United States Patent [19]

Jergins

[11] **3,902,553**

[45] **Sept. 2, 1975**

[54] **OFFSHORE DRILLING AT DEEP WATER LOCATIONS**

[76] Inventor: **Allen A. Jergins,** 900 N.E. Loop 410, San Antonio, Tex. 78209

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[21] Appl. No.: **440,814**

[52] **U.S. Cl.** **166/.5;** 175/8

[51] **Int. Cl.²** **E21B 7/12;** E21B 43/01

[58] **Field of Search** ..... 166/.5, .6; 175/5, 6, 7, 175/8, 9, 10

[56] **References Cited**

UNITED STATES PATENTS

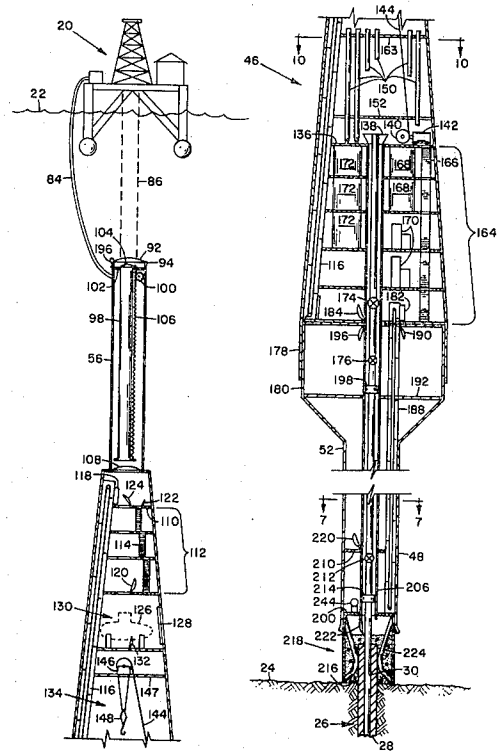
2,503,516	4/1950	Shrewsbury	175/8 X
2,937,006	5/1960	Thayer	175/6
2,965,174	12/1960	Haeber	166/.5
2,981,346	4/1961	Bauer et al.	175/7
3,202,217	8/1965	Watts et al.	175/5 X
3,372,745	3/1968	Holmes	166/.6
3,380,256	4/1968	Rebikoff	175/9 X
3,642,063	2/1972	Jergins	166/.5

Primary Examiner—Frank L. Abbott
Assistant Examiner—Richard E. Favreau
Attorney, Agent, or Firm—Cox, Smith, Smith, Hale & Guenther Incorporated

[57] **ABSTRACT**

Apparatus for drilling and completing hydrocarbon producing wells in waters of a substantial depth and for the redrilling and servicing of such wells. The apparatus includes a surface drilling rig, normally of the semi-submersible type, and a submersible drilling rig. The surface drilling rig sets and cements a conductor pipe into position in the floor of the body of water and may install other pipe stubs therein, such as a surface pipe, to initially begin the drilling operation. The submersible drilling rig, which is more easily transported in sections, is then assembled and lowered into position over the conductor pipe by filling ballast tanks located within the submersible drilling rig. The submersible drilling rig, which is supplied by means of an umbilical cord from the surface drilling rig is coupled to the conductor pipe in a watertight manner. The drilling operation begins from the interior of the submersible drilling rig, which houses well drilling equipment as well as logging and well completion equipment. The main working area of the crew in the submersible drilling rig is below the surface of the body of water but a considerable distance from the floor of the body of water. Therefore, the projection from the working area down to the conductor pipe at the floor of the body of water is a stingray type of design, which allows for connection to the conductor pipe. From the work quarters, a periscoping device can be extended up to the surface drilling rig for changing crews, receiving supplies, etc., and setting and cementing production casting or redrilling operations. If the drilled well becomes a production well, the submersible drilling rig will install production control valves which are left located on the floor of the body of water and thereafter move on to a new location.

17 Claims, 14 Drawing Figures



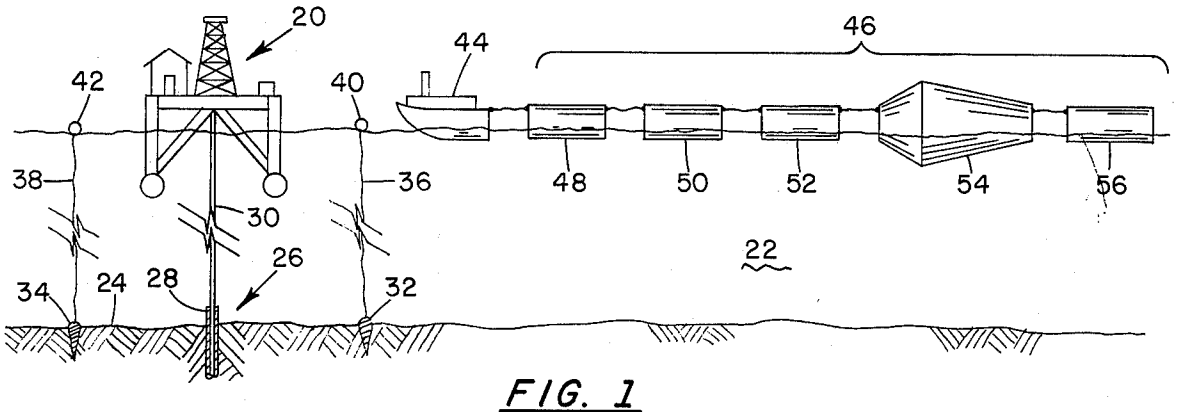


FIG. 1

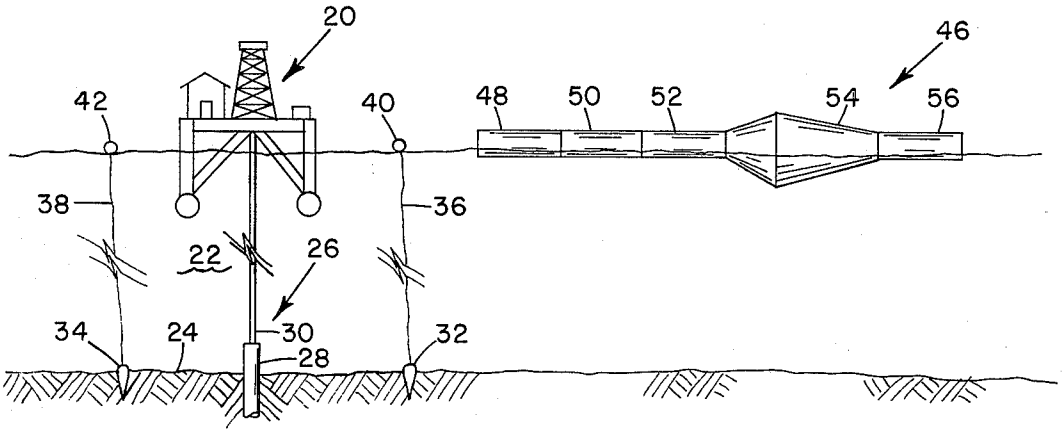


FIG. 2

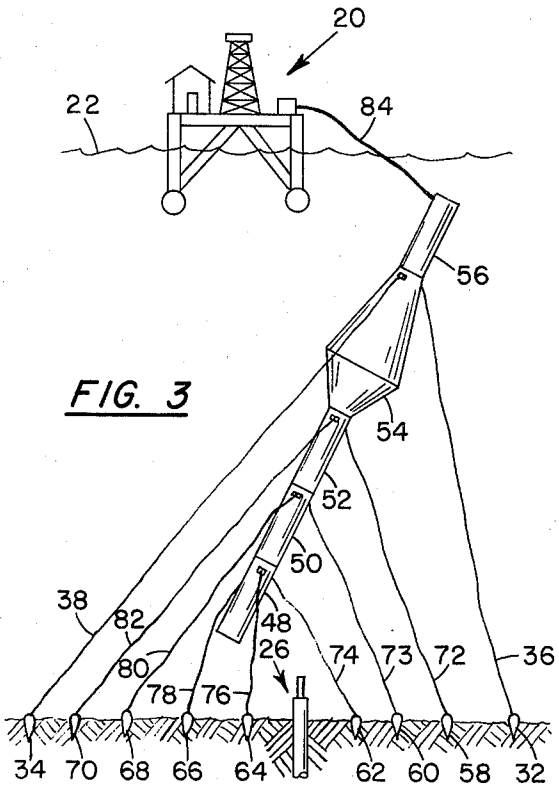


FIG. 3

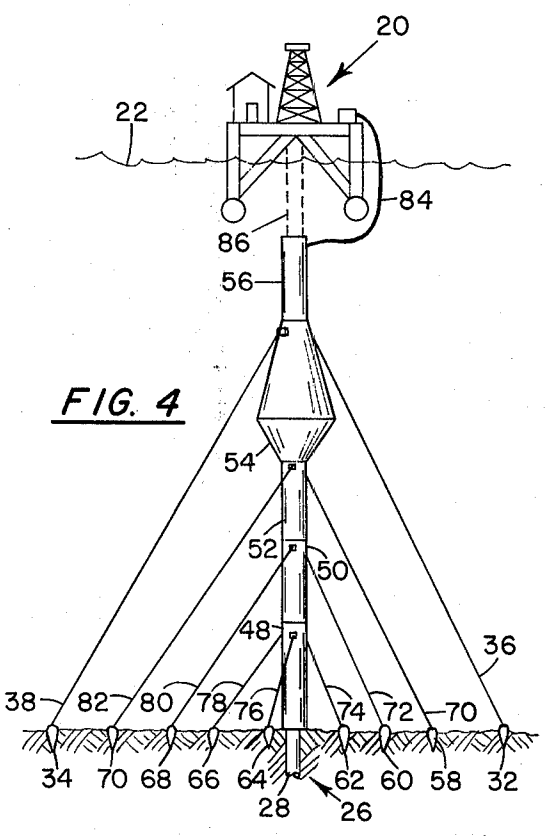


FIG. 4

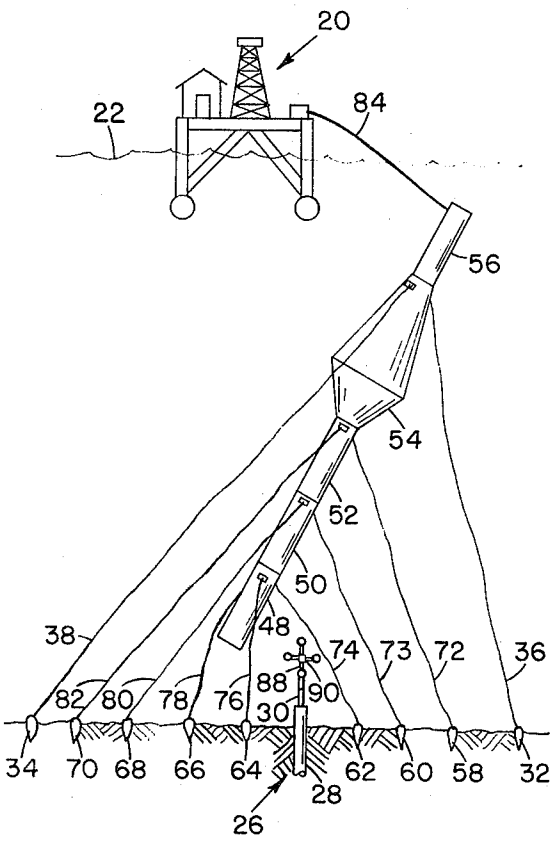


FIG. 5

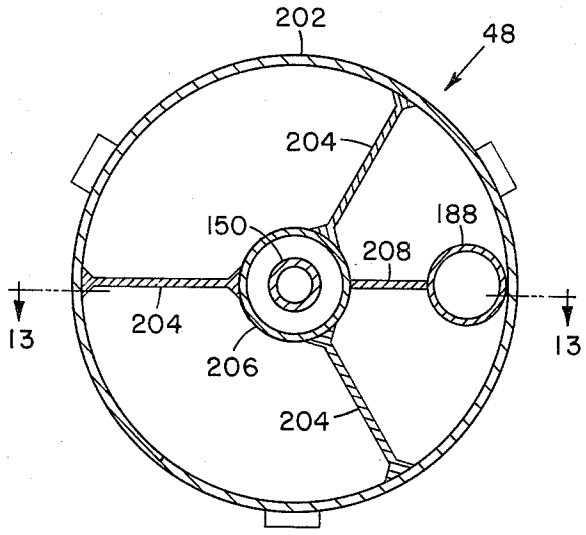


FIG. 7

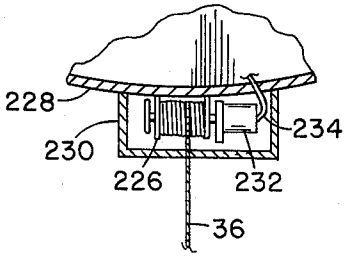


FIG. 8

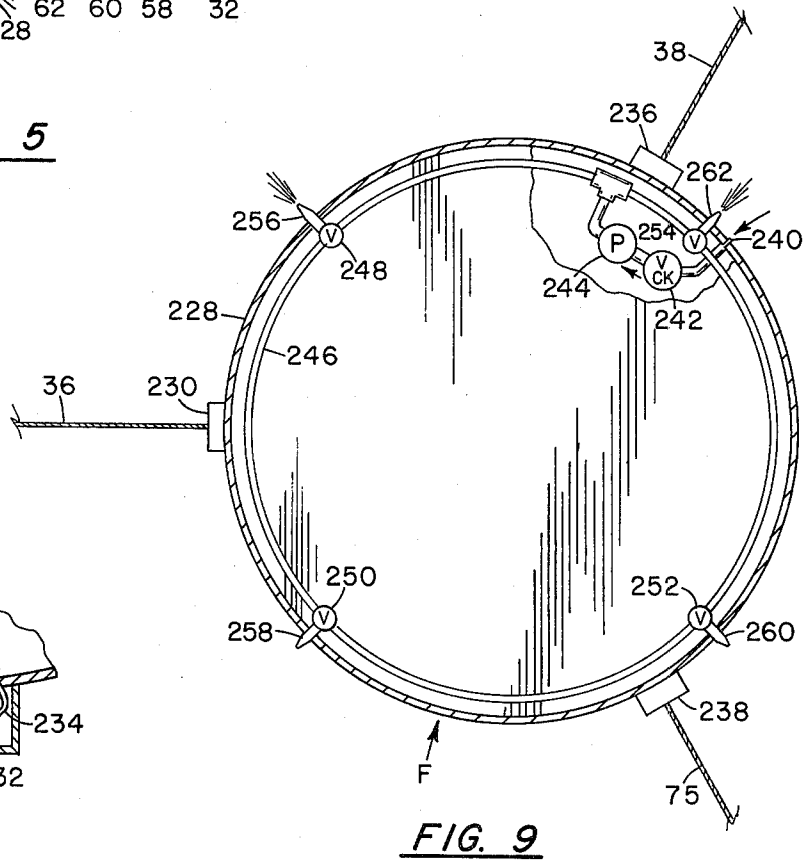


FIG. 9

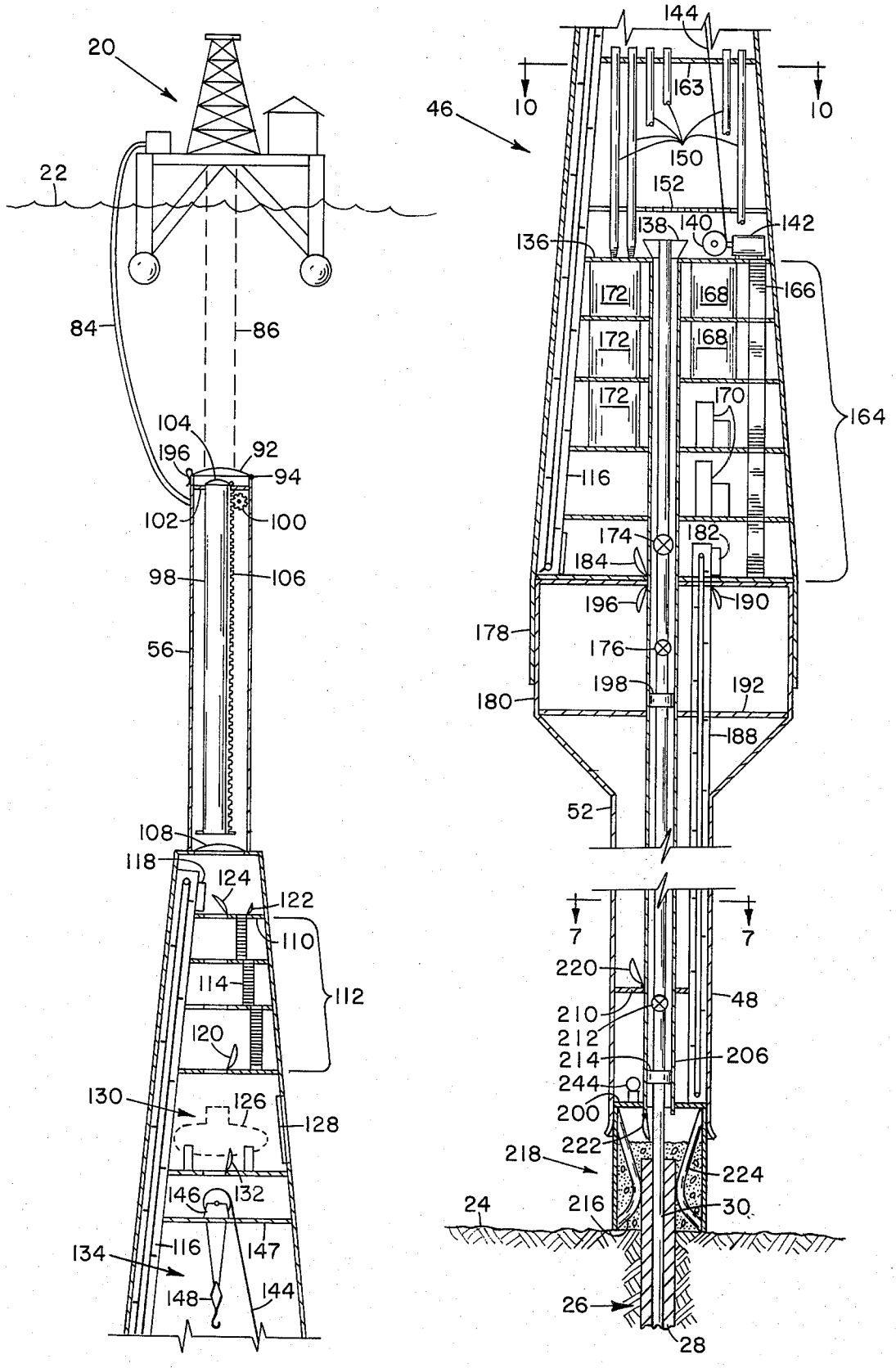

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FIG. 6

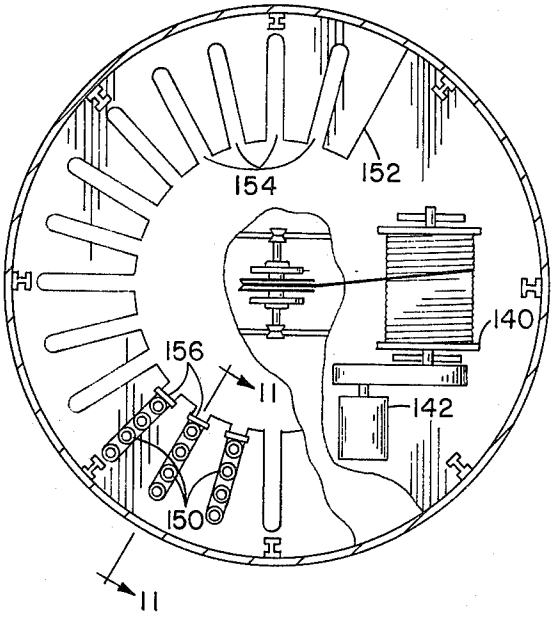


FIG. 10

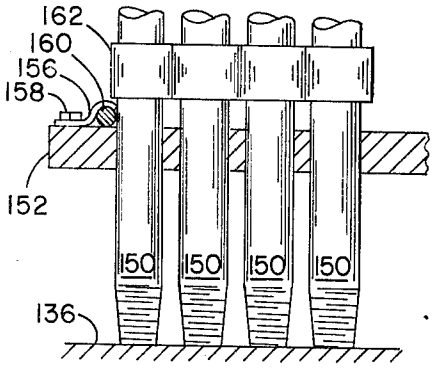


FIG. 11

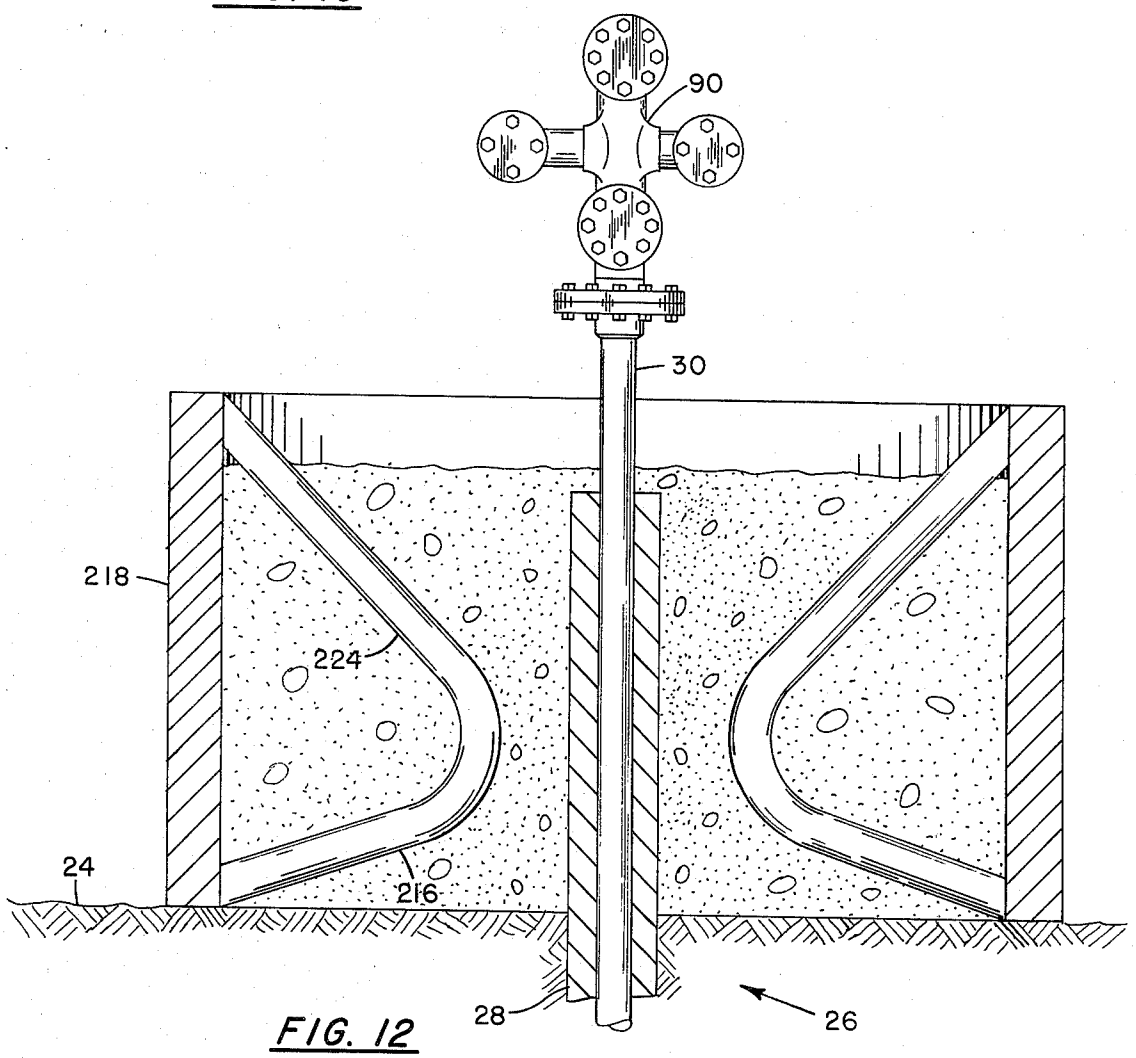


FIG. 12

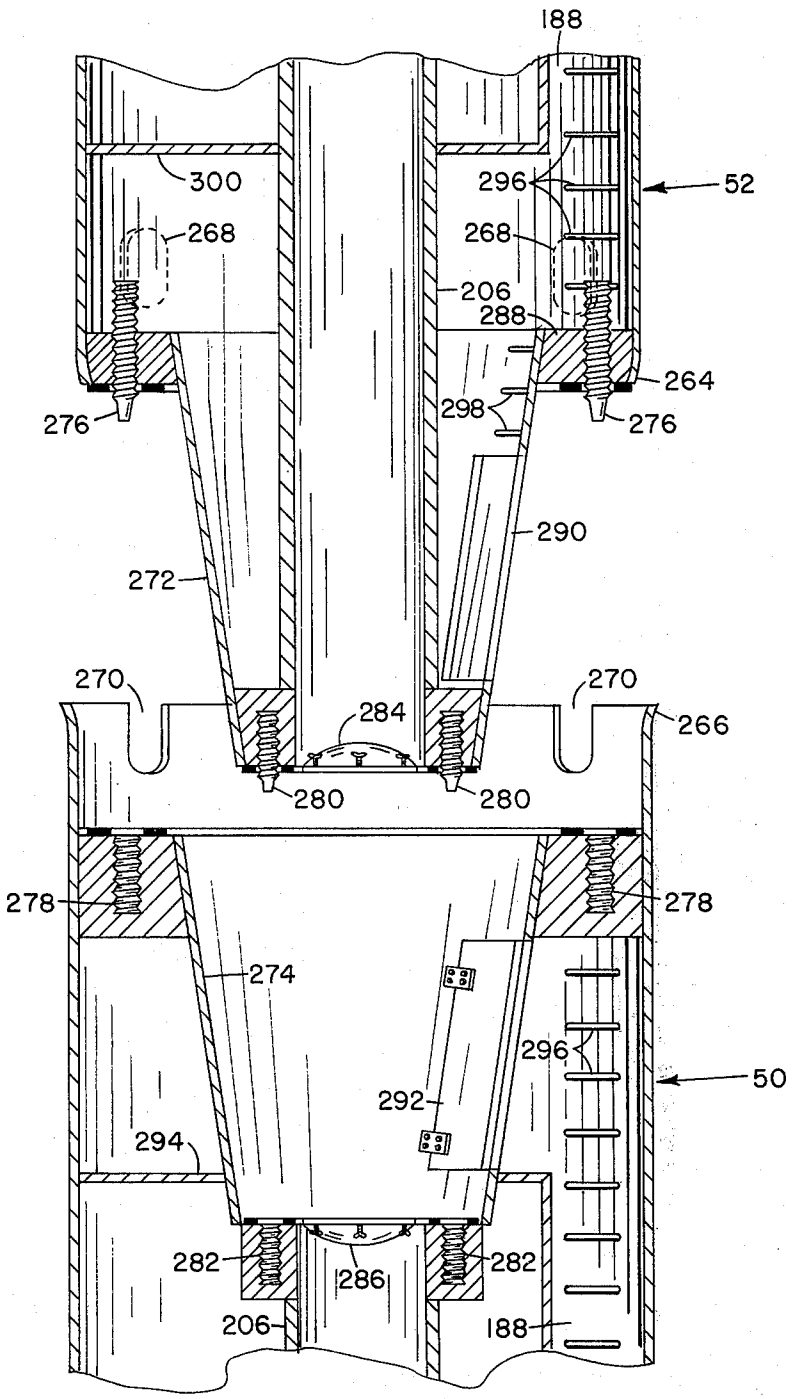

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FIG. 13

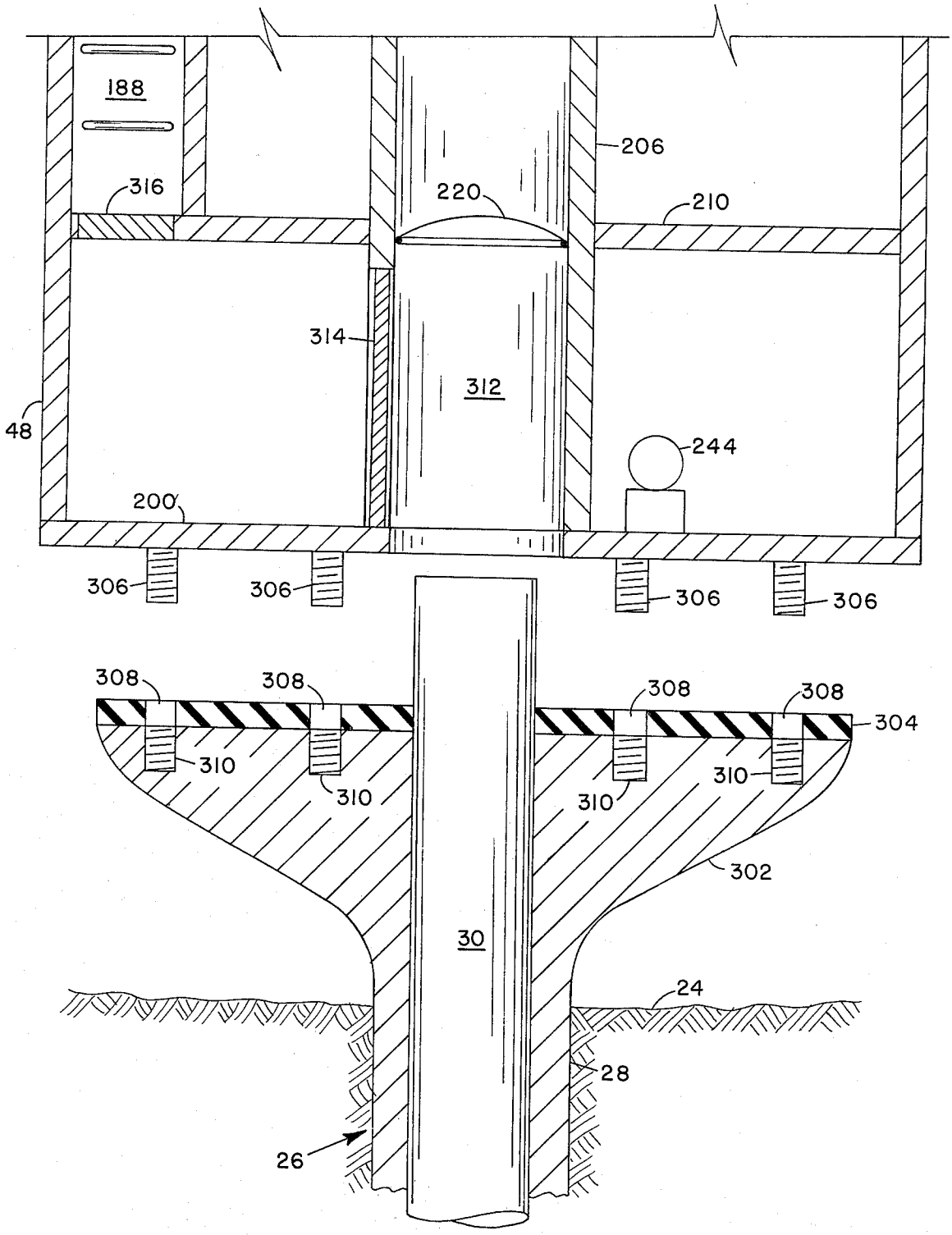

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FIG. 14

OFFSHORE DRILLING AT DEEP WATER LOCATIONS

BACKGROUND OF THE INVENTION

This invention relates to apparatus and method for drilling hydrocarbon producing wells on the floor of a body of water having considerable depth. In particular this invention was developed in conjunction with offshore drilling for gas and oil where the ocean floor is a considerable distance below the surface.

DESCRIPTION OF THE PRIOR ART

The present invention is an improvement over U.S. Pat. No. 3,516,489 issued on June 23, 1970 and U.S. Pat. No. 3,642,063 issued on Feb. 15, 1972, both of the previously mentioned patents having the same inventor as the present invention.

During recent months, the general public and the governments of numerous countries including the United States of America are trying to find new and better sources of energy. The United States, which is by far the largest energy consumer of any nation on earth, uses petroleum to provide approximately three fourths of all the mechanical energy used. Due to a diminishing domestic petroleum supply, the United States has become dependent upon foreign sources to meet its petroleum needs. To meet the increasing demand for petroleum and to eliminate the dependency upon foreign sources, searches have turned to more inaccessible locations such as Alaska and deeper formations of the earth and beneath the ocean floor. The Continental Shelf, which provides the best potential of meeting our immediate petroleum needs, is already in full development with over sixteen thousand such wells having been drilled in coastal waters for production of natural gas and crude oil. However, the Continental Shelf only provides a limited amount of petroleum that may last for a number of years. A much larger potential is the entire ocean floor which contains vast supplies of hydrocarbons including petroleum products of natural gas and crude oil. As time passes, wells are being drilled further and further offshore. Some government leases are being offered where the depth of the water is around **2500** feet deep.

During recent years thee has been considerable activity in the petroleum industry directed toward a practical deep water drilling apparatus and method that may be used to drill wells on the floor of a large body of water of considerable depth. At the present time several deep water drilling rigs are in operation, with various types of rigs being used. The most common rig being used in deep water drilling is the semisubmersible type well known in the industry, wherein all equipment and drilling apparatus is floating on the ocean surface. It is totally impractical to run pilings all the way down to the ocean floor when the body of water may be several thousand feet deep. One of the problems with the deep water drilling rigs of the semi-submersible type is that they are very strongly effected by wave and wind action. During rough weather the entire drilling operation must be ceased at a considerable loss of time, money and manpower. A hurricane or typhoon can become a total disaster.

Many articles have been written about the destructive force of the waves and how wave action interferes with the drilling of offshore petroleum wells. In "Sea Frontiers," Volume 19, Number 5, September-October, 1973, Pages 292–302 a good article by F. G. Walton Smith entitled Destructive Wind Waves describes and pictorially shows the destructive capability of the waves due to wind. Another article entitled Hurricane Season May Bring Severe Storms by Nixon Quintrelle appearing on pages 23–26 in June 5, 1972 issue of "Offshore" (a petroleum industry magazine) gave figures as to the millions of dollars damage to drilling rigs due to wave action. The above articles talk in terms of damage and destructive force. An even more staggering figure is the millions, and even billions, of dollars lost each year due to work stoppage on the drilling rig because of rough seas. No accurate figures are available as to the total loss due to rough seas, but it is estimated that a large drilling rig costs $35,000 a day to operate and many days drilling are lost completely. It is not uncommon for all work on a drilling rig to be stopped for a week at a time during rough seas.

The patents incorporated by reference eliminate many of the problems wherein a submersible drilling rig is lowered down to the ocean floor and connected to a conductor pipe set in from the surface rig. In the incorporated reference, the submersible drilling rig could complete most of the drilling operations and simply receive its drilling resources from the surface vessel or rig. However, because of the large diameter of the submersible drilling rig in the incorporated references, there is a reasonable limitation as to how far the submersible drilling rig can go under the surface of the body of water. Also, the submersible drilling rig had to be removed after drilling operations had been completed for the installation of the production pipe and cementing into place.

Currently, the deepest producing offshore petroleum well known to the inventor (who has considerable background knowledge in this area) is 1008 feet by Exxon off the coast of California. However, the government of the United States of America has leased some property for petroleum production in the Gulf of Mexico where the ocean depth reaches 2500 feet. Clearly some new method of drilling and completing petroleum wells in a deep body of water is vital. Also, a method for reconnection to a deep well for redrilling and later servicing is also vital to deep water production.

SUMMARY OF THE INVENTION

The present invention overcomes these problems by locating the submersible drilling rig a predetermined distance below the surface of the ocean, and from there extending a narrow tubular section called a stinger down to the conductor pipe for the drilling operation. a periscoping device may be extended up to the surface vessel for the cementing and installing of the production pipe and for crew changes or receiving supplies for the drilling of the well.

Therefore, it is an object of the present invention to provide a submersible oil drilling rig that may operate below the surface of a body of water

It is another object of the present invention to provide a submersible oil drilling rig that operates below the surface of a body of water, with the drilling operations being performed at one work level and the well head being located a considerable distance below the rotary drilling table on the derrick floor.

It is still another object of the present invention to have a submersible oil drilling rig of a stingray type of design wherein the stinger portion extends down to the

well head and the upper portion houses the rotary drilling machinery.

It is even another object of the present invention to provide a submersible drilling rig that has a periscoping type of arrangement that may extend above the surface of the body of water for certain drilling operations to be performed from the surface.

It is yet another object of the present invention to provide a method of drilling hydrocarbon producing wells in a deep body of water by using a surface and a submersible drilling rig in combination.

It is still another object of the present invention to provide a method of drilling deep water hydrocarbon producing wells wherein certain drilling operations are performed from a surface drilling rig and the remainder of the drilling operations are performed from a submersible drilling rig, thereby helping to prevent interference with the well drilling operations due to weather conditions with both the surface drilling rig and the submersible drilling rig operating simultaneously in the drilling of two or more wells.

It is another object of the present invention to allow access to the well head by workmen in an atmospheric environment when drilling in water of considerable depth.

It is yet another object of the present invention to provide a submersible drilling rig that may withstand extreme pressures of the ocean depths and maintain an atmospheric environment for the workmen.

The present application relates to the development of energy resources, and should be accorded a "special" status as contained in the Official Gazette notice of Oct. 26, 1973.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1–5 are a typical sequence of positions and connections between the surface rig and the submersible rig employing the present invention.

FIG. 6 is a sectional view of the submersible drilling rig when in the same position as illustrated in FIG. 4.

FIG. 7 is a sectional view along section lines 7—7 of FIG. 6.

FIG. 8 is a sectional view of the guide wire connectors to the submersible drilling rig.

FIG. 9 is a sectional top view of the submersible drilling rig showing guide wires coupled to the submersible drilling rig and illustrating a typical radial jet system used in stabilizing the submersible drilling rig.

FIG. 10 is a sectional view of FIG. 6 along section lines 10—10.

FIG. 11 is a sectional view of FIG. 10 along section lines 11—11.

FIG. 12 is an enlarged view of the end of the stinger connecting to the conductor pipe.

FIG. 13 is a sectional view along section lines 13—13 of FIG. 7 of two sections of the stingray being mated together.

FIG. 14 is a sectional view of an alternative method of connecting to the well head.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1-5, there is shown a sequence of events used to complete a hydrocarbon producing well embodying the present invention. In FIG. 1, a surface drilling rig 20 is operating in a body of water 22. For the purposes of this invention, refer to the body of water as the ocean though it should be realized that any other body of water would be sufficient. The surface drilling rig 20, while located a considerable distance above the ocean floor 24, will begin the drilling of a hydrocarbon producing well 26 by the setting of a conductor pipe 28 into position. The conductor pipe 28, which could have a diameter of approximately thirty inches and would be cemented at about one thousand feet below the ocean floor, carries a surface pipe 30 on the inside thereof. The installing of the conductor pipe 28 and the surface pipe 30 is well known in the well drilling industry. for the practising of the present invention the conductor pipe 28 should extend a short distance above the ocean floor 24, with the surface pipe 30 extending a short distance out of the conductor pipe 28. (See Fig. 2). The surface pipe 30 can be cemented at approximately two thousand feet below the ocean's surface and can have a diameter of approximately 20 inches.

During and after the preceding operations have been completed and the conductor and surface pipe 28 and 30, respectively, have been cemented into place, the surface drilling rig 20 installs anchors on the ocean floor. For the purposes of the description of FIGS. 1 and 2, only two anchors 32 and 34 are shown with attached lines 36 and 38, respectively, going to buoys 40 and 42. The anchors 32 and 34 go a distance into the ocean floor 24 and are solidly cemented into place.

A tug 44 pulls out the submersible drilling rig 46 that is divided into a number of sections, with the number of sections being determined by the depth of water in which it will be operating. Referring now to FIGS. 2 and 3 in combination, the stingray sections 48, 50 and 52 are combined with the submersible drilling section 54 and the periscope section 56. While this connection is taking place, the submersible drilling rig 46 is anchored to one of the anchors previously located on the ocean floor 24 by the surface drilling rig 20.

After all of the sections of the submersible drilling rig 46 have been assembled, the various anchors installed by the surface drilling rig 20 are attached to the submersible drilling rig 46. FIG. 3 shows more of the anchors than the previous two FIGS., however, this should in no way be interpreted as a limitation on the number of anchors that may be necessary in installing this particular type of well drilling operation. For the purposes of illustration, anchors 32, 34, 58, 60, 60, 64, 66, 68 and 70 have been attached to submersible drilling rig 46 by means of lines 36, 38, 72, 74, 76, 78, 80 and 82 respectively. After connecting the lines to the submersible drilling rig 46, ballast tanks, as will be subsequently described, are filled with water causing the stingray sections to sink towards the ocean floor 24. By the use of the anchor lines the stingray section can be guided down over the hydrocarbon well 26 and conductor and surface pipes 28 and 30. As the submersible drilling rig further fills water into the ballast tanks and the bottommost portion of the stingray sections is brought over the hydrocarbon well, the submersible drilling rig 46 is slowly brought into the upright position and lowered over the conductor and surface pipes 28 and 30, which are received into the bottommost portion of the submersible drilling rig 46. (See FIG. 3 and 4). The lowering of the stingray sections 48, 50 and 52 over the well 26 may be controlled by remote control devices with the control panel being located on the surface drilling rig 20. More detail will be given subse-

quently on the mating of the conductor and surface pipes 28 and 30 to the submersible drilling rig 46.

After the submersible drilling rig 46 has been properly installed into place, drilling operations will continue from the submersible drilling section 54 until the hydrocarbon producing well is completed or abandoned. The submersible drilling rig 46 is supplied by an umbilical cord 84 that supplies air, power and controls electronics to the surface drilling rig 20 as well as supplying mud for the drilling operation. For resupplying or the running and setting of production casing by cementing, a periscope type of device can extend from periscope section 56 up to the surface drilling rig 20, as indicated by the dotted lines 86. When the periscoping element does extend up to the surface drilling rig 20, as will be explained in more detail subsequently, it should be held in place by a tension harness and rollers which would permit the surface drilling rig 20 to rise and fall with the wave action without disturbing the submersible drilling rig.

After the drilling operations have been completed and the production casing has been installed into place, control valves, commonly called a Christmas tree, will be located on top of the production casing 88. After the Christmas tree 90 has been properly installed, the drilling mud is removed from the well 26 and replaced by water in a manner well known in the hydrocarbon well drilling industry so that the product from the well 26 will flow when the valves on the Christmas tree are opened. The well is now ready to produce. Thereafter, the submersible drilling rig is detached leaving the Christmas tree 90 on the ocean floor. The ballast tanks inside the submersible drilling rig are slowly emptied and the submersible drilling rig 46 slowly rises to the surface in the manner shown in FIG. 5. Afterwards the surmersible drilling rig 46 can be moved to another location for further drilling pipelines or a storage tank for further preparations and the hydrocarbon producing well 26 may be subsequently connected to either pipelines or a storage tank for further production as desired. If the hoped for hydrocarbon producing well 26 turns out to be a dry hole, it will be plugged by cementing before the submersible drilling rig 46 is moved to another location.

Referring now to FIG. 6 of the drawings, there is shown a vertical section view of the submersible drilling rig in the same position as shown in FIG. 4. The surface drilling rig 20 is connected to the submersible drilling rig 46 by means of umbilical cord 84. Though the surface drilling rig 20 in the present invention is shown as a semi-submersible type well known in the industry, other types of surface drilling vessels may be used to accomplish the same purpose. The umbilical cord 84 connects to the periscope section 56 to supply the submersible drilling rig 46 with power, air, mud and other things needed in the drilling operation. The upper portion of the periscope section 56 has a watertight door 92 that is connected by the means of hinge 94 and latch 96 to hold it in connection with the outer housing of periscope section 56.

Inside of periscope section 56 is a cylinder 98 that may be extended to the surface drilling rig 20 along dotted lines 86 by means of an electrically powered gear 100. While the cylinder 98 is extending up to the surface drilling rig 20, seal 102 prevents any water from entering the periscope section 56. Also, the cylinder 98 has a watertight door 104 that will remain closed unless the cylinder 98 has been extended to the floor of the surface drilling rig 20. This watertight door 104 may then be opened for the purposes of extending the cylinder to resupply the submersible drilling rig 46. Also, the surface rig 20 may run the production casing through cylinder 98 should the drilling end up in a hydrocarbon producing well.

For purposes of illustration, the electrically powered gear 100 is depicted as a sprocket with matching gears 106 or cogs being shown on cylinder 98 for the raising and lowering thereof. However, it should be realized that any conventional method of raising and lowering cylinder 98 may be used.

As an additional safety feature to insure that none of the water that may leak into the periscope section 56 would not leak into the submersible drilling section 54, another watertight door 108 is installed between the two sections. The watertight door 108 would not be open unless the cylinder 98 was extended to the floor of the surface drilling rig 20 or fully retracted into the submersible drilling vessel and any water than may have leaked in was pumped out of the periscoping section 56. Though not shown, the watertight door 108 actually consists of two doors, one for each section 54 and 56.

Immediately below the periscoping section 56 is a landing 110 on which many of the supplies from the surface drilling rig 20 may be initially received. Just below landing 110 is an area than may be used for crew quarters 112, with ladders 114 connecting the various landings. Also running from the crew quarters 112 down through the submersible drilling section 54 is an elevator shaft 116. The elevator shaft 116 has a door 118 that may seal it off from crew quarters 12. Also, the lower portion of the crew quarters 112 has another watertight door 120 so that the entire crew quarters may be sealed in case of an emergency to prevent water from leaking into the quarters. Upper doors 122 and 124 prevent water from leaking in from landing 110.

Also provided is an emergency vehicle such as a miniature submarine, which may be located immediately below the crew quarters 112. A door 128 is provided in the side of the submersible drilling section 54 to allow the miniature submarine to float out in case of an emergency. One of many ways that the door 128 could be arranged would be to have explosive latches that may be blown in case of an emergency, thereby allowing the miniature submarine compartment 130 to fill. The lower portion of the miniature submarine compartment 130 has a waterproof hatch 132 that will operate in the same manner as the watertight door at the top of the compartment 130. It should be realized that the miniature submarine 126 does not set across the center of the submersible drilling section 54 so as to interfere with any drilling operations that may be performed from the surface drilling rig 20.

Immediately below the miniature submarine compartment 130 is the drilling compartment 134. On the floor 136 of the drilling compartment 134 is located a conventional rotary table 138 that is utilized during drilling operations along with a conventional draw works 140 that is powered by electric motor 142. Although an electric motor 142 is shown, it is appreciated that any other conventional type of power source may be utilized as long as it is practical under the circumstances.

The draw works 140 is connected by means of cable 144 to the crown block 146 and travel block 148. The crown block is mounted on platform 147. The crown block 146 and travel block 148 should be movable to one side to allow the running of production pipe from the surface drilling rig 20 as will be described in more detail subsequently. The draw works 140, in conjunction with the crown block 146 and travel block 148, is used to install or remove drill pipe in a manner that is well known in the drilling art. For example, if an additional section of drill pipe needs to be connected, the travel block 148 would be connected to one of the drill pipes 150 that would be stored within drilling compartment 134 and the drill pipe would be lifted into position over the rotary table 138 and connected to the drill pipe extending therefrom. As the newly installed section of drill pipe 150 extends down into the hydrocarbon well 126, other sections of drill pipe 150 will be connected in a similar manner.

Referring to FIG. 10 of the drawing, there is shown in more detail the storage arrangement for the drill pipes 150. Close to the floor 136 of the drilling compartment 134 is located an annular plate 152 for containing the drill pipes 150 in position. Within annular plate 152 there is a series of slots 154 into which drill pipes 150 may be stored. At the end of each slot 154 is a clamp 156 that is bolted to the annular plate 52 by means of screw 158. The clamp 156 holds a rod firmly against the outermost of the drilling pipes 150. This can be seen in more detail in FIG. 11, which is a cross sectional view along section lines 11-11 of FIG. 10. Also, to hold the drill pipes 150 in position during movement from a harbor to the drilling location, a bracket clamp 162 has been secured around the drill pipes 150 by means of bolts, screws or other conventional means. Another annular plate 162 is contained at the top of drilling compartment 134 and contains a similar amount of both clamps and screws to hold the uppermost portion of the drill pipes 150 in position.

Immediately below the drilling compartment 134 is located a mud control compartment 164. Within the mud control compartment 164 accurate readings and measurements are kept to insure that the mud used in the drilling operation is of the proper weight, density and composition as is necessary in the petroleum drilling industry. If a change in the composition of the mud is necessary, the changes may be made within mud control compartment 164 for immediate application in the well 26 with further changes in the mud composition being made in the surface drilling rig 20. A shaker table, well known in the petroleum drilling industry, may be located in the mud control compartment 164 to remove the cuttings from the mud. The cutting may then be blown through the hull of the submersible drilling rig 46 in a manner very similar to methods used by submarines to dispose of waste materials. A shaker table may be located in both the submersible drilling rig 46 and on the surface drilling rig 20 to provide alternative sources of disposing of cuttings from the petroleum well 26. Ladder 166 provides for easy movement between the various levels of the mud compartment 164 to check the mud tanks 168 and control equipment 170. Any additional area in the mud control compartment 164 not used for mud storage will be used for ballast tanks 172.

The lower portion of the mud control compartment 164 is also the bottom of the submersible drilling section 54. A control valve 174 will shut off the hydrocarbon well within the submersible drilling section 154. Immediately below the drilling section 54 another control valve 176, which is in the uppermost portion of the stingray section 48, 50 and 52, will also cut off the hydrocarbon well 26. The upper stingray section 52 docks with the submersible drilling section 54 in such a manner that a watertight seal is formed. An outer flange 178 extends down over the head portion 180 of stingray section 52. Between this outer flange 178 and the head portion 180, the watertight seal is formed. Also, in the floor of the mud compartment 164 are watertight hatches 182 and 184 so that the submersible drilling section 54 can be separated from the stingray section 52. Elevator shaft 116 of the submersible drilling section 54 ends at the floor of mud control compartment 164. Watertight hatch 182 provides for movement between the submersible drilling section 54 and stingray section 52 by means of ladder. Elevator shaft 188 extends through the stingray section 48, 50 and 52, and through the floor of the mud control compartment 164. The uppermost part of the elevator shaft 188 may be retracted into the head portion 180. The top of head portion 180 is sealed by hatch 190, though for pictorial purposes the elevator shaft 188 is shown as terminating inside the mud control compartment.

It should be understood that the entire head portion 180 of stingray section 52 may be sealed in a watertight manner with the hatch 190 sealing the top portion of the elevator shaft 188 and hatch 196 sealing off the center section that receives the tubing necessary for the petroleum well 26. Also contained in the head portion 180 is a blow-out preventer 198 that is of the conventional type used in the drilling industry. Floor 192 provides a place where workmen may operate valve 176 if necessary.

The stingray sections, which are identical with the exception of the uppermost and the lowermost portions, are constructed in the following manner. The elevator shaft 188 runs from the head portion 180 through back of the stingray sections 48, 50 and 52. The elevator shaft ends at the lower platform 200 of stingray section 48. It should be understood that as many stingray sections as are necessary to extend from the submersible drilling section 54 to the ocean floor will be used. Between each of the submersible drilling sections there will be a watertight bulkhead with hatches for sealing off the separate sections, to aid in the floating of the sections to the particular drilling location.

Referring now to FIG. 13 of the drawings, there is shown an enlarged cross section of two typical mating sections of the stingray taken along section lines 13-13 of FIG. 7 though at a different level on the stinger. In the mating of sections 52 with section 50, inward flange 264 slideably mates into outward flange 266, when notches 268 have been aligned with grooves 270. The flare of flanges 264 and 266 allow for easy mating of stingray section 50 and 52. Also, extension 272 fits into socket 274 in much the same way as the male and female electrical connections with the socket 274 being funnel shaped for easy mating with extension 272. When sections 50 and 52 have been brought toether, bolts 276 screw into threadable connection 278 to bring the sections into a watertight relationship so that no water may leak in between the two sections. The bolts 276 may be remotely controlled by a motor drive or hydraulic means and as many bolts as are necessary

to obtain the watertight seal may be used. Also, bolts **280** may be connected with threadable connections **282** to seal the cylinder **206** in a watertight manner. Again, the bolts **280** may be remotely operated by a motor driven type of screw.

Now that the two sections **50** and **52** are mated together, hatch **284** of section **52** and hatch **286** of section **50** may be removed to allow the drilling operations to be performed through cylinder **206.** The elevator shaft **188** extends down to ledge **288,** which opens the elevator shafts up to the entire circumference of section **52.** Between the extension **272** and cylinder **206** is a watertight door **290** that may be removed after sections **50** and **52** have been mated together in a watertight manner. Also, section **50** has a similar watertight door **292** and ledge **294** that extends around the upper circumference of section **50.** Again the watertight door **292** may be removed after the two sections **50** and **52** have been mated together in a watertight manner. By removal of the two doors **290** and **292,** personnel may come down the elevator shaft **188,** move through the opening created by the doors **290** and **292** and continue down the elevator shaft **188** in the lower section. Though the elevating mechanism is not shown in the attached drawings, it should be understood that any conventional type of elevating device may be used. For safety purposes and ease in transferring between sections, ladder steps **296** have been included on the backside of the elevating shaft **188** in such a manner as not to interfere with the normal elevating mechanism. Also steps **298** aid in the transfer between one section and the other. Above ledge **288** is the watertight ceiling **300** that insures that the distance between ceiling **300** and ledge **294** is watertight and at normal atmospheric pressure to allow for ease in the transferring of personnel and material.

The stingray sections, which must withstand severe amounts of pressure at ocean depths of several thousand feet, are constructed basically the same. Referring back and forth between FIG. **6** and FIG. **7,** which is cut along section lines **7—7** of FIG. **6,** a better understanding of the construction of the stingray can be obtained. The outer hull **202** of the stingray section **48** is of a cylinder configuration with internal ribs **204** radiating inward to give additional support. At the center of the outer hull **202** is another cylinder **206** to which the supporting ribs attach. Within the internal cylinder **206** is located the drill pipe **150,** which extends downward into the surface pipe **30** and conductor pipe **28** from the submersible drilling rig **54.** Mud that flows down inside the drill pipe **150** may flow back to the submersible drilling rig **54** between the outside of the drilling pipe **150** and cylinder **206.** Also, the elevator shaft **188** is attached to the outer hull **202** and inner cylinder **206** by means of ribs **208.** With the exception of the elevator shaft **188,** the space between outer hull **202** and inner cylinder **206** may be filled with water and used as ballast tanks in the submersing of the submersible drilling rig **46.** A divider **210** (shown in FIG. **6**) prevents the water from the ballast tanks from reaching the work area immediately above lower platform **200,** so that members of the drilling crew can move to the lower platform **200** during a normal drilling operation. Immediately above the lower platform **200** is located the master control valve **212,** which is the first cutoff for the petroleum well **26.** Another blow-out preventer **214** is connected above the lower platform **200** in a manner well known in the petroleum drilling industry.

The lower platform **200** should be a watertight bulkhead of considerable strength to prevent the ocean, which exerts a great deal of pressure at these considerable depths, from flowing into the stingray section **48.** When the submersible drilling rig **46** is initially positioned over the conductor pipe **28** and surface pipe **30,** the surface pipe **30** terminates before reaching lower platform **200.** Since the internal portion **216** of bottom **218** is exposed to ocean pressures durng the installation of the submersible drilling rig **46,** hatch **222** must also be capable of withstanding extreme pressures. For ease of positioning, rib support member **224** curve inward to provide a type of funnel guidance to guide section **48** over well **26.** Once the submersible drilling rig **46** is positioned, with surface pipe **30** and the conductor pipe **28** being contained in the bottom **218,** a bonding material is pumped through lower platform **200** to bond bottom **218** to conductor pipe **28.** After the bond has been made and rigorously tested, the water may be pumped out of the bottom **218** and hatch **222** removed. Any cleaning of the bonding material from the surface pipe **30** would be performed and a blow-out preventer installed in cylinder **206.** A master control valve **212** is installed above the blow-out preventer **214.** Now the drilling operation is ready to begin.

Before describing the method of operation of the present invention, additional structures should be shown. For the ease of illustration in FIG. **6,** all of the anchors and their connecting lines were not shown. However, FIG. **8** depicts a typical manner in which the anchor lines may be connected to the submersible drilling rig **46.** The line **36** is attached to a winch **226,** which is bolted to the outer surface of the appropriate section of the submersible drilling rig **46.** A cover **230** has been cut away to better illustrate the invention. An electrical motor **232** operates the winch **226** which controls line **36.** Power to the electrical motor **232** is supplied by means of conduit **234,** which is connected to its source of power through the outer surface **228.**

Referring now to FIG. **9** of the drawings, there is shown an elevated view of the submersible drilling rig **46,** with the outer surface **228** being cut away in such a manner as to illustrate the anchor line and stabilizing valves as would be necessary in this type of device. Other portions of the submersible drilling rig **46** are not shown for this illustration. The anchor lines **36, 38** and **74** are connected to their respective winches, which are contained in winch covers **230, 236** and **238.** The winches contained in winch covers **236** and **238** operate in a manner similar to the winch and motor contained within winch cover **230.** As the submersible drilling rig is located over the hydrocarbon well **26,** the appropriate winch motor is activated causing the cable attached thereto to help upright the submersible drilling rig **46.** The ballasts contained within the submersible drilling rig **46** also aid in this operation. Once located in the vertical position, all of the lines including lines **36, 38** and **74** should be tight to hold the submersible drilling rig in a rigid location. To aid in maintaining the submersible drilling rig in the vertical position, water is brought in through inlet **240** to check valve **242.** The check valve **242** is connected to pump **244,** which is in turn connected to tubing **246** that circles the outer surface **228** of the submersible drilling rig **46.** At a number of places along the tubing **246** are located control valves, and for the purposes of the present in-

vention four control valves 248, 250, 252 and 254 have been shown evenly disbursed around the tubing 246. Connected to the control valves 248, 250, 252 and 254 are nozzles 256, 258, 260 and 262 respectively, which extend through the outer surface 228 of the submersible drilling rig 46. By controlling the control valves with a computer means, when a force F is applied to the outer surface 228 of the submersible drilling rig 46, the appropriate control valve will be actuated to jet a stream of water through the outer surface 228 to counteract that force F. In FIG. 9, a force F is shown applied to one side of the outer surface 228 and being counteracted by a stream of water jetisoned from nozzles 256 and 262. This force F can be caused from such things as underwater currents that exist in many drilling locations.

Though the present invention is shown only with a limited number of anchors and anchor lines connected to the submersible drilling rig, as many as are necessary to adequately install, anchor and remove the submersible drilling rig may be used. Also, as many nozzles as are necessary on tubing 246 to counteract force F may be used with other nozzles and respective control valves being contained on other levels of the submersible drilling rig to aid in combatting ocean currents. As many levels with as many nozzles as necessary and practical may be used without varying from the scope and intent in the present invention. Also, the nozzles just described may be used in positioning the submersible drilling rig 46 into position and upon subsequent removing of the submersible drilling rig 46.

METHOD OF OPERATION

Once a particular location has been decided upon as the place where a petroleum well will be drilled, and if this location is in water of considerable depth, the surface drilling rig 20 and the submersible drilling rig 46 will be towed to that particular location. Once at the location the surface drilling rig 20 will set and cement the ocnductor pipe in the ocean floor. The conductor pipe will be approximately thirty inches and will be cemented from the ocean floor to a depth of about one thousand feet below the ocean floor. The top of the conductor pipe 28 should extend several feet above the ocean floor to allow easy mating with the submersible drilling rig as will be subsequently described.

After the conductor pipe 28 has been properly set and cemented, the surface drilling rig will run a surface pipe 30 through the conductor pipe to a depth of approximately 2,000 feet below the ocean floor. The surface pipe could have a diameter of approximately 20 inches. The conductor pipe should be set and cemented a distance below the conductor pipe, with a logical point for the setting and cementing of the surface pipe 30 being approximately two thousand feet below the ocean floor. The surface pipe 30 will be disconnected above the ocean floor and several feet above the uppermost portion of the conductor pipe 28.

While the surface drilling rig was running and setting both the conductor pipe 28 and the surface pipe 30, a number of anchors, with 32 and 34 being illustrative examples, are set in the ocean floor around the hydrocarbon producing well 26. From the anchors 32 and 34, lines 36 and 38 are run to the surface and attached to buoys 40 and 42, respectively. The two anchors 32 and 34 shown in FIGS. 1 and 2 are only illustrative of how the anchors may be set in the ocean floor.

Now that the surface drilling rig 20 has been disconnected from the hydrocarbon producing well, the submersible drilling rig 46 assembled with the separate sections 48, 50, 52, 54 and 56 being connected together. After these sections have been connected together in a watertight manner, ballast tanks within sections 48, 50 and 52 begin to fill. The anchors are connected to the submersible drilling rig 46 so that as the ballast tanks of stingray sections 48, 50 and 52 fill the submersible drilling rig 46 is moved into the upright position over the hydrocarbon producing well 26 as shown in FIG. 3. According to the depth at which the drilling operation is taking place, additional ballast tanks within the drilling rig section may also have to be filled to provide enough downward force to sink the submersible drilling rig 46.

By filling of the ballast tanks and the pulling of the various lines attached to the anchors, the submersible drilling rig is slowly lowered into position over the hydrocarbon producing well 26 so that the lower end of stingray section 48 mates over the stub provided by conductor pipe 28 and surface pipe 30. The lower portion of stingray section 48 has a funnel shaped type of guide by ribs 224 to allow for easy mating of stingray section 48 over conductor and surface pipe 28 and 30, respectively. Once into position and securely anchored, cement or other appropriate bonding material may be pumped through the lower platform 200 and around conductor pipe 28 and surface pipe 30, thereby securing them to the bottom 218. After the cementing has taken place, water remaining in the bottom 218 may be pumped out to allow a work crew to begin the drilling operation.

A drill pipe is now run from the rotary table 138 to the surface pipe 130 by using the crown and travel blocks 146 and 148 to connect the drill pipe as needed. Any cement that may have lodged in surface pipe 30 will now be drilled out. Before further drilling takes place, a blow-out preventer 214 and master control valves 212 will be installed in the stingray section 48. Also, a blow-out preventer 198 and control valve 176 will be installed in the upper stingray section 52. To allow for disconnection of the submersible drilling section 54 in case of emergencies, a control valve 174 is installed in the submersible drilling section 54.

Now the drilling operations are ready to proceed, with mud being supplied by mud tanks 168 and controlled in mud compartment 164. Mud supplied through umbilical cord 84 maintains the mud tanks 168 at a suitable level and provides the means whereby the mud may be run through umbilical cord 84 up to the surface drilling rig 20. On the surface drilling rig 20, or in the mud control compartment, the cuttings are removed from the mud in a manner well known in the petroleum drilling industry. Any ingredients that need to be added to the mud will be added in the surface drilling rig 20 to bring it within the general range necessary to this particular drilling operation. However, further modifications to the mud density and composition will be made in the mud control compartment 164 to provide the delicate balance needed for the particular petroleum well. The drilling proceeds in the normal manner, with the mud flowing through the drill bit into the hydrocarbon well 26 and back up along the outside of the drill bit carrying the cuttings back up to the submersible drilling rig 46 and thereafter up to the surface drilling 20.

During the drilling operation, if additional pipe or supplies are needed the cylinder 98 will be extended up to the surface drilling rig 20 for resupplies as necessary. However, it is not intended that the normal drilling operation proceed with the cylinder 98 in the extended position because surface wave action on the surface drilling rig 20 may be reflected down to the submersible drilling rig 46. To help prevent this translation of wave action to the submersible drilling rig 46, a tension harness type of arrangement with rollers should be used in the surface drilling rig 20 to hold the cylnder 98 into positon.

Once the drilling operation has been completed and it is desirable to run the production casing, the cylinder 98 is extended up to the surface drilling rig 20. The rotary table and crown block with the travel block are moved to one side so that the production casing can be run from the surface drilling rig through the cylinder 98, periscope section 56, submersible drilling section 54 and the sections of the stingray 48, 50 and 52 and then into the hydrocarbon well 26. This production casing is run to whatever depth the well has been drilled and is set and cemented into position in a manner well known in the petroleum well drilling industry. If the production casing needs to be cleaned because of the cementing, this cleaning operation can take place from the submersible drilling rig 46.

After the production casing has been set into place and properly cemented, and a string of production tubing has been run into the casing, then control valves 90 commonly called a Christmas tree are installed immediately above platform 200 in stingray section 48. After installation of the Christmas tree 90, customary steps will be taken to bring the well into production such as cleaning the well 26 of mud and replacing with water. One of the lower ballast tanks can be used to pump off the excess mud and oil while bringing the well 26 into its final stage of readiness before production, thereby preventing spillage into the ocean. A vent between the well 26 and the ocean is necessary to prevent excess gas accumulation in the submersible drilling rig 46, while bringing the well 26 into production. Any drill pipe, casing, etc. above platform 200 is removed and hatch 220 (see FIG. 6) is installed at divider 210. Water is pumped back into bottom 218 of stingray section 48 to equalize pressures. Thereafter bottom 218 is disconnected from stingray section 48 by means of an explosive seal contained therebetween that would disconnect one from the other. By the removing of water from the ballast tanks and loosening cables that go to the anchors, the submersible drilling rig is slowly raised to the surface of the body of water leaving behind the bottom 218 as shown in FIG. 12 and the control valve 90. Thereafter the submersible drilling rig 46 may be moved to another drilling site. The hydrocarbon producing well 26 may be connected at any convenient time to a production line which carries the crude oil to a storage point or pipeline for further transportation and refinement.

An alternative method of connecting to the well 26 is shown in FIG. 14 wherein the conductor pipe 28 is installed with a flange 302. The top of the flange 302 has a sealing pad 304. As stingray section 48 of the submersible drilling rig 46 moves into position over the well 26, the lower platform 200 mates against sealing pad 304. Screws 302 attached to lower platform 200 fit through holes 308 and into threads 310 of the flange 302. The screws 306 may be hydraulically or electrically operated to tighten the stingray section 48 in a watertight manner to the flange 302 and to the well head of well 26. As many screws as are necessary may be used with the sealing pad being of a size up to the diameter of the lower platform 200. A beeper, commonly used in the petroleum industry to locate underwater wells, may be attached to well 26 to aid in positioning stingray section 48.

A watertight hatch 220 keeps the ocean pressures from flooding cylinder 206 while the submersible drilling rig 46 is being connected to well 26. Once into position and sealed, pump 244 removes the ocean water and creates atmospheric conditions in chamber 312. Thereafter, hatch 220 is removed along with watertight door 314 to allow direct access to the well 26. Atmospheric conditions exist between divider 210 and lower platform 200. Additionally a safety hatch 316 is located at the bottom of elevator shaft 188, which can be closed during connection to the well 26 and in cases of emergency. After the well 26 has been drilled and is completed into a well ready for production, the screws 306 are released and the submersible drilling rig 46 moves to a new location leaving the Christmas tree 90 attached to the well 26.

Later if it becomes necessary to drill the well 26 deeper or to service the well in any manner, such as installing new casing or production pipes, the submersible drilling rig 46 may be reconnected to flange 302. The only preliminary step that may be necessary would be the cleaning of sealing pad 304 by means of a rotary brush mechanism or the like. Previous methods of servicing production wells at substantial depths did not allow the complete range of servicing as is necessary in the petroleum industry. Service modules that may be lowered to the well head could only perform very limited functions where the present invention, upon reconnection, could perform essentially all the same services to a production well as could be performed by a jack-up rig in shallow water without the problems caused by wave action.

By use of the present invention the drilling operations can proceed day and night in all kinds of weather without numerous interruptions due to unfavorable weather conditions as is common in the North Sea area where 90 foot waves are not uncommon and elsewhere around the earth. By the use of the present invention there is no need to shut down drilling operations under any type of adverse weather conditions.

The drilling section, which is approximately 50 feet in diameter, will withstand normal pressure of the ocean at about 500 feet below sea level. The stingray sections, which are approximately from ten to fifteen feet in diameter may extend several thousand feet below sea level and must withstand a considerable amount of pressure.

It should be understood that the submersible drilling rig 46 may be completing one hydrocarbon producing well while the surface drilling rig 20 is starting another well by setting in a conductor pipe in the ocean floor, or completing the well currently being drilled by the submersible drilling rig 46. This gives the maximum utilization of equipment. Also the submersible drilling rig 46 may return to a deep water well after a number of years of production and redrill the well, plug the old producing zone if it has been exhausted, and complete the well in a new producing zone. The old depleted well

may be deepened to an untapped oil zone, and recompleted as a new producing well.

What is claimed is:

1. A submersible apparatus for drilling and completing a well on the floor of a deep body of water, said apparatus comprises:
- an elongated housing having an interior near atmospheric pressure;
- shaft means connected to a first end of said elongated housing, said shaft means extending between said elongated housing and said well being drilled, said shaft means being of considerably less traverse cross sectional area than said elongated housing so said shaft means can withstand increased pressures of lower depths in said deep body of water;
- drilling means disposed in said elongated housing for drilling said well substantially vertical of said housing and through said shaft means, said shaft means allowing workmen to work at the wellhead near atmospheric conditions by sealing to said wellhead;
- sealing means on the lowermost portion of said shaft means for sealing said shaft means to said well;
- ballast means in said shaft means and elongated housing for controlling the buoyancy of said apparatus; and
- means for positioning said apparatus over said well.

2. The submersible apparatus for drilling a well on the floor of a deep body of water as recited in claim 1 including a means to cut off said well and disconnect therefrom to allow movement of said apparatus to another location.

3. The submersible apparatus for drilling a well on the floor of a deep body of water as recited in claim 2 further including a periscoping means attached to a second end of said elongated housing, said periscoping means being extendable above the surface of said body of water and in substantially vertical alignment with an opening in said periscoping means, said elongated housing and said shaft means to allow certain drilling functions to be performed from the surface of the body of water through said opening and to resupply said apparatus with parts and personnel through said opening.

4. The submersible apparatus for drilling a well on the floor of a deep body of water as recited in claim 3 wherein the sealing means includes the lower part of said shaft means seated over said well by a funnel means and sealed thereto by cementing substance deposited around said well, said lower part of said shaft means being detachable and left in position when said apparatus is moved to another location.

5. The submersible apparatus for drilling a well on the floor of a deep body of water as recited in claim 3 wherein said drilling means is moveable to allow the performance of certain drilling operations from the surface of said body of water by clearing the path of said opening to the surface.

6. The submersible apparatus for drilling a well on the floor of a deep body of water as recited in claim 3 wherein the sealing means includes the lower part of said shaft means seated over said well and connected thereto with a flanged head of said well forming a watertight seal to the lower portion of said shaft means, said flanged head having means for disconnection and subsequent reconnection of said submersible apparatus to said flanged head and sealing thereto to allow near atmospheric conditions at said well head.

7. A submersible apparatus for drilling a well in a deep body of water, said apparatus comprising:
- an elongated housing submerged in said body of water having an upper and lower extension, said upper and lower extension being of substantially reduced cross sectional area than said elongated housing with said lower extension withstanding increased pressures of lower depths in said deep body of water, said elongated housing being supplied from the surface of said body of water and maintained near atmospheric conditions;
- means for positioning the lower extension of said elongated housing over pipe means set in the floor of the body of water;
- means for sealing said lower extension to said pipe means;
- drilling means disposed in said elongated housing for drilling said well through said lower extension and said pipe means; and
- means for extending said upper extension to the surface of said body of water.

8. The submersible apparatus as given in claim 7 wherein ballast means control buoyancy of said elongated housing, said positioning means includes anchor means for moving said apparatus into position and securing into place.

9. The submersible apparatus as given in claim 8 wherein said extending means allows running and setting of production casing from a surface vessel floating on said body of water above said well, said drilling means being movable to allow said running and setting from said surface vessel.

10. The submersible apparatus as given in claim 9, wherein said elongated housing is divided into sections for easy transportation, each section being sealable during transportation and emergencies while drilling.

11. The submersible apparatus as given in claim 9 further including a means for escaping from said apparatus during emergencies while under the body of water.

12. A method for drilling a well in a deep body of water consisting of the following steps:
- setting a pipe in the floor of the body of water;
- submersing a submersible drilling rig over said pipe;
- sealing said submersible drilling rig to said pipe;
- drilling said well from said submersible drilling rig;
- extending said submersible drilling rig to the surface of said body of water;
- running and cementing production pipe from a surface drilling rig through said submersible drilling rig;
- installing control valve means to said production pipe at the well head of said well to allow later connection to a transportation means for moving any products produced from said well, and
- removing said submersible drilling rig from said well.

13. The method for drilling a well in a deep body of water as given in claim 12 including the following step of cleaning said well before removing said submersible drilling rig, material cleaned from said well being contained in said submersible drilling rig.

14. The method for drilling a well in a deep body of water as given in claim 13 including:
- putting anchor means in the floor of the body of water while setting the pipe;
- attaching said submersible drilling rig to said anchor means; and

filling ballast tank to aid in submersing said submersible drilling rig.

15. The method for drilling a well in a deep body of water as given in claim **14** further includes assembling different sections of said submersible drilling rig in a watertight manner to prevent leakage at expected water pressures.

16. The method for drilling a well in a deep body of water as given in claim **15** wherein the step of running and cementing including the moving of drilling means within said submersible drilling rig to allow said running and cementing from said surface drilling rig.

17. The method for drilling a well in a deep body of water as given in claim **16** wherein removing said submersible drilling rig from said well includes detaching the lowest part of said submersible drilling rig that has been sealed to said pipe and leaving said lowest part upon said removing.

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