will install control valves, commonly called a Christmas tree, will leave the drill pipe in the hole as a substitute for tubing, and if the well is productive will complete the well as an oil or gas producer on the ocean floor. The guy lines **22**, **24**, and **25** are utilized again in repositioning the submersible hull vessel **40** over the well site **20** when the well is completed.

FIG. 6 shows the submersible hull vessel **40** being removed from the well site **20** after the Christmas tree **50** has been installed. As pointed out previously, the buoyancy of the submersible hull vessel **40** may be controlled through ballast tanks positioned in the submersible hull vessel **40**. The guy lines **22**, **25**, and **24** are utilized to stabilize the submersible hull vessel **40** as it is raised to the surface of the body of water **10**.

FIG. 7 is an elevational, sectional view of the submersible hull vessel **40** shown positioned at the well site on the floor of a body of water. Generally, the submersible hull vessel **40** is of a size which will accommodate normal drill pipe and which will allow drilling of a well in a known manner through use of a rotary table well known in the drilling art. Although the dimensions of the submersible hull vessel **40** may be subject to variation, the dimensions are such that the equipment set forth hereafter may be accommodated in such submersible hull vessel. The submersible hull vessel during drilling of a well on the floor **12** of a body of water rests on floor **12** through a plurality of fins such as fin **52** and fin **54** shown in FIG. 7. Such fins may have disposed between the bottom portion **56** of the submersible hull vessel **40** and the lower portions of the fins, such as fins **52** and **54**, a plurality of jacks or support means which will be explained in detail subsequently to aid in positioning the submersible hull vessel **40** in the event that the floor **12** is not substantially horizontal. Conductor pipe **34** is shown along with surface pipe **36** in FIG. 7. The lower part of submersible hull vessel **40** is equipped with a watertight seal **58** to prevent water from coming into the lower portion of submersible hull vessel **40**, and to allow proper

circulation of the drilling mud while a well is being drilled on the floor of a body of water. The lower portion of the submersible hull vessel **40** includes a ballast tank **60** and a ballast tank **62** which may be filled with water to control the buoyancy of the submersible hull vessel **40** as explained previously. A staircase **64** leads from the bottom portion **56** of the submersible hull vessel **40** to the platform **66**. Additional ballast tanks **68** and **70** are provided near a blowout preventer **72**. A control valve **74** is positioned above blowout preventer **72** and additional ballast tanks **76** and **78** are disposed horizontally of control valve **74**. A plurality of watertight hatches, such as hatches **80**, **82**, and **84** are provided for sealing the respective compartments in the lower portion of the submersible hull vessel **40**. A jet water pump **86** is provided and a mud sump **88** and mud pump **90** are coupled to line **92** which in turn goes through the cable connection **44** to the surface vessel where air, mud, electric power, telephone, television, and fresh water may be provided as pointed out previously. A conventional rotary table **94** is utilized during the drilling operation along with a conventional draw works **96** which may be operated by electric power supply motors **98**. Although an electric power supply is contemplated as part of the best mode for practicing the invention, it will be appreciated that other power supply sources such as internal combustion engines may be utilized and the exhaust from such internal combustion engines is discharged through a snorkel at the surface of the body of water. Drill pipe sections such as those shown in group **100** are positioned inside the submersible hull vessel **40** and are circumferentially positioned around the rotary table **94** as will be explained in detail subsequently.

The draw works **96** has stored thereon a cable **102** which passes over a crown block **104** positioned on support **106** in a manner well known in the drilling art.

The drill pipe is stored in section **100** on a finger board **108**. The finger board **108** will be explained in detail subsequently.

The crown block **104** is coupled to the traveling block **110** which has elevators **112** coupled thereto in a manner well known in the drilling art.

Cable **24** is shown coupled to a hoist **114** and the operation of hoist **114** and cable **24** has been explained previously.

A plurality of water jets may be utilized and positioned at points **116** and **118** to provide stability to the submersible hull vessel **40**. The upper portion of the submersible hull vessel **40** includes a platform **120** on which is positioned supports **122** and **124** for a small submarine **130**. Submarine **130** gains access to the upper portion of the submersible hull vessel **40** through hatch means which include pivotal doors **132** and **134**. The pivotal doors **132** and **134** allow the submarine **130** to enter the submersible hull vessel **40**.

Watertight hatches **136**, **138**, **140**, **142** and **144** allow sealing off the sections in the upper part of the submersible hull vessel **40**.

A detachable nose **146** is coupled to the upper part of the submersible hull vessel **40**. The detachable nose **146** may be removed after towing of the submersible hull vessel **40** to the well site.

Chamber **148** is a watertight capsule which may be utilized as a personnel capsule for the transfer of personnel and small parts from the submersible hull vessel **40** to the surface drilling vessel **30**.

Area **150** may be utilized for food stores, clothing, or other items and compartment **152** may be utilized as a galley. Area **154** may be utilized as crew quarters with staircase **158**, **160** and **162** providing access from platform **120** to the personnel capsule **148**.

The interior of the sumbersible hull vessel **40** will be in air at atmospheric pressure thereby allowing the personnel operating inside of the submersible hull vessel **40** to remain in such submersible hull vessel for extended periods of time although the vessel may be operating at substantial depths so that the entire submersible hull vessel may be completely submerged. Thus, artificial atmosphere in the submersible hull vessel **40** is avoided. Of course, it will be appreciated that if the submersible hull vessel **40** is of substantial length because of design and engineering effectiveness, part of the upper portion of the submersible hull vessel **40** will protrude from the water when the submersible hull vessel is in operation on the floor of a body of water.

The arrangement shown in FIG. 7 for various equipment and compartments of a submersible hull vessel **40** has been chosen because such arrangement is thought to be optimum in the operation of the submersible hull vessel **40** but it will be appreciated that variations and changes may be made to accommodate various engineering design requirements. It will be apparent to those skilled in the drilling art that the crown block and traveling block and draw works are utilized for drilling a well through the use of drill pipe stored as shown in section **100**. The method of drilling the well after the submersible hull vessel **40** rests on the floor of the body of water is fairly conventional except that the completion of the well on the floor of the body of water is thought to be completely novel.

FIG. 8 is a top view of the submersible hull vessel **40** showing the cable or connection **45** coming from the submersible hull vessel **40** to the surface vessel floating on the body of water. Cable **24** is shown coupled to winch **114** and cable **22** is shown coupled to winch **164**. Cable **25** is shown coupled to a winch **166**.

It will be appreciated that when the submersible hull vessel **40** is floated into position near the well site that the winches are coupled to the anchors which have been positioned near the well site so that the winches can move the submersible hull vessel **40** into positions over the conductor pipe and surface pipe which has been set by the surface drilling vessel. The winches, such as winch **114**, winch **164**, and winch **166**, are positioned on the exterior of submersible hull vessel **40** but are operable from inside of the submersible hull vessel **40**. Although only a single conductor **45** has been shown it will be appreciated that a plurality of cables or tubes may be utilized to provide air exhaust from the submersible hull vessel **40** to the surface vessel and for providing power, air, drilling mud and fresh water from the surface vessel to the submersible hull vessel **40**. It will be appreciated, of course, that the foul air in the submersible hull vessel **40** also could be exhausted from the hull into the body of water by the use of air compressors.

FIG. 9 is a partial-sectional top view of the submersible hull vessel **40** showing winch **114** coupled to cable **24**. The operation of winch **114** is well known with a power source feeding power through cable **170** from inside the submersible hull vessel **40** to a motor **172** which in turn drives spool **174** having a cable thereon. The winch **114** is positioned on the exterior of the submersible hull vessel **40** in a manner explained previously.

FIG. 10 is a side elevational view showing submersible hull vessel **40** positioned at the well site **20** with submarine **130** moving into position near the submersible hull vessel **40**. Surface vessel **30** is coupled to the submersible hull vessel **40** through line **45**. As explained previously, the submersible hull vessel **40** is anchored through guy leads **22**, **25**, and **24**. The submarine **130** may be of a relatively small type which carries only several people and has a limited amount of storage space. The submarine **130** is utilized, as explained previously, to transport personnel and equipment to and from the submersible hull vessel **40**.

FIG. 11 is a cross-sectional, top view showing the radial jet system utilized in providing stability to the submersible hull vessel **40**. Cable **25** is shown coupled to winch **166**, cable **24** is shown coupled to winch **114** and cable **22** is shown coupled to winch **164**.

A plurality of water jets such as water jet **116** and water jet **118** are positioned circumferentially in the upper portion of the submersible hull vessel **40**. As shown in FIG. 11, the jets may be eight in number although fewer jets or more jets may be provided. The jets shown in FIG. 11, in addition to the jets **116** and **118**, are **180**, **182**, **184**, **186**, **188** and **190**. An intake **192** allows water from the body of water in which the submersible hull vessel **40** is working to enter through a check valve **194** to a pump **196**. Pump **196** provides pressure to the water and allows selective discharge through the valve such as valves **198**, **200**, **202**, **204**, **206**, **208** and **210** as well as valve **212**.

It will be appreciated that suitable equipment may be provided inside the submersible hull vessel **40** to allow selective discharge from the one or more of the radial jets to aid in stabilizing the submersible hull vessel **40** during the drilling of the well and during completion of the well. It will be appreciated that the check valve and pump arrangement shown with respect to jet **180** may be duplicated for each of the radial jets. Since the submersible hull vessel **40** is positioned in water, the radial jet system utilizes the abundance of the water to provide stability to the submersible hull vessel **40** in the manner just described.

FIG. 12 is an upper sectional view of the submersible hull vessel **40** showing the finger board **108**. The draw works **96** driven by motor **98** also is shown in FIG. 12 with cable **102** from the draw works coupled to the crown block **104**.

The finger board **108** includes a plurality of slotted members such as **214**, **216**, **218**, **222**, **224**, **226**, **228**, **230**, **232**, **234**, **236**, **238** and **240**.

As shown in FIG. 12 with respect to slot **238**, a plurality of drill pipe sections such as **242**, **244**, **246** and **248** are positioned in slot **238**. As additional sections are required to be added to the drill string during drilling of the well, the drill pipe sections are removed from the slots in the finger board **108** and added to the drill string in a manner well known in the drilling art.

FIG. 13 is a partial-sectional, elevational view taken along line **13—13** of FIG. 12 showing drill pipe sections **242**, **244**, **246** and **248**. Upper finger board **108** is shown having suitable fastening means **250** for holding the plurality of drill pipe sections in position, particularly when the submersible hull vessel **40** is being moved from one well location to another well location while the submersible hull vessel **40** is in a horizontal position on the surface of the body of water. A similar lower finger board **252** is positioned in the lower portion of the submersible hull vessel **40** to accommodate the lower portions of the drill pipe, such as sections **242**, **244**, **246** and **248**. The lower finger board **252** also has suitable fastening means **254** for holding the drill pipe sections in position within the slots in the finger board.

The fastening means **250** and **254** may include members **256** positioned between a clamp **260** and a section of drill pipe, such as drill pipe **248**, and a nut **262** which may be tightened to hold clamp **260** in position. The arrangement of the fastening means **254** may be similar to the arrangement of fastening means **250**.

FIG. 14 is a bottom view showing the radial fins and the jacks positioned on the bottom of the submersible hull vessel **40**. A plurality of radial fins, such as fins **52** and **54**, may be positioned on the bottom of the submersible hull vessel **40**. Additional radial fins, such as fins **264**, **266**, **268**, **270**, **272** and **274**, may be positioned on the bottom of the submersible hull vessel **40**. Although eight such radial fins are shown, it will be appreciated that fewer radial fins may be provided or a greater number of radial fins may be provided depending upon drilling conditions and engineering design which will give optimum performance when the submersible hull vessel **40** is utilized for drilling a well and completing a well.

Hydraulic rams or jacks **280**, **282**, **284** and **286** also are provided on the bottom of the submersible hull vessel **40**. The hydraulic rams or jacks **280**, **282**, **284** and **286** are disposed on the bottom of the submersible hull vessel **40** so that the submersible hull vessel **40** may be positioned on the floor of the body of water so that a straight hole may be drilled during the drilling operation. It will be appreciated that three hydraulic rams or jacks may be used to give tripod stabilization.

A circular rigid flange or plate member **290** is coupled to the bottom of the submersible hull vessel **40** through suitable fastening means such as bolts similar to bolt **292**. The circular flange member **290** has an opening **294** through which the drill pipe passes during drilling operations when the submersible hull vessel **40** is positioned on the floor of a body of water. When the well is completed, the circular flange member **290** remains on the floor of the body of water and the control valves are positioned on the circular flange member **290**.

FIG. 15 is a partial-sectional, elevational view of the submersible hull vessel **40** showing such submersible hull vessel **40** positioning the control valves or Christmas tree **50** on the well during the completion operations explained previously in conjunction with FIGS. 1, 2, 3 and 4. Radial fins **52** and **54** are shown positioned on the floor **12** of a body of water.

One of the hydraulic rams or hydraulic jacks **284** also is shown positioned on the bottom of the submersible hull vessel **40** with ram **298** coupled to plate **300** which rests on the floor **12** of the body of water and provides leveling of the submersible hull vessel **40**. A watertight seal **58** is positioned between the conductor pipe **34** and the circular flange member **290** of the submersible hull vessel **40**. Surface pipe **36** has the drill pipe and production tubing positioned therein for completing the well as explained previously. The Christmas tree **50** includes a plurality of valves which are well known in the art and upon completion of the installation of the Christmas tree **50**, the circular flange member **290** is removed so that the Christmas tree remains on the floor of the body of water as the submersible hull vessel **40** is floated to the surface of the body of water. It will be appreciated that installation of the Christmas tree or control valves will be performed in air at approximately atmospheric pressure.

It will be appreciated that the circular flange plate member **290** is of sufficient diameter to prevent damage to the Christmas tree **50** as the submersible hull vessel **40** is floated from the floor of the body of water to the surface of such body of water.

It will be apparent to those skilled in the art of drilling wells and completing wells that various refinements and improvements may be made in the procedures which are related to completing a well such as logging, coring, and perforating, and the pressures of the formations being tested may cause refinements and variations in accepted well drilling procedures and well completion procedures. However, it will be appreciated that the present invention encompasses such variations and modifications since the present invention provides a submersible hull vessel which may be completely submerged in a body of water during drilling of a well and during completion of such well.

I claim:

1. Apparatus for drilling a well on the floor of a body of water, said apparatus including in combination:

an elongated housing whose interior is at atmospheric pressure and having an opening in one end,

support means coupled to the end of said housing having said opening,

removable plate means positioned over said opening,

drilling means disposed in said housing for drilling a well longitudinally of said housing, said drilling means including pipe storage means positioned circumferentially in said housing for storing pipe substantially longitudinally of said housing,

ballast means in the end of said housing having said

opening for controlling the buoyancy of said housing, and

positioning means for controlling the vertical attitude of said housing during drilling of a well, said removable plate means being left on the floor of the body of water after drilling and completing of a well.

2. Apparatus defined by claim 1 wherein said pipe storage means includes a planar, substantially circular member having a central opening, and a plurality of slots positioned radially from said opening to allow a plurality of pipe sections to be stored in each of said slots.

3. Plate means adapted for positioning on the bottom of a submersible drilling vessel, said plate means including in combination:

a substantially flat, circular member having a central opening for positioning on a pipe cemented to the subterranean formation,

fastening means for coupling said member to said drilling vessel, and

means for sealing said opening to said pipe.

4. Apparatus for drilling and completing a well on the floor of a body of water, said apparatus including in combination:

an elongated housing having at least one opening,

ballast means positioned in said housing,

plate means removably coupled to said housing, said plate means including a central opening for positioning on a pipe cemented to the subterranean formation, and means for sealing said opening to said pipe, and

positioning means coupled on said housing to provide positioning of said housing when said housing is in said body of water.

5. Apparatus defined by claim 4 and further including pipe storage means including a substantially flat circular member having a circular central opening, and a plurality of slots positioned radially from said circular central opening.

6. Apparatus defined by claim 4 and further including drilling means positioned in said housing.

7. A system for drilling and completing a well on the floor of a body of water, said system including in combination:

surface vessel means adapted for drilling a hole on said floor of said body of water and for cementing a pipe to at least a portion of the subterranean formation,

submersible drilling vessel means including removable plate means adapted for coupling to said pipe during drilling and completion of a well on the floor of said body of water, and

means coupling said surface vessel means with said submersible drilling vessel means to provide fluid communication during drilling and completion of said well on the floor of said body of water.

8. A system defined by claim 7 wherein said submersible drilling vessel means includes pipe storage means having a substantially flat, circular member with a circular, central opening and a plurality of slots positioned radially from said circular, central opening.

9. A system defined by claim 7, wherein said submersible drilling vessel means includes positioning means for positioning said submersible drilling vessel means on the floor of said body of water.

10. A system defined by claim 7, wherein said submersible drilling vessel means includes blowout preventer means.

11. A system defined by claim 7, wherein said submersible drilling vessel means includes valve control means.

12. Apparatus for drilling a well on the floor of a body of water having a pipe cemented to the subterranean formations in said floor, said apparatus including in combination:

an elongated housing having a portion of its interior at substantially atmospheric pressure and having an opening in one end suitable for performing drilling and completion operations through said opening into said subterranean formations,

sealing means positioned over said opening for watertight coupling of said housing to said pipe to prevent water from entering said housing,

drilling means disposed in said housing for drilling a well longitudinally of said housing, said drilling means including pipe storage means positioned circumferentially in said housing for storing pipe substantially longitudinally of said housing, and

control means for controlling the buoyancy and position of said housing during drilling of a well, said control means providing selective, substantially atmospheric pressure to at least a portion of said housing near said opening after said housing has been watertight coupled to said pipe.

13. A system for drilling and completing a well on the floor of a body of water, said system including in combination:

surface vessel means adapted for drilling a hole on said floor of said body of water and for running and cementing a plurality of pipes to portions of the subterranean formations,

submersible drilling vessel means including sealing means adapted for watertight coupling to selected ones of said pipes during drilling and completion of a well on the floor of said body of water, and

means coupling said surface vessel means with said submersible drilling vessel means to provide fluid communication during drilling and completion of said well on the floor of said body of water.

References Cited

UNITED STATES PATENTS

1,263,155	4/1918	Trautman	114—16.7
2,375,299	5/1945	Hartnett	114—16.7
2,937,006	5/1960	Thayer	175—6
3,063,507	11/1962	O'Neill et al.	114—.5 X
3,095,048	6/1963	O'Neill et al.	175—6
3,353,364	11/1967	Blanding et al.	175—6 X
3,380,256	4/1968	Rebikoff	61—46.5
3,413,946	12/1968	Von Schultz	61—46.5

ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

61—69; 114—.5, 16.7; 175—6, 7