Aug. 25, 1970 R. A. McCLINTOCK 3,525,388

SUBSEA DRILLING APPARATUS

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FIG. 1.

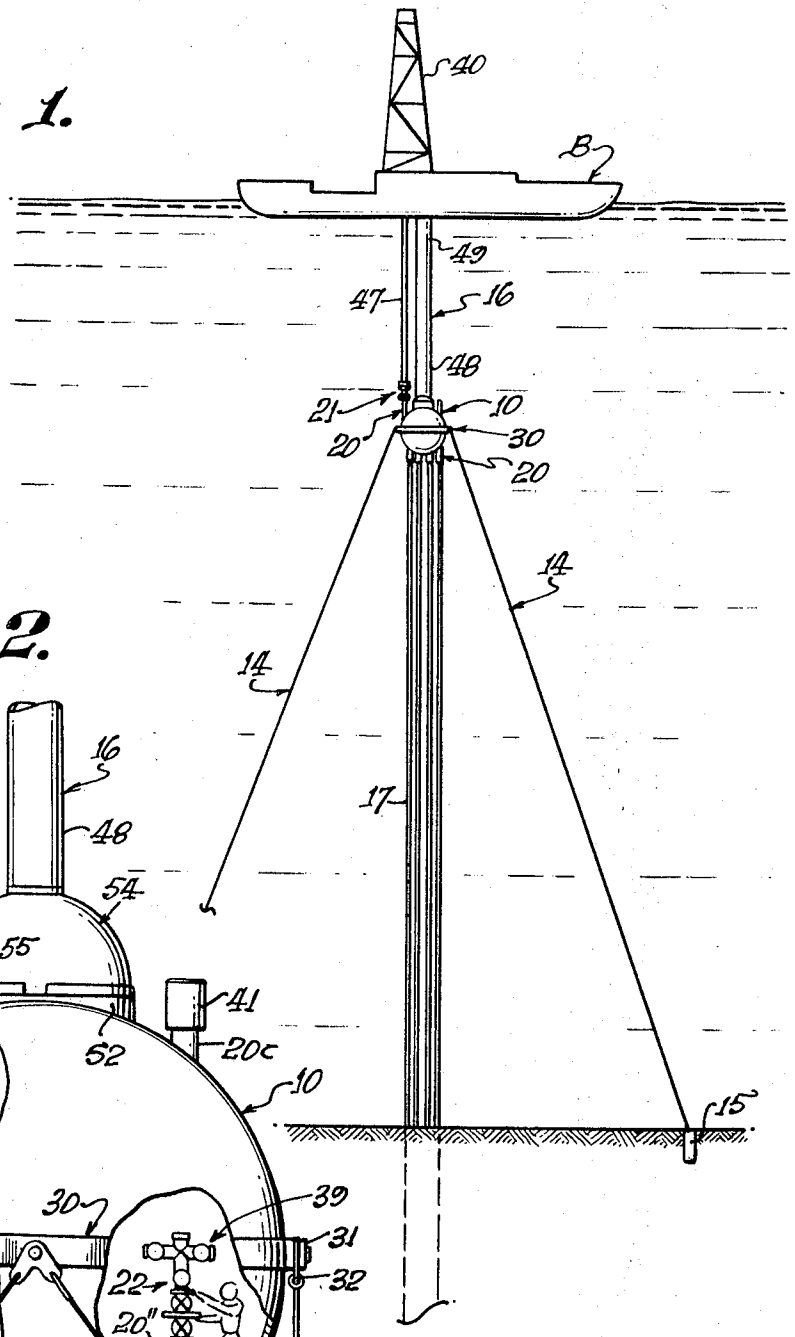
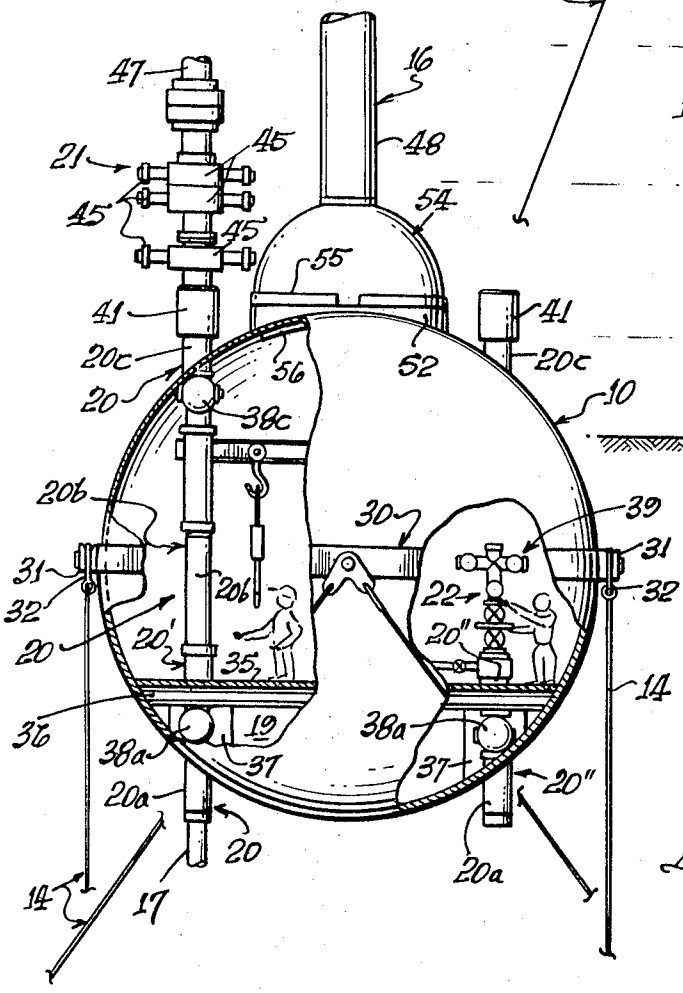


FIG. 2.



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SUBSEA DRILLING APPARATUS

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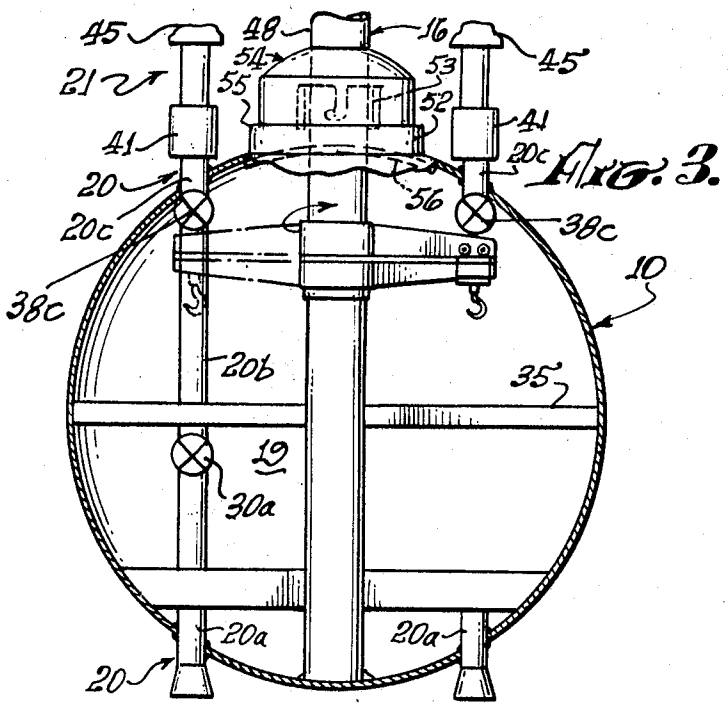


FIG. 3.

FIG. 4.

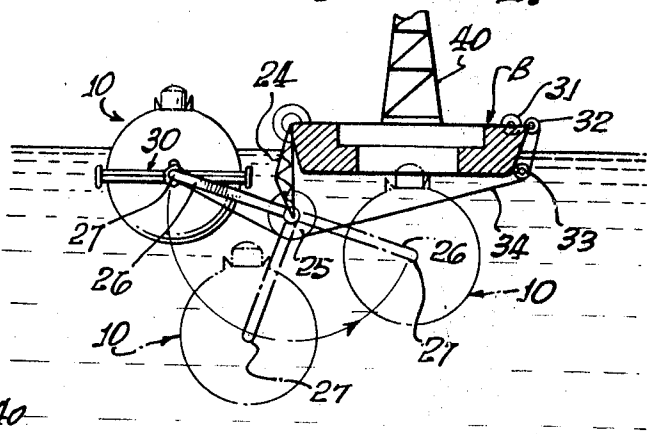
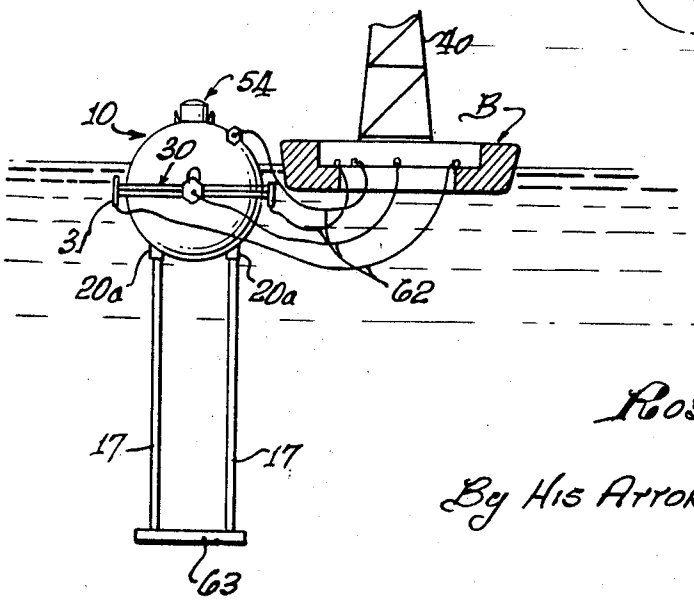


FIG. 5.



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SUBSEA DRILLING APPARATUS

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FIG. 7.

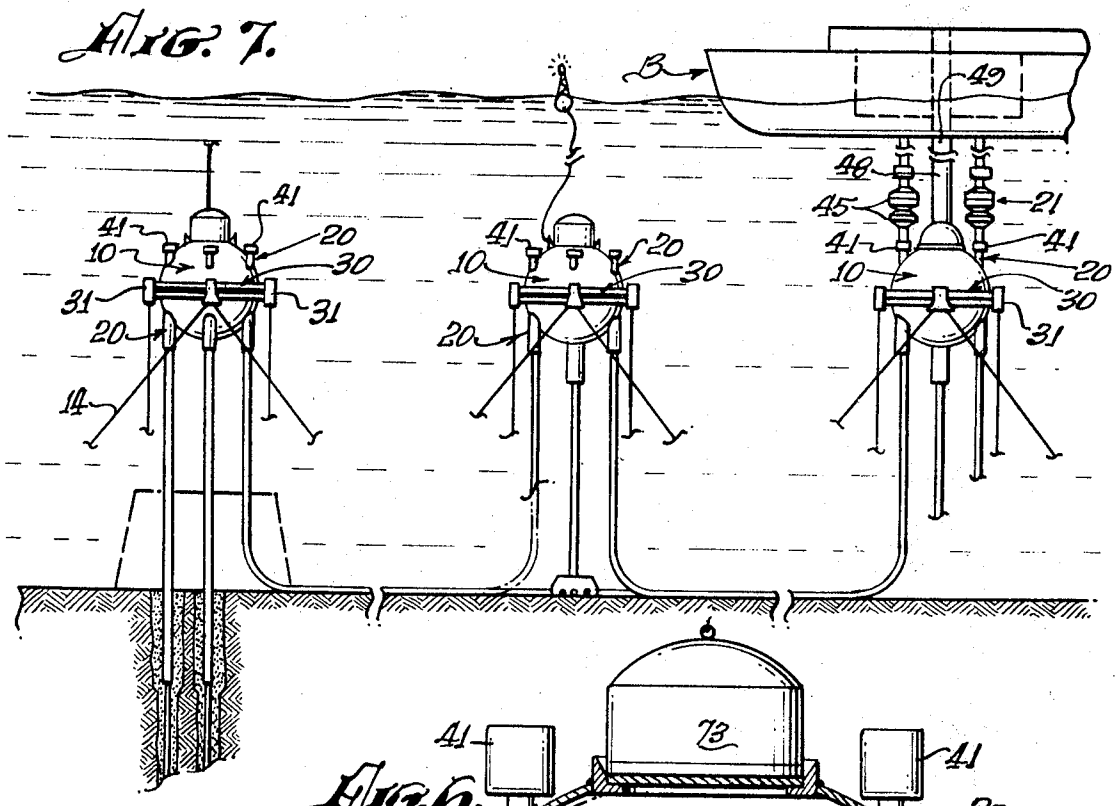
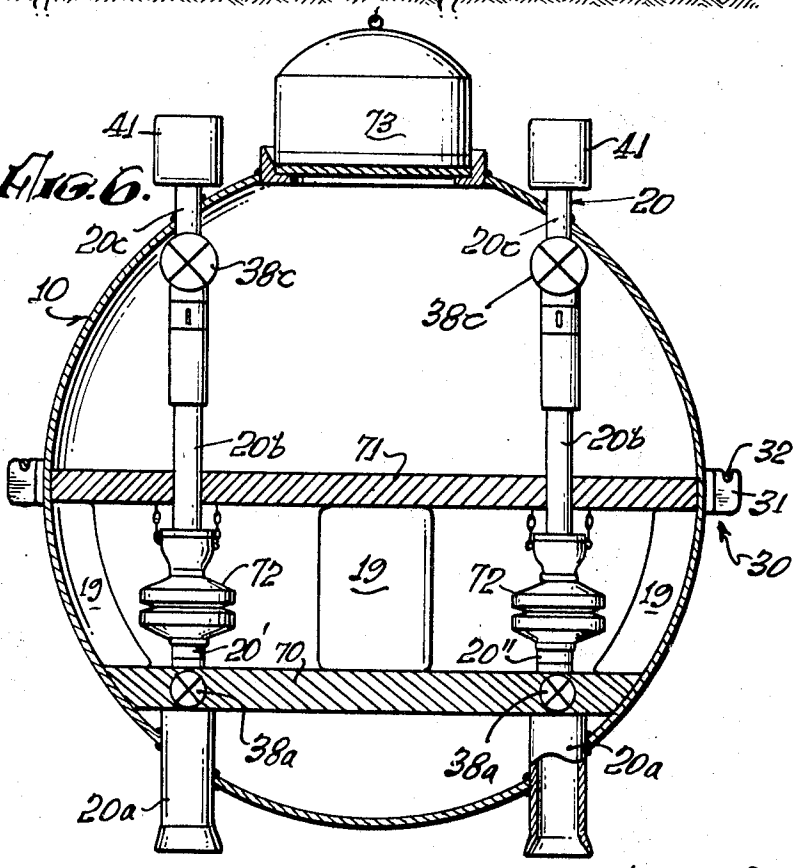


FIG. 6.



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SUBSEA DRILLING APPARATUS

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FIG. 8.

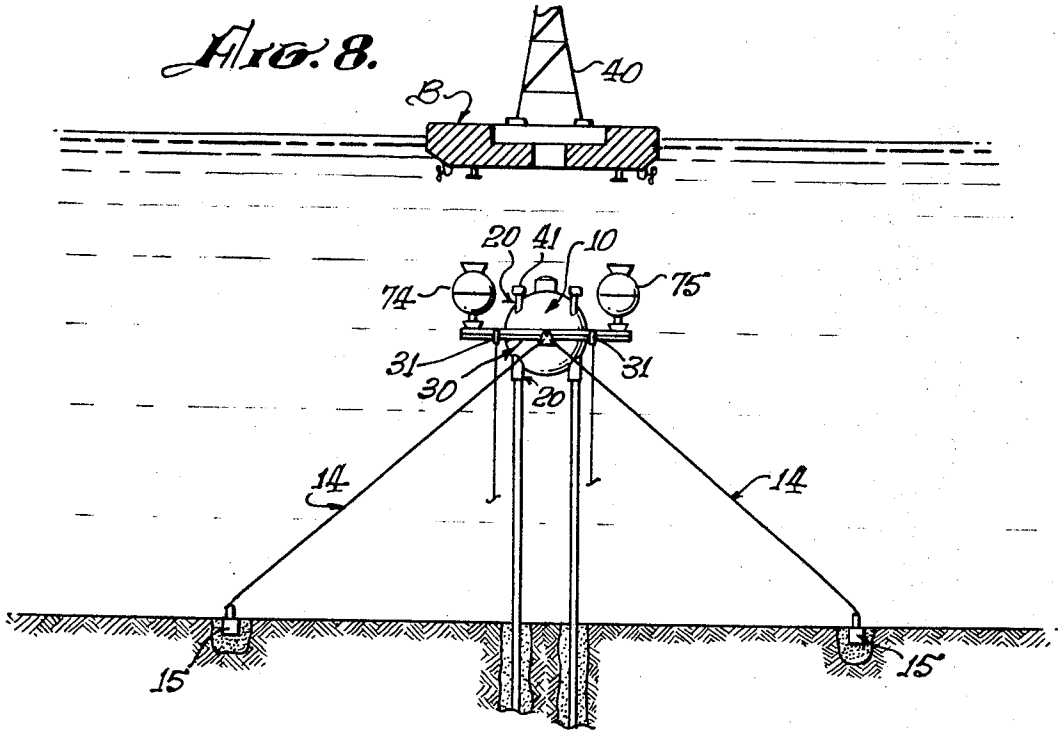
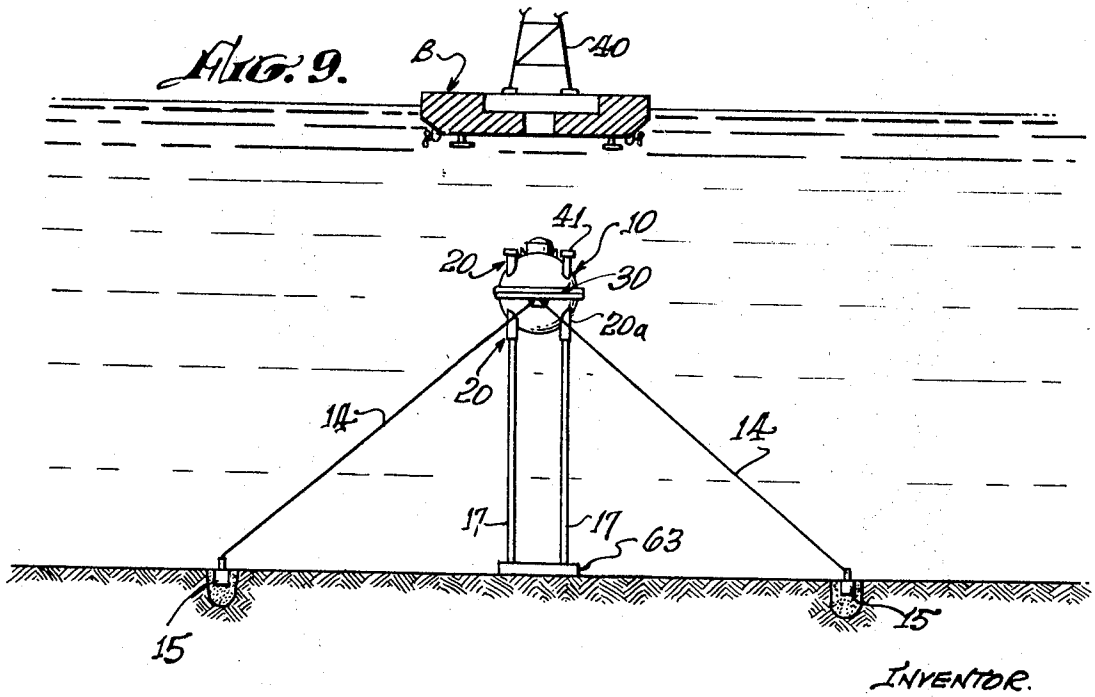


FIG. 9.



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3,525,388

SUBSEA DRILLING APPARATUS

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Int. Cl. E21b *43/01, 15/02*
U.S. Cl. 166—.5 11 Claims

ABSTRACT OF THE DISCLOSURE

A device in accordance with the present invention in its presently preferred form includes a submerged structure, such as a sphere, with a positive buoyancy and means for adjusting such buoyancy from positive to slightly negative. The submerged structure is anchored or moored to the floor beneath the body of water by lines or elongate members which are slightly in tension due to the positive buoyancy of the structure. The structure contains working space which is maintained free of water and at a predetermined pressure which is most generally atmospheric. The submerged structure is buoyed in the water at a depth which is below the wave and surface action of the water, but spaced above the ocean floor at a depth beneath the surface which is readily accessible. Means for access from the water surface to the working space is provided. Within the working space of the structure or adjacent to the structure exploration, mining or well drilling equipment such as blowout preventers, completion equipment or production equipment, or remedial equipment is positioned. Means are provided for passing through the structure from a vessel, barge or other floating or moored platform, positioned above the submerged structure. Conduits or similar means are extended from the submerged structure to the floor beneath the body of water and generally to the portion of ocean floor being drilled, worked or completed. The conduits are in operative connection with the equipment within the working space of the structure. For drilling or well working operations, other than completion or production, means are provided for passing to the ocean floor from the vessel, or other moored or floating platform, through the top of the submerged structure and into operative connection with well drilling equipment such as blowout preventers, rotating heads or other completion equipment positioned adjacent or within the submerged structure. In effect, the structure establishes a wellhead and working space for drilling, completion, production, remedial and like operations at a level which is below the surface of the water at a depth to avoid interference by wave and current action, surface hazards or the like, so that useful work can be more readily performed and access to the apparatus and equipment is more readily available. The submerging of such structures also removes objects having an aesthetically undesirable appearance from the public view.

This invention relates to a method and apparatus for drilling or working in the earth beneath a body of water.

BACKGROUND OF THE INVENTION

The field of the invention is that of mining, drilling, completion, production, and remedial servicing of offshore oil and gas wells.

The offshore drilling and servicing of wells for oil and gas is generally performed from either a fixed platform carried by a leg structure resting on the bottom and supporting a drilling platform disposed above the upper level of wave action or a floating platform which may be either a semi-submersible platform, or a vessel, a barge or a moored structure.

Fixed platforms as heretofore known to the art are supported from the ocean floor by legs which position a drilling platform above the wave action of the water surface. Such platforms are, of course, severely limited in the depth of water in which they can be utilized. Among some of the disadvantages of such platforms, in addition to their severe limitations or as to the depth of water in which they can be utilized, are their unsightliness, extreme expense and structural difficulties. Some of the inherent difficulty in construction and utilization of such platforms is obvious when it is considered that the columns upon which the platform is suspended to a substantial depth above the water surface must support literally millions of pounds. Thus, the legs or columns of the platform must be expensive and complicated engineering structures which are submitted to compressive loads, of, for example, 6½ million pounds. Storm conditions will exert additional leads and stress factors upon such platforms. Such factors make it apparent that as drilling and other subsea operations are performed in greater depths of water the use of platforms supported above the water surface by columns extended from the floor beneath the body of water are impracticable. Additionally, there is no certainty that they can be adequately supported by the structure of the ocean floor at the points at which it is desired to locate them.

Semi-submersible platforms constitute a platform supported by buoyancy chambers positioned beneath the wave action of the water with the drilling platform disposed above the level of wave action by columns or other supports extended from the submerged buoyancy chambers. These semi-submersible platforms are expensive and do not withstand rough weather actions and other force factors as well as a barge or the fixed platforms. For the foregoing reasons and for many additional reasons, the drilling of offshore wells in substantial water depths has become increasingly accomplished through the use of floating drilling barges.

The present invention is particularly adapted to be used in combination with drilling barges, of the type presently known to the art, in deep water and permits the operation of such vessels in an efficient manner comparable to the manner of operation employed in shallow water.

One of the primary difficulties of drilling a well from a floating vessel in the present state of the art, which is solved by the present invention, is that the wellhead equipment must necessarily be located on the ocean floor instead of on a platform intimately asociated with the drilling derrick and the rotary table ordinarily associated therewith.

In general, in accordance with the present state of the art, to start a drilling operation from a vessel, such as a drilling barge, the drilling equipment, such as the drill string and drill bit, is suspended from the drilling derrick and is lowered through an opening in the barge down to the ocean floor. After the well has been spudded in and surface pipe has ben set, the blowout preventer stack is lowered to the ocean floor and is connected to the surface pipe. A drilling conduit, i.e., a riser, is then connected to the wellhead equipment which comprises primarily the blowout preventer stack comparable to those employed in operations on land. The riser is extended upward to the barge and through the drilling opening in the hull (usually known as the "Moon Pool") to a position just below the rotary table. The rotary table is carried on a platform on the barge just below the derrick. Drilling mud is then circulated through the riser and into the well. The present state of the art of deepsea well drilling or working operations from floating vessels, involves the locating of drilling equipment, such as blowout preventers and wellhead equipment including well completion equipment, at the

ocean floor. This is necessary in drilling operations conducted from a floating platform since the wellhead equipment cannot be located at the vessel due to the wave and surface action of the water which causes the vessel to roll, pitch, heave, surge and yaw. This makes it impractical to risk the installation of the equipment, particularly the blowout prevention equipment at the vessel since a rupture in the well conduit below the blowout preventers would cause serious difficulties.

The location of wellhead equipment at the ocean floor causes serious difficulties in drilling from a floating vessel and to a large extent imposes a practical limitation as to the depth of water in which drilling vessels can be economically utilized. For example, if the water is greater in depth than that in which diving operations can be performed, then all access to the blowout preventer stack both during drilling operations and subsequent operations must be by some remote means. Many solutions have been offered for such access but all are subject to many disadvantages. During installation of the blowout preventer stack on the surface casing, the connection of the stack to the casing must be made remotely if the depth of the water is in excess of approximately 250 feet, since a diver cannot descend and work efficiently below the depth. Thus, during the connection, guiding means must be provided for bringing the blowout preventer stack into position to be connected to the surface casing and this connection is then most generally accomplished remotely by means of hydraulic equipment. Such equipment is costly and subject to failure and after a number of sets of such equipment have been installed on the ocean floor, the hydraulic systems and lines become both complex and cumbersome. Obviously, if there should be a malfunction in any part of the connection or in any other hydraulic lines, no access is available to determine the cause or the nature of the malfunction and no inspection or checking of the equipment can be made.

The present invention obviates such difficulties, and presents many advantages over subsea drilling and mining methods and apparatus heretofore known to the art. Although the present invention is not limited thereto it is particularly applicable to offshore drilling operations for oil and will accordingly be described in connection with such operations. It will be seen, however, that the present invention is also applicable to other operations to be performed beneath a body of water of substantial depth and is also particularly applicable to the production of wells which have been drilled into production zones beneath the ocean floor or to other mining operations.

SUMMARY OF THE INVENTION

The present invention is an improved method and apparatus for drilling and working in the earth beneath a body of water. The apparatus includes a structure submerged at a predetermined depth in the body of water. The predetermined depth is such that the structure is spaced above the subsea floor but substantially below the wave and surface action of the water. Means are provided for maintaining the structure at the predetermined depth. The structure defines a working chamber therein with means for extending drilling pipe strings or similar means from the chamber to a well in the subsea floor. Wellhead equipment, or similar equipment, is positioned within the structure or adjacent thereto. Access means are provided to the structure from the water surface.

OBJECTS OF THE INVENTION

It is a primary object of the present invention to provide a method and apparatus for subsea drilling, mining and working by which the wellhead equipment is positioned in stabilized state at a predetermined accessible depth. Another object of the present invention is to provide a well drilling and servicing apparatus which does not subject any connections with the ocean floor to undue stresses so that the working conduits extending between the well and the structure can be maintained in slight tension or compression as desired.

Still another object of the invention is to provide a wellhead apparatus which can be permanent in nature, which is spaced as far as possible from the ocean bottom while being sufficiently submerged as not to interfere with surface activities or shipping and which is not detectable from the water surface.

A further object of the invention is to provide a remote wellhead apparatus for drilling and working on a floor beneath a body of water which can be either salvaged and transported for exploratory purposes or which, if desired for production or other permanent purposes, can be left in place.

It is another object of the present invention to provide such well drilling and working apparatus which can be quickly positioned at the proposed well site but which can also be quickly and economically salvaged and relocated.

Another object of the present invention is to provide such apparatus which is standardized for different drilling and working operations and for different depths of water in which such operations are performed.

A further object is to provide such apparatus having lower initial cost, installation cost and operating cost than the apparatus heretofore known to the art.

It is another object of the present invention to provide a method and apparatus for subsea well drilling and working operations by which the overall cost per well is less than by use of presently known structures.

Still another object of the present invention is to provide a method and apparatus for providing a wellhead apparatus, which permits the efficient use of well drilling vessels and which affords efficient servicing of the wellhead and associated equipment in connection with drilling or production operations regardless of the depth of the water in which the well is located.

A further and primary advantage of the present invention is to provide apparatus and means adapted to be used in connection with a floating drilling vessel which permits the use of drilling and working equipment and operations in deep water in a manner similar to that employed in drilling in relatively shallow water.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form a part of the specification following and which illustrate certain presently preferred embodiments of the invention:

FIG. 1 is a semi-diagrammatic illustration of a well drilling vessel associated with a submersible well head or working structure constituting a presently preferred embodiment of the invention arranged as for drilling a well;

FIG. 2 is a greatly enlarged, partially sectional view in elevation of the working space structure shown in FIG. 1;

FIG. 3 is an enlarged view in elevation of the apparatus of FIG. 2 showing other structural details thereof;

FIGS. 4 and 5 are schematic drawings showing means of positioning a working structure beneath a ship preparatory to anchoring the structure to the ocean bottom;

FIG. 6 is an enlarged sectional view of an alternate arrangement of the working structure of the present invention;

FIG. 7 is a schematic view showing different installations of the working structure in connection with producing wells;

FIG. 8 is a view of an alternate arrangement for increasing the buoyancy of the working structure; and,

FIG. 9 is a partially schematic view of an alternate means for stabilizing the working structure.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The apparatus of the present invention is shown in its presently preferred embodiment in FIGS. 1, 2 and 6.

Prior to a detailed description of such presently preferred embodiment a general description of the apparatus is set out hereinafter with reference to FIGS. 1 and 2. The fundamental unit of the invention is in the presently preferred embodiment, a buoyant sphere, or what has been referred to in the preceding paragraphs as a "working structure." This working structure constitutes a hollow body adapted to be submerged. The body is of sufficient size to constitute the necessary working space for one or more persons. In all figures, the spherical body of this working structure is generally designated by the numeral **10**. The body is of sufficient size to support preferably one but in some instances two decks, and to define an air chamber sufficient to furnish the required buoyancy as described hereinafter. The structure provides sufficient head room to allow a person to stand erect therein. The structure is sufficiently weighted and ballasted to have a limited amount of buoyancy which preferably can be varied and is provided with suitable means for the attachment of anchoring cables **14** at a plurality of points thereon. The cables extend diagonally downward in spaced radial arrangement to suitable anchors such as indicated at **15** which are effective to hold the structure in a substantially stable attitude at the submerged depth. The depth is such that the structure is substantially free from the effect of wave action or other current conditions at the surface of the water. In the presently preferred embodiment the depth at which the structure is anchored is approximately 150 to 250 feet and drilling is shown, as an example, in FIG. 1 at a total depth of approximately 900 feet.

Entrance and exit means comprise a vertically extending shaft **16** extending up to the drilling or service barge. Entry or exit can also be made by a diver or by means of a diving bell through a suitable air lock hatch and bulkhead door means. Drilling or working operations are carried on through a conduit extending from the working structure **10** to the subsea floor. Such conduit is in part provided by a plurality of access tubes **20** extending vertically through the working structure. Each access tube extends from an exterior point adjacent the lower surface of the working structure to or through the working structure. A conductor pipe is connected to the lower end of the access tube and extends into the well bore, as more fully described hereinafter. In FIG. 2 a conventional drilling vessel riser system **21** is connected to the upper end of one of the access tubes **20***b* while a production Christmas tree **22** is shown connected into the access tube **20''** as described more fully hereinafter. Thus, the access tubes are utilized to enable a continuous conduit to be formed from the vessel to the well bore during drilling or well bore operations or from the well bore to the interior of the structure during completion or production operations. In the case of drilling operations, various pieces of the equipment including the blowout preventers, can sometimes be positioned within the structure.

The degree of buoyancy can be regulated by emptying or filling a ballast volume which is suitably located within the structure as at **19** in the illustrative embodiment.

In order to more fully describe the construction, utility and method of operation of the apparatus of the present invention, an illustrative presently preferred embodiment as shown particularly in FIGS. 1, 2 and 3 will now be described.

In its presently preferred form the working structure **10** is spherical in configuration and is, for example, 40 feet in diameter. The walls of the sphere are formed of steel two inches in thickness. Such a sphere defines an interior working space of approximately 22,000 cubic feet. Provision is typically made for the drilling, working or production of twelve or more wells by use of such a structure and the weight of the spherical structure including twelve wellhead assemblies and accessories would be approximately 1,200,000 lbs.

In the illustrative application shown in FIG. 1 the water depth is shown as approximately 900 ft. The structure **10** is submerged and stabilized at a depth of approximately 150 to 250 feet which is below any significant wave of surface action of the water. The illustrative drilling vessel shown is a typical drilling barge B of the type presently in use and is 400 feet in length with a 124 foot derrick or mast **40**.

The sphere **10** is moored and stabilized by means of eight cables **14** attached to the equator band **30** of the sphere at four equidistant attachment points **31** spaced around the periphery of the sphere at such equator band. Two diverging mooring cables are affixed by means of a suitable yoke **32** which is pivotally connected to the respective attachment point or boss **31**. The cables are then anchored and suitably cemented to the ocean floor at radially circumferentially points **15** in the ocean floor. The sphere is thus prevented from moving upward or horizontally to any appreciable extent. Downward movement of the sphere is, of course, prevented by the positive buoyancy of the sphere. Illustratively, the mooring cables as previously described, would weigh approximately 4,000 lbs. At 20% net positive buoyancy and at a loaded weight as previously described, the additional load capacity of the sphere is approximately 4.5×10^5 lbs. A ballast tank capacity of 5.5×10^5 lbs. is provided.

Referring now particularly to FIGS. 2 and 3, a single working deck **35** is provided with a reinforced section **36** beneath the deck and suitable reinforcing beams, or plates **37**, supporting the deck **35** to the extent necessary to support the loads placed thereon. The volume beneath the deck also comprises the ballast tanks with suitable inlets, outlets and pumps (not shown) to eject and allow entrance of ballast water to the tanks.

Each of the access tubes **20** is constructed in such manner as to allow a continuous vertical conduit through the sphere or to provide access to the conduit extending downwardly or upwardly from the sphere. (The different access tubes are designated by primes, that is **20'**, **20''**, etc., while the parts of an access tube are designated by alphanumeric combinations, that is **20***a*, **20***b*, etc.) Thus, referring first to the access tube **20'** being utilized as a drilling conduit in the illustrative embodiment, a lower section **20***a* extends through the lower surface of the sphere and is suitably sealed where it passes through the wall of the sphere. A valve **38***a* is positioned in the lower access tube section **20***a*. The valve is of a type well known to the art which when in the open position allows a clear passage through the conduit. The upper end of the lower section terminates above the working deck and is adapted for coupling to other equipment. For example, completion equipment **39** may be connected into the right hand access tube **20''** of FIG. 2 or it may be connected for through passage of conduit as shown in connection with access tube **20'**. The through connection conduit **20***b* is shown in FIG. 2 as utilizing a telescoping joint so that it can be inserted between the lower section **20***a* and the upper section **20***c* of the access tube **20**. The upper section **20***c* is comparable to, and in vertical alignment with, the lower section **20***a* and terminates below another valve **38***c*. The through section **20***b* is thus adapted to be inserted between the upper and lower sections **20***a* and **20***c* of the access tube to provide a continuous sealed conduit therebetween.

For drilling operations, there is affixed to the exterior end of the upper section **20***c* of the access tube **20'** a riser assembly **21** of the type well known to the art which extends to a position just below the rotary table on the barge. The riser assembly **21** is connected to the access tube **20'** by suitable remotely connectible and disconnectible means such as a hydraulic connector **41**. This connector is of the type commonly employed and well known to the art which is connected to and disconnected from the access tube by hydraulic lines, mechanical means or electrical means (not shown). Above the connector is the blowout preventer stack also well known to the art but which is positioned at the ocean floor in the prior state of the art. Such

blowout preventer stack includes a plurality of blowout preventers **45** of the conventional type which include gates controlled by hydraulic lines (not shown) and adapted to close around the drill string as well as gates also operable by hydraulic lines adapted to close the surface casing completely when no working string is present within the conduit.

The riser tube **47** of the riser assembly is then connected to the uppermost blowout preventer and extended through the cellar of the drilling barge to a point below the rotary table which is mounted upon the barge above the cellar. The vessel carries the usual derrick and rotary table for driving a drill string and working in a well bore. The riser tube **47** includes a deflection joint to allow for horizontal movement of the vessel relative to the structure and a slip joint to allow for vertical movement of the vessel. Such deflection and slip joints are not shown in the figures but are again of the type well known to the art. Exemplary of the riser assembly **21** the conductor pipes **17** and the access tubes through the sphere is the fact that, in the presently preferred embodiment the bore through the access tubes is 34 inches. The conductor pipe **17** is connected to and extended from the structure by being landed in the lower section **20***a* of the access tube **20'**. The conductor pipe is landed and seated within the lower section of the access tube in the conventional manner by means of landing seats of the type well known to the art, the outside diameter of the conductor pipe being approximately equal to but slightly less than the inside diameter of access tube **20'**. The manner in which such conductor pipes are installed in the structure will be more apparent in connection with a description of the operation of a presently preferred embodiment of the invention as set out hereinafter.

Entry to the interior chamber of the structure can be had by any of the three means described hereinbefore, i.e., an entry tube, a diving bell or an air lock and hatch adapted for entry by a diver. In the presently preferred embodiment as shown in FIGS. 1, 2 and 3 and particularly in FIGS. 2 and 3, the preferred means for entry is by way of an entry tube **48**. The entry tube **48** is of substantial inside diameter sufficient to allow passage of men and equipment therethrough by means of ladders or cable elevators or the like. The entry tube extends upwardly from the structure through the cellar of the vessel and terminates with its upper end **49** above the water surface and at a conveniently accessible location relative to the ship's hull. As shown particularly in FIG. 3 in this embodiment, the lower end of the entry tube **48** is connected to the structure by means of a remotely disconnectible coupling. In the embodiment shown, a mechanical coupling is utilized. A female portion **51** of the coupling is connected to the working structure by means of welding or the like. The lower end of the entry tube then includes the portion **53** of a mechanical connector such as a J-slot connector which can be operated to connect and disconnect the entry tube from the structure by means of a partial turn of the tube. Such connector constructions are conventional and differ primarily in dimensions and proportions.

At the lower end of the entry tube **48** there is also provided a section **54** of increased transverse cross-section as compared to the cross sectional area of the tube **48**. In the embodiment shown the enlarged portion is in the form of a hemispherical dome and suitable sealing or gasketing means are provided between the peripheral edge **55** of the dome and the upper surface of the boss **52**. The boss is annular in configuration with a substantially conventional water-tight hatch **56** covering the opening through the boss and adapted to seal the sphere when the entry tube is not in place. Due to the increased transverse area of the enlarged portion **54** of the entry tube, a sealing pressure is exerted from the water pressure surrounding the sphere when the entry tube is pumped free of water as described hereinafter. When the entry tube is in position and a seal is effected the hatch **56** is opened and moved out of closing position to permit access to the working structure.

In order to more clearly illustrate some of the other structural aspects of the apparatus of the present invention and its manner of operation a typical operation utilizing the presently preferred embodiment of the apparatus as shown in FIGS. 1, 2 and 3 will now be described. After the well site has been selected the mooring cables **14** are preset by positioning and anchoring them into concrete from the vessel while they are suspended loosely from the vessel. The cables are arranged with their anchor points radially about the well site as discussed hereinbefore. By utilizing the ballasting capacity of the structure it is caused to have a slight negative buoyancy after it has been towed or otherwise moved to the well site. It is then lowered into position by suitable means, examples of which are discussed hereinafter in connection with FIGS. 4 and 5, until it is suspended at the desired depth beneath the drilling vessel. The anchor cables are then tensioned by means of the derrick on the vessel and connected to the anchor point **30** on the equator of the sphere. Ballast is then pumped from the sphere until it achieves the desired degree of positive buoyancy. At this point the spherical structure is held at the desired depth and stabilized location beneath the drilling vessel which has been positioned and anchored.

The entry tube **48** is then lowered by means of the derrick on the vessel and connected to the structure by means of the connector **51**. The locks and hatches between the interior of the structure and the entry tube or shaft **48** are still maintained closed. Water is then pumped from the entry tube assembly after which the locks and hatches may be opened and entry can be had to the interior of the structure through the entry shaft **48**. The subsea drilling and working structure **10** in combination with the drilling vessel B is then in a condition at which drilling and working operations can be commenced. It should be noted at this point that suitable equipment handling means such as the 360° variable radius boom, are positioned within the chamber for handling and moving the heavy equipment to be positioned therein. Conveniently the boom can be rotatably mounted upon an extension of the entry shaft connector.

In a typical drilling operation, one of the access tubes **20'** is completed through the sphere by positioning the through section **20***c* between the upper and lower access tube sections **20***a* and **20***b* respectively. The access tube **20'** then extends completely through the working chamber within the structure but is sealed therefrom. A conventional spudding string is then lowered from the drilling vessel and through the access tube **20'** to the earth beneath the working structure. Spudding operations are then carried out by rotating the drill until the required depth to which the conductor pipe **17** is to be set is reached. The conductor pipe is then lowered, typically by stripping over the drill string until the required length of conductor pipe has been lowered. The upper end of the conductor pipe **17** is then seated by means of a landing seat into the lower portion **20***a* of the access tube. At this point the conductor pipes extend into the well bore to the desired depth and cementing operations are carried out. Additional casing or surface pipe can be set in the conventional manner. With the conductor pipe **17** thus in position drilling operations with circulation can then be commenced by lowering and connecting the riser assembly to the upper end of the access tube **20** where it is hydraulically connected. It should be noted that during these operations the valves at each end of the access tube are, of course, open to provide a through-conduit through the structure. When the riser assembly has been positioned and connected between the vessel and the structure, drilling operations can be carried out in the usual manner.

When production of a well is obtained, production trees can be installed at the upper end of any conductor pipe by closing the lower valve **38***a* and then connecting a conventional production Christmas tree at the working deck **35** via an access tube to the upper end of the conductor pipe.

FIG. 4 shows an illustrative means by which the working structure may be submerged preparatory to being anchored to the ocean bottom. Referring to FIG. 4, there is shown the barge B, provided with a depending bracket or crane arm **24** carrying a bearing shaft on which a sheave **25** is mounted for rotation about a horizontal axis. The sheave has a yoke **26** affixed thereto for rotative movement therewith. The arms of the yoke straddle and are pivotally attached at diametrically opposed points as at **27**, to band **30** extending around the equator of the working structure **10**.

A hawser extends from a winch drum **31** on the ship over guide pulleys **32** and **33** at the upper and lower edges of the hull and is wound about and affixed to the sheave **25**. As the howser **34** is wound in on the drum **31**, the working structure **10** is caused to be submerged and is swung about the center of the axis of rotation of the sheave **25** until it is positioned directly beneath the center of the ship, the length of the yoke **26** being such as to achieve this movement. After being thus positioned, the working structure can be disengaged from the yoke arms and lowered into position at the desired level at the ship, for example, by taking up on the anchor lines **14**.

Referring now to FIG. 5, there is shown an alternative embodiment of the present invention in which conductor pipes **17** are affixed to the lower access tubes **20***a* of the structure prior to positioning of the structure. This can be done when the depth of the water is known and the distance above the subsea surface is predetermined. In this connection, there is also shown in FIG. 9 the embodiment of the structure illustrated in FIG. 5 after it has been placed and anchored to the ocean floor. Referring first to FIG. 5, the structure with the conductor pipes attached thereto can be towed to the site location with the equator band connected to the underside of the ship by means of lines **62** at the connecting points **31** of the sphere. The structure is then ballasted to have a slight negative buoyancy and allowed to sink and swing itself into position directly below the ship while supported by the lines **62** after which the mooring lines **14** can be attached and arranged in the manner previously described. In the embodiment as shown in FIGS. 5 and 9, the lower end of the conductor pipes is connected to a base plate **63** which is adapted to rest upon the ocean floor. In such an embodiment, the conductor pipes would be of a larger than normal diameter and of greater wall thickness since they would be adapted in such an embodiment to accommodate the passage therethrough of surface casing and also to provide additional safety support for the structure in case of flooding or any accidents which might occur to impair the water-tight integrity of the structure.

There is illustrated in FIG. 7 the fact that different types of working structures can be provided for various operations and utility. As shown in FIG. 7, the working structure **10** at the left of that figure is equipped for receiving production from one or more wells. The working structure **10** at the center of FIG. 7 is shown as being employed to house gas and oil separation means with means for returning the gas to the formation to prevent storage problems in connection with the gas. It should be understood that in a given situation it may be preferable to locate storage or separation means on a floating vessel, in a terminal in shallow water, or in a terminal ashore. The working structure **10** at the right of FIG. 7 is shown as still being employed for drilling operations after the previous two structures have been put into use as production or separation structures.

In FIG. 6 there is shown another alternative embodiment of the present invention illustrating the fact that a plurality of working decks can be positioned within the working structure, such decks being designated as **70** and **71**. Further in the embodiment as shown in FIG. 6 drilling equipment such as low pressure blowout preventers **72** are positioned within the structure rather than exteriorly thereof. There is also shown in connection with the embodiment of FIG. 6 the use of a diving bell **73** which can be lowered from the vessel into sealing engagement with the structure for access to the structure rather than by means of an entry shaft such as previously described in connection with the presently preferred embodiment of the invention.

In FIG. 8, there is illustrated another alternative embodiment of the present invention whereby additional buoyancy spheres can be attached to the primary working structure **10**, such auxiliary spheres being designated as **74** and **75** and being utilized to accomplish a greater degree of positive buoyancy for the structure to support greater loads thereon.

Although deep water applications of the present invention have been described as illustrative, shallow water or shallow production zone applications of the present invention are also feasible. For example, smaller working structures can be employed when an oil or gas production zone is anticipated or found at shallow well depth or water depth. A lesser number of access tubes and conductor pipes are then utilized in each structure to prevent the need of drilling or orienting the conductor pipes at large angles to the vertical.

In summary, the above system concept and working structure arrangement enables, in essence, the deep sea surface to be raised to levels readily susceptible for exploration but so located as to avoid ice, wind, and wave action. This concept gives rise to numerous substantial advantages such as (1) reducing incremental costs for drilling at greater depths; (2) eliminating permanent structures which present navigational hazards; (3) removing structures which are aesthetically undesirable; (4) permitting relocation of erroneously located structure; (5) enabling salvage of valuable equipment; (6) minimizing diving costs; and (7) standardization of equipment.

I claim:

1. Apparatus for drilling and working in the earth beneath a body of water comprising:

a submerged structure defining a working chamber therein and having a positive buoyancy;

means under tension connected to said structure and to the earth beneath a body of water for preventing said structure from substantially moving upward or horizontally and for maintaining said structure at a predetermined depth above the subsea floor but substantially below the wave and surface action of the water;

means for varying the buoyancy of said structure whereby additional weight added to said structure may be counteracted to thereby maintain said structure with said positive buoyancy;

passage means extending into said chamber for extension of a pipe from said chamber to a well in the subsea floor;

means for positioning wellhead equipment at said chamber, and

access means to said working chamber from the surface of said water.

2. The structure of claim **1**, wherein said tension means comprise cables.

3. The apparatus as defined in claim **1** in which a plurality of conductor pipes are extended from a plurality of well bores to said chamber in communication therewith.

4. The apparatus as defined by claim **1** in which said structure is moored at said predetermined depth to said subsea floor.

5. The apparatus as defined by claim **4** which also includes in combination therewith a floating vessel moored above said structure.

6. The apparatus as defined by claim **5** which also includes a conductor conduit extended from the vessel through the structure and to the subsea floor.

7. Apparatus for drilling and working in the earth beneath a body of water comprising:

a submerged structure defining a working chamber therein and having a positive bouyancy;

means under tension connected to said structure and to the earth beneath a body of water for preventing said structure from substantially moving upward or horizontally and for maintaining said structure at a depth above the subsea floor but substantially below the wave and surface of the water;

means for varying the bouyancy of said structure whereby additional weight added to said structure may be counteracted to thereby maintain said structure with said positive bouyancy;

a first plurality of access openings through the lower surface of said structure;

means for closing said openings to entrance of liquid through said openings;

a second plurality of access openings through the upper surface of said structure in alignment with said first plurality;

means for closing said second openings to the entrance of liquid to said chamber; and

means adapted to connect a conductor conduit from a respective one of said first openings to a well bore in the subsea floor.

8. The structure of claim 7, wherein said tension means comprise cables.

9. The subsea drilling and working apparatus as defined in claim 7 in which each of said first plurality to openings is adapted to be connected to wellhead equipment positioned within said chamber in communication with a respective one of said well bores through one of said conductor conduits.

10. The subsea drilling and working apparatus as defined in claim 9 which includes in combination therewith a floating drilling vessel positioned at the water surface above said structure, a riser assembly extending from said vessel and in communication with one of said first openings through wellhead equipment including at least one blowout preventer positioned exteriorly of said structure adjacent said opening, and a drilling conduit within said structure connected between said respective first and second openings in communication with said riser system and said conductor pipe.

11. The apparatus as defined in claim 10 in which a plurality of conductor pipes are extended from a plurality of well bores to said chamber in communication therewith.

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