

May 10, 1960

D. P. THOMPSON ET AL
OFFSHORE DRILLING PLATFORM

2,935,854

Filed June 21, 1954

5 Sheets-Sheet 1

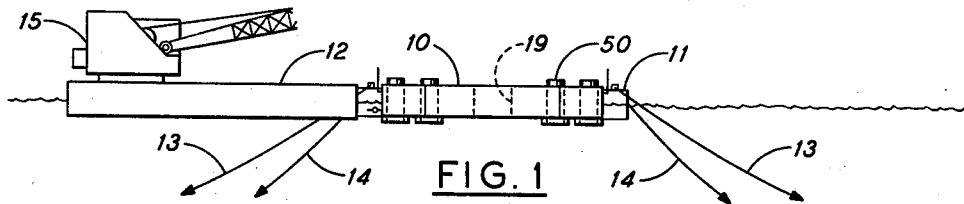


FIG. 1

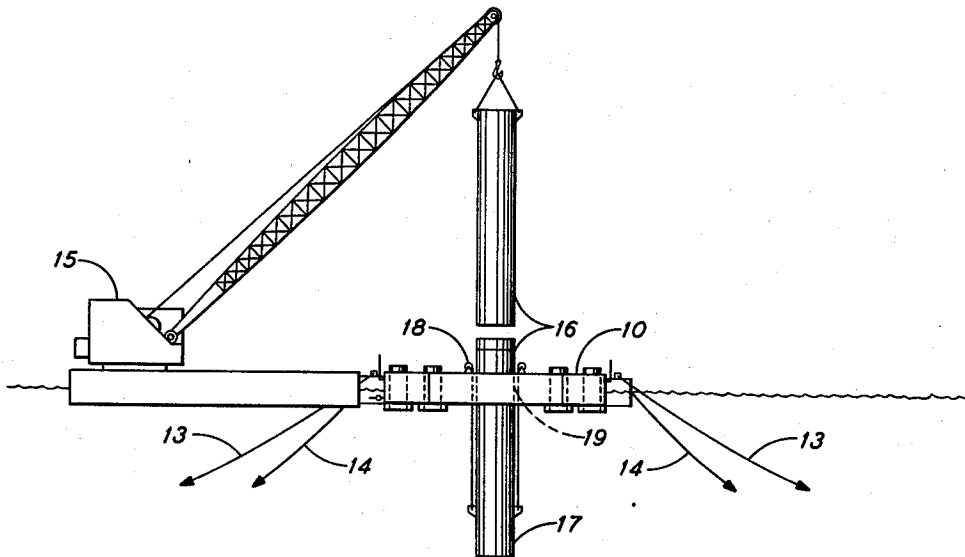


FIG. 2

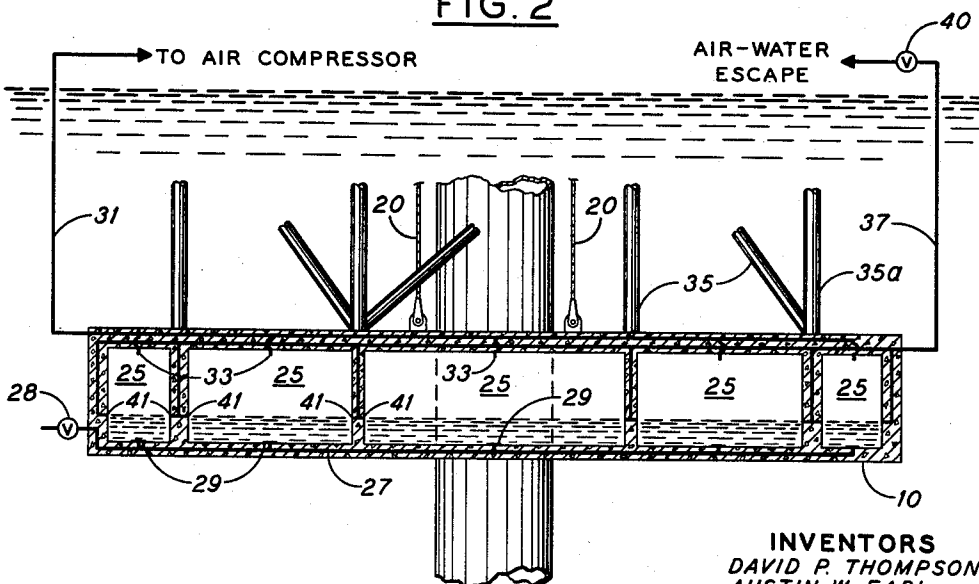


FIG. 5

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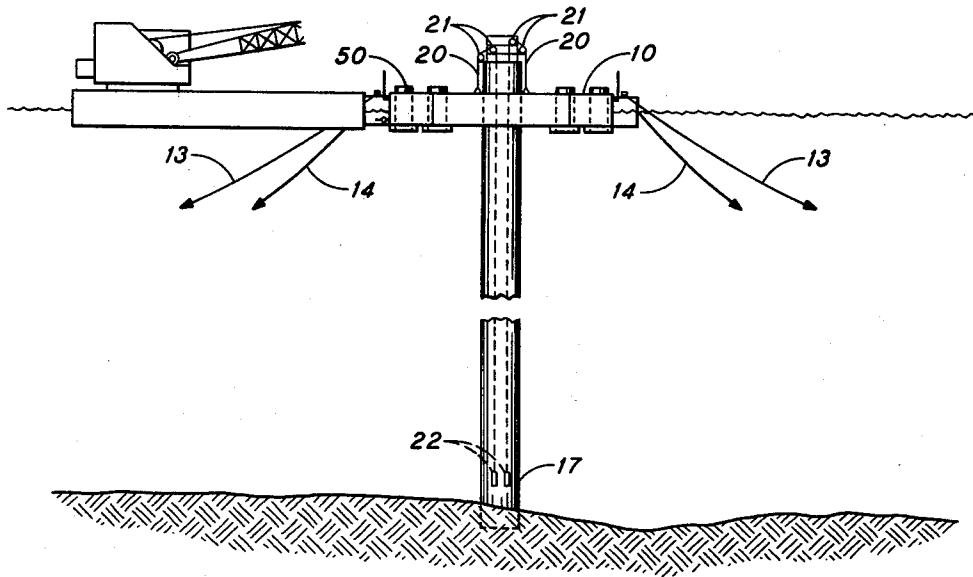


FIG. 3

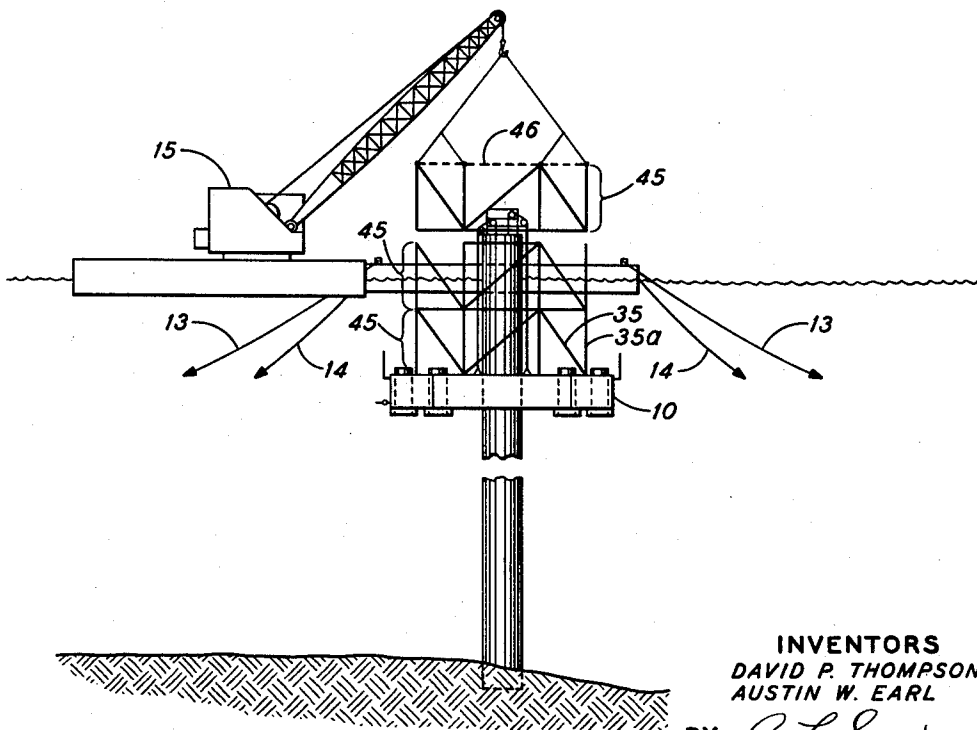


FIG. 4

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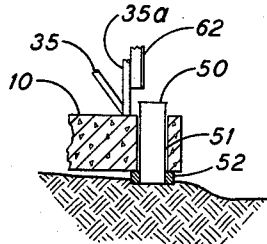
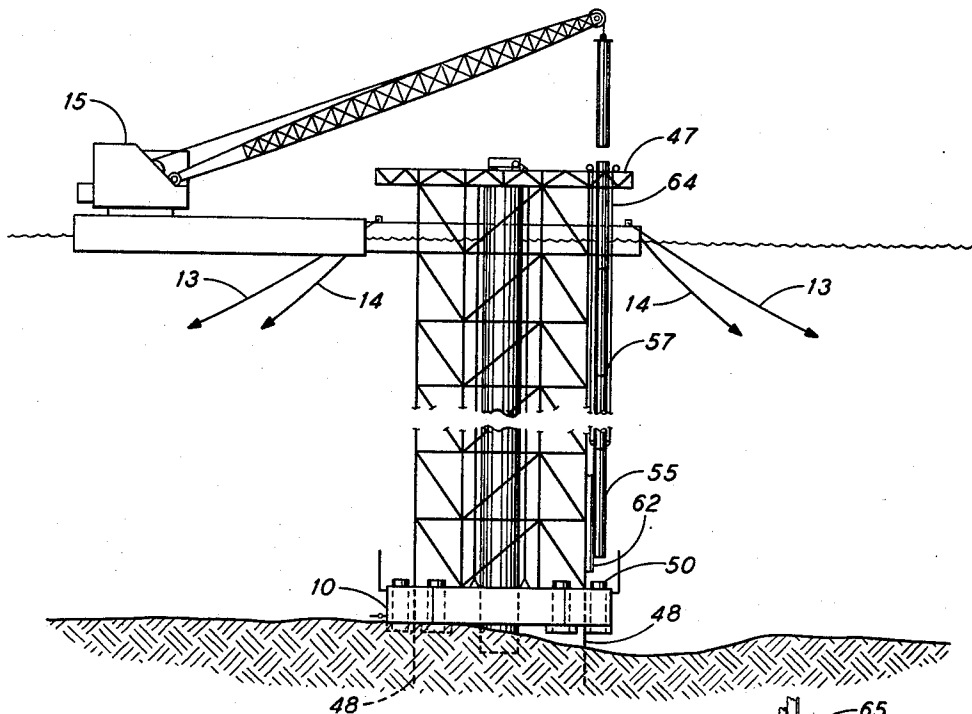


FIG. 7

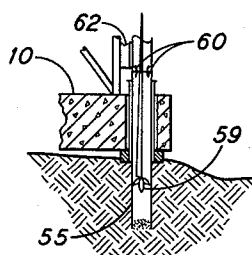


FIG. 9

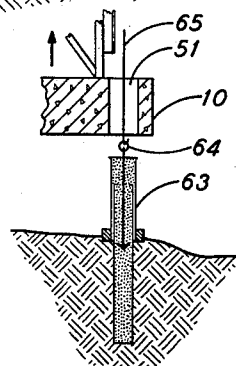


FIG. 11

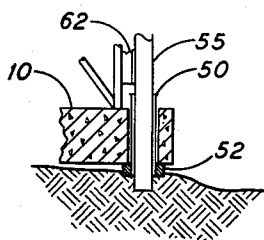


FIG. 8

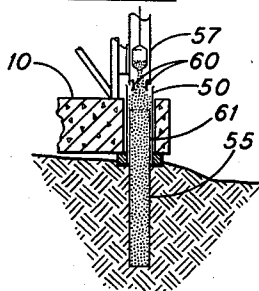


FIG. 10

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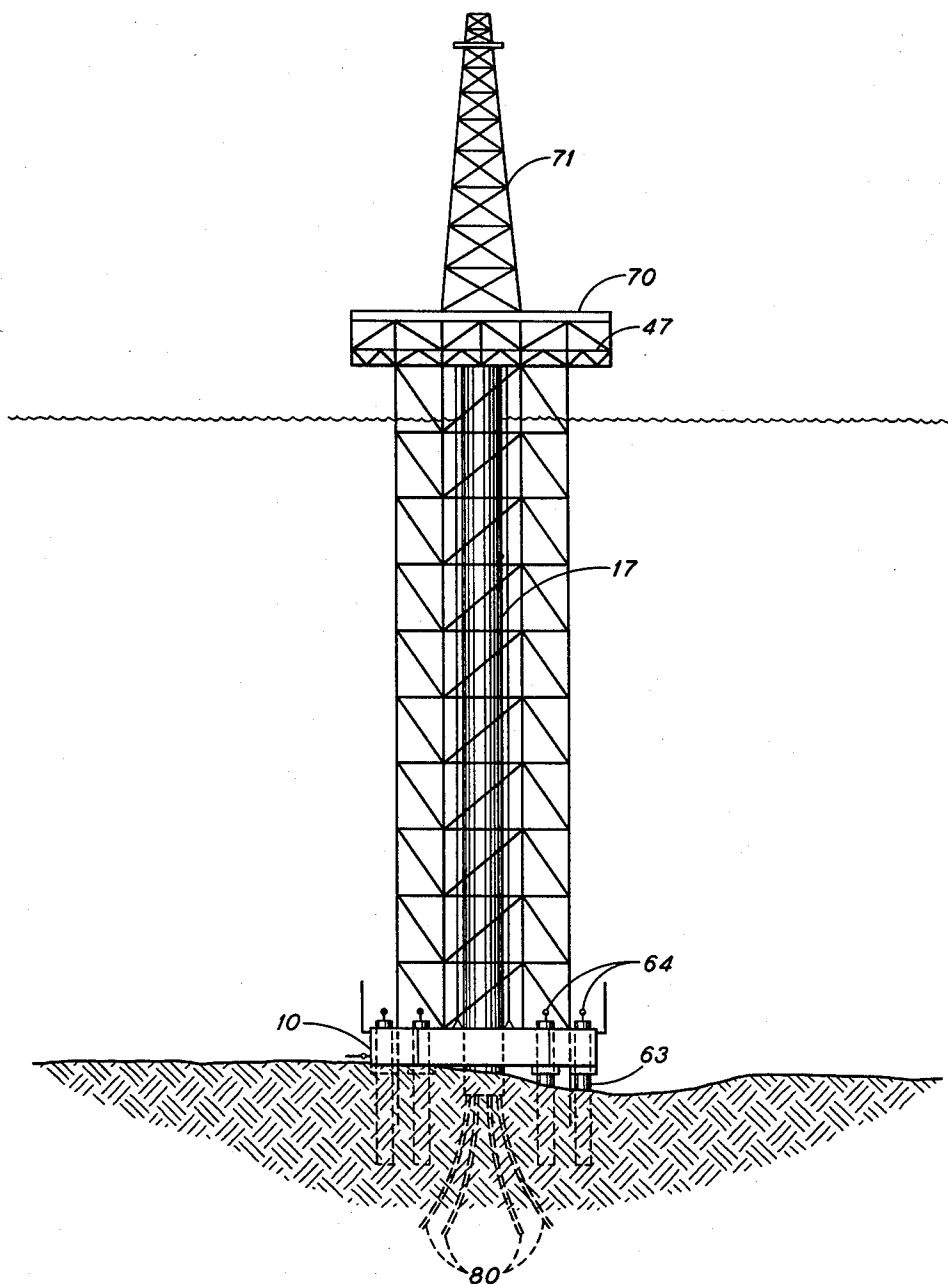


FIG. 12

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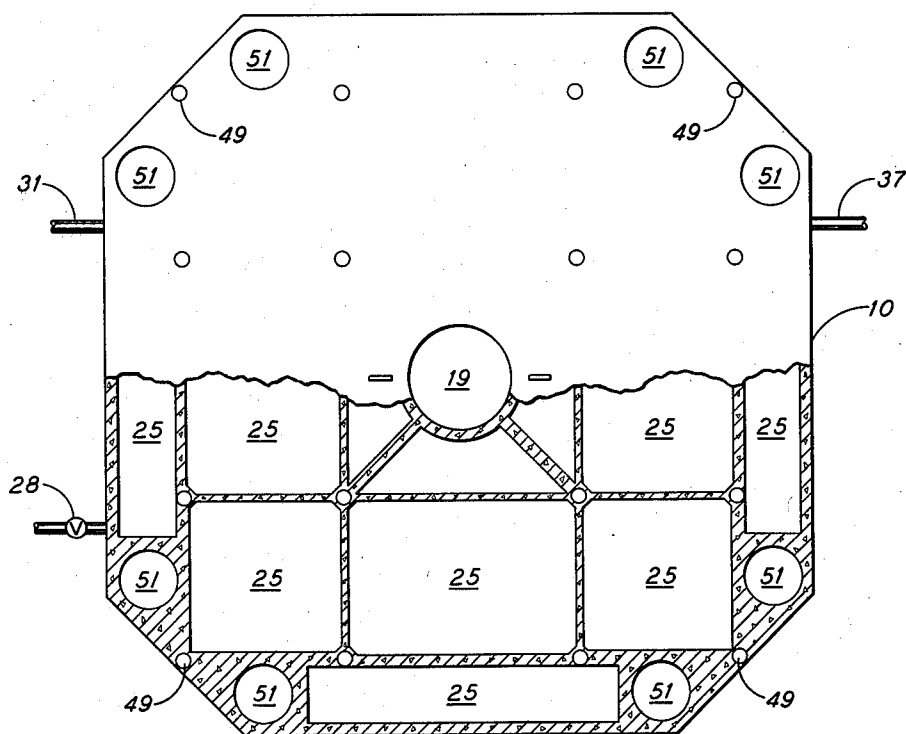


FIG. 13

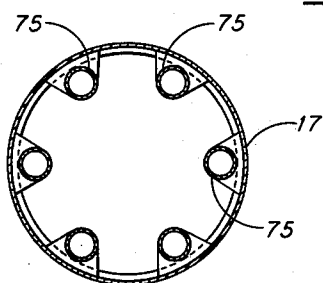


FIG. 14

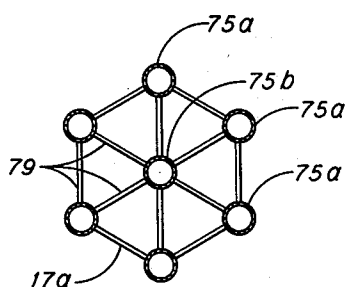


FIG. 15

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OFFSHORE DRILLING PLATFORM

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Application June 21, 1954, Serial No. 438,132

1 Claim. (Cl. 61—46)

The present invention relates to working platforms establishable above a body of water, more specifically to methods of and apparatus for establishing such work platforms over a body of water, and has for an object the establishment of a working platform which may be used for drilling oil and gas wells along the Continental Shelf where water depths of up to about 500 feet may be encountered, the structure being arranged for assembly and disassembly at the drilling site by control of the buoyancy and stability of the assembled structure throughout either the assembly or disassembly steps by regulation of the water level within a foundation pontoon and support of the structure during assembly from the top of a guide caisson initially contacting the bottom, and along which said structure is lowered, said pontoon being adapted to engage the underwater bottom directly or through load-bearing caissons permanently connected to the underwater bottom, but from which the foundation pontoon may be raised.

While it has been proposed heretofore to construct offshore drilling platforms, which may be assembled and disassembled over an underwater drilling site, such structures have been primarily designed for relatively shallow bodies of water, such as those encountered in inland lakes or rivers, or along the near-shore portion of the Gulf of Mexico. In these locations, the depth of water does not ordinarily exceed about 50 to 100 feet. Unfortunately, the use of such structures is not applicable at locations where the depths of water extend from 100 to 500 feet, as encountered in the Continental Shelf along the Pacific coast.

The problem of establishing a movable structure at such depth is particularly important where the ocean bottom slopes sharply away from the coast line, and where underwater drilling sites only a few miles off the coast lie beneath a few hundred feet of water. Because the probability of failure in exploratory drilling at such underwater sites is greater than the probability of success, it is highly desirable to be able to move the working platform when unsuccessful exploratory drilling has been completed, rather than to build and abandon a still useful structure. Drilling at such sites is necessarily exploratory; that is to say, the earth's surface below the water has not been sufficiently penetrated to determine the commercial availability of oil or gas. Economical justification of a program to discover petroleum at such underwater drilling sites frequently depends upon the ability to move and re-use, at a number of exploratory sites, the structure supporting a working platform, wherein the said platform and supporting structure may cost in the range of one to three million dollars. Contributing heavily to the high cost of an offshore drilling structure is the great expense involved in the labor and marine construction equipment necessary to build such an installation. Therefore, the ease with which a structure and platform can be erected or disassembled at a deep water drill site may represent a very great financial gain. The shorter the time involved in erecting or dismantling a platform and

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structure the less is the chance of losing valuable and expensive construction time due to the unpredictable action of weather and waves.

In accordance with the present invention, a method of establishing an underwater drilling platform above a body of water is provided wherein the component parts are so arranged that the structure can be readily assembled and disassembled and is stable throughout its assembly and disassembly. To this end, there is provided a foundation pontoon, adapted to be floated to the drilling site, said pontoon having a central opening through which a guide caisson is passed to the underwater bottom and anchored thereto. The pontoon is then arranged to be supported from the upper end of the guide caisson, such as by a plurality of lines and winches, and the buoyancy of said pontoon decreased by admitting water to a plurality of buoyancy chambers therein. A plurality of buoyant and permanently-sealed framework assemblies are then erected on said foundation pontoon sequentially, coincident with gradual lowering of the work platform support structure which is effected by the winches and lines from the upper end of the guide caisson. The weight of the submerged foundation pontoon is controlled as each buoyant framework assembly is added by maintenance of the water level in the pontoon's buoyancy chambers at substantially a constant value by supplying compressed air to said buoyancy chambers. The structure is maintained stable during assembly by virtue of the center of gravity of the component parts being held below the center of buoyancy of the component parts, and by virtue of the overturning moment resistance offered by the guide caisson. The buoyant framework assemblies are then added until the entire structure extends to a position such that a drilling, or work platform may be mounted at a predetermined height above the water level. When the foundation pontoon engages underwater bottom, and erection is completed, the buoyancy chambers are permitted to flood by release of compressed air from said chambers.

In accordance with another aspect of the present invention, there is provided a method of supporting the foundation pontoon on bottom through a plurality of caisson-receiving openings formed around the periphery of the foundation pontoon. In carrying out the invention, there is inserted into each of the openings a sleeve member having a collar-like bearing surface through which load may be transferred from the bottom of the foundation pontoon to a foundation caisson embedded in the underwater bottom. In the preferred method of establishing these load-carrying caissons on bottom, a caisson tubing is guided through each of said sleeve members on a caisson follower which extends upwardly through the water's surface, after the foundation pontoon has been landed on bottom. Said caisson tubing is forced downwardly into the underwater bottom by driving or excavating with suitable earth-moving means until the lower end of the caisson tubing engages a suitable depth of earth stratum capable of supporting the necessary weight, and also until the upper end of the caisson tubing is a suitable distance below the top of the sleeve member. After the foundation caisson has been constructed to its final depth, the lower end of the caisson follower is disengaged from the upper end of the caisson tubing and retracted to the top of the sleeve member. Concrete or similar binding and load-carrying material is then added to the interior of the caisson tubing until both the caisson and the sleeve are filled, including the annular space between the caisson and the load-supporting sleeve.

Disassembly of the entire structure after the completion of unsuccessful exploratory drilling operations from the work platform may be accomplished through successive removal of the work platform and the framework

assemblies. By introducing compressed air into the buoyancy chambers of the foundation pontoon at a pressure sufficient to displace a predetermined amount of water, the buoyancy of the entire structure is increased, thereby permitting the plurality of lines and winches at the upper end of the guide caisson to raise the remaining framework assemblies and the foundation pontoon. The arrangement of the foundation caissons is such that the foundation pontoon may be lifted directly off the individual foundation caissons, which are themselves permitted to remain at the original underwater drilling site.

Further objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, which form an integral part of the present specification.

In the drawings:

Fig. 1 is a schematic representation of the positioning of a foundation pontoon constructed in accordance with the invention after being floated to a drilling site.

Fig. 2 is a schematic representation of the method of passing the guide caisson through the foundation pontoon, ultimately extending said guide caisson to the underwater bottom.

Fig. 3 is a schematic representation showing the guide caisson extended to the underwater bottom with the foundation pontoon arranged to be supported from the upper end of said guide caisson.

Fig. 4 is a schematic representation of the method of adding each buoyant framework assembly to the other buoyant framework assemblies already assembled on the foundation pontoon.

Fig. 5 is a cross-sectional view particularly illustrating the interior construction of the foundation pontoon, including the various conduits used in controlling the buoyancy thereof, while the framework assemblies are being positioned sequentially on the pontoon.

Fig. 6 is a schematic representation, illustrating the method of introducing and guiding a foundation caisson tubing by means of a caisson follower, through a load-transmitting sleeve member in the foundation pontoon, after the structure has been extended to the underwater bottom with a working platform first erected above the water's surface.

Figs. 7, 8, 9 and 10 are schematic representations of the successive steps of installing and constructing a foundation caisson in the underwater bottom.

Fig. 11 is a schematic representation of the manner in which the foundation pontoon may be raised from a load-carrying caisson during disassembly of the entire structure.

Fig. 12 is a schematic representation of the completed offshore drilling structure and work platform with a derrick positioned thereon for drilling a plurality of wells.

Fig. 13 is a combination plan and cross-sectional view of a preferred form of the foundation pontoon, particularly illustrating the various openings for the central guide caisson and the peripherally-located foundation caissons.

Fig. 14 is a cross-sectional view of a preferred form of the guide caisson, illustrated in the foregoing figures, and particularly illustrating the several drilling positions available at the work platform.

Fig. 15 is a cross-sectional view of an alternative arrangement for a guide caisson, which will allow a plurality of well bores to be drilled through the vertical tubular members thereof, and which may be substituted for the guide caisson illustrated in Fig. 14.

Referring now to the drawings, it will be observed that the various figure numbers have been arranged numerically to particularly illustrate the sequence of steps involved in the erection of an underwater drilling platform above a body of water. As will be described hereinafter, the disassembly of the platform for movement to a subsequent drilling site will be substantially in the reverse

order; i.e., with the steps following the decreasing order of figure numbers.

As an initial step contemplated by the method of the present invention, a foundation pontoon 10 constructed of reinforced concrete or steel is adapted to be towed, while floating, from its construction site to a drilling site. Pontoon 10 is then positioned and stabilized over the desired drilling site by a plurality of stabilizing pontoons or barges, two of which have been illustrated and designated as 11 (behind pontoon 10) and 12. Anchor pontoons, such as 11, are desirably held in position by anchor lines, such as those indicated as 13 and 14. One of the anchor barges, such as 12, may be used as a support for an erection crane, indicated generally as 15.

After spotting of foundation pontoon 10 at the desired location, a guide caisson member 17, including a plurality of segments 16, is introduced through a central opening 19 in pontoon 10 and lowered, step by step, as the segments are assembled, in the manner suggested in Fig. 2. Desirably, a lowering winch arrangement 18, manually or engine operated, is provided adjacent to opening 19 for supporting caisson assembly 17 as it is lowered through pontoon 10. In this way, the lowering of guide caisson 17 may be controlled directly from foundation pontoon 10, independently of crane 15.

Caisson 17 is thus progressively lowered until the lower end engages the underwater bottom, as particularly shown in Fig. 3. The lower end of the caisson 17 is then desirably forced into the underwater bottom by jetting or excavating the unconsolidated ground directly under the caisson. In some instances, it may be desirable to add concrete in the lower end of caisson 17 to assure a firm connection between the underwater bottom and the caisson, but in other foundation strata it may be unnecessary to do so.

As further illustrated in Fig. 3, guide caisson 17 is then arranged to support from its upper end the foundation pontoon, as well as the super-structure which is to be built thereon, through a winch and weight counter-balancing system. This arrangement includes a pair of cables 20, secured to the upper portion of pontoon 10 adjacent opening 19, a pair of manual or engine operated winches 21, and weights 22 secured to the opposite ends of cable 20. Each of the pair of cables 20 is preferably reeved in a manner to reduce the work required of the winches 21. After foundation pontoon 10 has been thus supported from the upper end of guide caisson 17, the buoyancy tanks or chambers 25 (best seen in Figs. 5 and 13) within pontoon 10 are partially flooded so that the buoyancy of the pontoon assembly becomes slightly negative.

To assist in the explanation of the manner in which the entire structure is maintained in a balanced and stable condition during its erection or disassembly, a brief description of the internal construction of the foundation pontoon 10 will be particularly helpful at this time.

In accordance with the present invention, pontoon 10 is desirably formed of concrete so that pontoon 10 is both corrosion-resistant and of sufficient weight when in final position and flooded to resist the unbalanced overturning movements due to wind, waves or earthquake forces without exerting uplift forces on the foundation caissons. Because of the great weight of the pontoon when flooded, the buoyancy of the pontoon during assembly is carefully controlled by a particular arrangement of conduits for admitting and releasing fluids to and from buoyancy tanks 25 to prevent excessive loads from being exerted on the guide caisson 17, the cables 20, and the winches 21. The cross-sectional view of pontoon 10 shown in Fig. 5 particularly illustrates this combination of conduits. As there shown, the interior of foundation pontoon 10 comprises a plurality of integrally formed or cast buoyancy tanks, identified as 25. Each of these buoyancy tanks is connected in common with each other through three systems of conduits which control the water level, control the counter-balancing air pressure within

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the tanks, and measure the pressure or water level in the tanks. The first of these three systems of conduits is identified as conduit means 27, which is adapted to admit water to the bottom of each of the buoyancy tanks 25 through at least one sea valve 28. As shown, all of the bottom openings 29 in chambers 25 are connected in common to conduit 27. The second conduit system is arranged to be connected to an air compressor through conduit means 31, so that compressed air may be supplied through openings 33 in the top of each buoyancy chamber 25. The purpose of supplying compressed air to chambers 25 in the present arrangement is to permit a portion of each chamber to remain unfilled with water but yet prevent the hydrostatic head of water from collapsing the pontoon structure when the pontoon is at any depth. By controlling the air pressure within tank 25 to counterbalance the hydrostatic head outside of the pontoon, it is possible to construct pontoon 10 economically of reinforced concrete and thereby obtain the advantages mentioned above. With proper weight considerations, the pontoon may also be constructed of steel.

Control of buoyancy of the structure during assembly on the pontoon, as contemplated by the present invention, is contributed to, in part, by the structural elements 35, partially illustrated in Fig. 5, which are sealed at their ends so that each framework assembly 45 is buoyant. The framework assemblies 45, each having a center portion adapted to engage closely and slidably guide caisson 17, are then super-imposed, one above the other, on pontoon 10. However, an important part of the buoyancy control is provided by adjustment of air pressure in tanks 25 to maintain the depth of water therein at a desired level as the buoyant framework assemblies 45 are added to pontoon 10. In the arrangement shown in Fig. 5, this control is provided by the signal conduit means 37, which serves as an air-water escape line. The openings to line 37 in buoyancy chambers 25 are positioned at a predeterminable level so that the total weight of water in all of the buoyancy tanks, together with the weight of the foundation pontoon 10, may be maintained just slightly greater than, or equal to, the neutral buoyancy of the foundation pontoon 10 when submerged.

By control of valve 40 in air-water escape line 37, there is then provided a visible or audible signal as to the maintenance of this desired water level. Hence, the buoyancy of the structure during erection of a plurality of buoyant framework assemblies, of which elements 35 are a portion, will be indicated by the return of either air or water, depending on the location of the water level within tanks 25. When the water level is at its proper height, there will be a flow of compressed air through ports 41 in chambers 25, through conduit means 37 exhausting through valve 40, which may either be visually indicated or audibly detected. When the water level rises above ports 41 in tanks 25, water will be forced to rise to the surface and block the return of air.

From the foregoing description of the method of maintaining control of the buoyancy of the structure during assembly or disassembly, it will be understood that the framework assembly, such as the one being lowered by crane 15 and identified as 45 in Fig. 4, are prefabricated of tubular members 35 and 35A so that they may be placed sequentially and secured one above the other in the assembly process. The members 35 and 35A may be braced by temporary cross-members 46 during such assembly. As mentioned above, each of framework assemblies 45 is constructed with the majority of the individual structural members 35 sealed, so that the elements themselves have a positive buoyancy and give to framework assembly 45 a positive buoyancy. When combined with pontoon 10, the partially-completed structure is preferably arranged to have a neutral or a slightly negative buoyancy. Final control of the assembly is carefully balanced and regulated so that the unbalanced downward load is counterbalanced by the cables 20, winches

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21 and weights 22 acting through the top of guide caisson 17, as shown in Fig. 3. The vertical segments in adjacent assemblies are preferably bolted together (not shown) so that they may be readily assembled or disassembled. Some of the vertical columns 35A of the framework assemblies may be so arranged on the foundation pontoon 10 to permit drilling of wells therethrough, as will be described hereinafter.

Super-positioning of the plurality of the framework assemblies is then continued until the foundation pontoon rests on bottom, and the remainder of the structure extends through the body of water to provide an upwardly-extending section upon which is mounted first a work platform 47. This arrangement is particularly illustrated in Fig. 6. At this point in the construction of the platform, the entire structure is leveled if necessary by the insertion of jacking piles 48 through openings 49. By means of these jacking piles, the pontoon may be raised or lowered to plumb the structure prior to the insertion of the foundation-support caissons through openings 51 in pontoon 10. In certain cases, where the underwater bottom is sufficiently consolidated and leveled, it is possible for the foundation pontoon to serve alone as the load-supporting member for the entire structure including drilling platform 70, the derrick 71 and the weight of drill pipe, mud and other equipment and materials necessary for the drilling of a deep well.

In accordance with another aspect of the present invention, where the underwater bottom is unconsolidated, a unique method is provided for supporting foundation pontoon 10 on a plurality of foundation caissons. The construction of these foundation caissons is particularly illustrated, both as to their method of construction and their completed structures, in Figs. 7 to 11, inclusive.

In accordance with the present invention, a sleeve member designated as 50, is inserted and temporarily secured within foundation-caisson-receiving openings 51 in foundation pontoon 10. Sleeve member 50 desirably extends through openings 51 with the lower end thereof having a support collar 52 through which the load of foundation pontoon 10 may be transferred to sleeve 50. While not illustrated in detail, the sleeve 50 as mentioned above is temporarily supported by the upper end of pontoon 10 within the opening 51, for example by a remotely-removable pin through sleeve 50, during the time the pontoon is being lowered to bottom. Alternatively, collar 52 may be provided with a buoyancy chamber to support sleeve member 50 against the bottom of pontoon 10. The construction of sleeve 50 and its position within openings 51 is particularly illustrated in Fig. 7.

As shown in Figs. 6 and 8, a caisson pipe 55 is adapted to be inserted through sleeve 50 and the lower end brought into engagement with the underwater bottom directly below collar 52. Caisson 55, as further shown in Fig. 6, is desirably lowered into the positions shown in Figs. 8, 9 and 10 by a caisson follower, designated as 57, which extends from the top of caisson tubing 55 to a position well above the water's surface. Guide rails, designated as 62, direct the caisson follower 57 and the caisson tubing 55 to pass through the sleeves 50. Caisson tubing 55 and follower 57 may be assembled in sections, as shown in Fig. 6, with the follower being supported by winches through lines 64. Thus, the caisson and caisson follower may be used as a guide tubing for the further construction of the foundation caisson.

As schematically represented in Fig. 9, the interior of caisson tubing 55 is excavated by any suitable means, such as by dredging with orange-peel bucket 59. Alternatively, the interior of the caisson 55 may be jetted or driven into the bottom and the excess soil material within the caisson tubing 55 removed hydraulically or by bucket excavators. After caisson tubing 55 has attained a depth sufficient to insure adequate bearing strengths in the soil, caisson follower 57 is disengaged from caisson tubing 55, for example by release of a plurality of pivoted

hooks 60 schematically indicated in Fig. 9, which are used temporarily to hold caisson 55 on follower 57.

As indicated in Fig. 10, the caisson shell 55 is desirably terminated at its upper end within the length of sleeve 50 so that a bond may be effected between sleeve 50 and caisson shell 55 by the introduction of sealing material, such as grout or concrete, which is added to fill not only the length of caisson 55 but also to extend upwardly into the upper portion of sleeve 50. The filling of sleeve 50 is then continued until the annular space indicated as 61, between sleeve 50 and caisson 55, is also full of the sealing material. Thus, there is provided a bond between the outer surface of caisson 55 and the inner portion of sleeve 50. Reinforcing steel cages (not shown) may be formed within the caisson, if desired, to increase the load-carrying capacity thereof.

Anchor eyes 64 may be forced into the caisson concrete before it has set, to which tie rods 65 extending to the surface, may be attached as shown in Fig. 11 to control the ascent of the pontoon during disassembly.

With the caisson constructed in accordance with Figs. 7 to 10, inclusive, there is obtained a complete foundation caisson identified as 63 in Fig. 11. Fig. 11 also has been used to indicate that the foundation caissons are intended to be left at the original drilling site when the foundation pontoon 10 is raised during disassembly of the drilling structure. Thus, it will be seen that caissons 63 provide foundation supports for the entire drilling structure which may be intimately incorporated in the underwater bottom to provide adequate bearing support for the drilling structure, but which do not require that the drilling structure be permanently secured to the foundation bed. Accordingly, it will be seen that the foundation caisson structure is an important feature in the provision of a portable drilling structure of the type contemplated for use in relatively deep water.

Fig. 12 shows the completed drilling structure with the foundation caissons 63 in a completed state for supporting the foundation pontoon 10 on bottom. As contemplated in the present invention, a drilling platform 70 is adapted to support a derrick 71 directly thereon, which is positioned above the work platform 47 at a sufficient height to prevent waves, even under storm conditions, from sweeping over the top of the drilling deck.

Fig. 14 particularly illustrates the preferred inner construction of cylindrical caisson 17, shown in Figs. 1 to 12. As seen in Fig. 14, a plurality of stiffener pipes 75 are arranged around the outer periphery of caisson 17 and extend throughout the length thereof. Conduits 75 are useful, not only as stiffening members for the column, but also as guides through which individual well bores may be drilled into the underwater bottom. The arrangement is particularly useful where a number of wells are to be drilled from the platform and deflected outwardly in the manner indicated by bores 80 in Fig. 12.

While guide caisson 17 has been illustrated in Figs. 1 to 12, inclusive, as a substantially cylindrical member, this member may be formed from a plurality of spaced tubes of smaller diameter, and interconnected to form a braced, open-framed column. Fig. 15 illustrates such an arrangement wherein a hexagonal pattern of guide columns 75A may be suitably welded together in a structural framework pattern by cross-braces 79. Preferably, each of the six outer guide columns 75A is welded to a central guide column 75B to form the completed guide caisson 17A. With the arrangement of Fig. 15 being utilized as a guide column, opening 19, through the central portion of foundation pontoon 10, may be suitably modified to engage closely the outer circumference of guide caisson 17A. Other configurations, such as rectangular, square or other polygonal arrangements of the vertical caisson members, may also be used.

Among the modifications which may be made in the apparatus and the method of constructing the drilling platform, it will be appreciated that control of the weight

of the foundation pontoon 10 and the buoyant framework assemblies 45 may be modified by the provision of additional level-controlling means in the buoyancy tanks 25 of pontoon 10. This control may be provided by the addition of conduits in the buoyancy chambers 25 at different levels and suitable valve means for controlling the flow of water into and out of the tanks. Thus, the level or depth of water in the buoyancy tanks may be controlled, if desired, so that the framework assemblies effectively control the depth at which the structure floats in the water.

Disassembly of the completed drilling structure, for removal to another drilling site, as mentioned above, will in general be in the reverse sequence of steps to those specified for its construction. However, where oceanographic conditions permit, pontoon 10 with one or more of the framework assemblies mounted thereon may be moved as a body to the new location. Likewise, in the initial establishment of the structure, a sub-assembly of the complete structure may be made on land or near shore and then towed to the desired location.

When drilling has been successfully completed into a petroleum-bearing formation from the drilling structure, the pontoon, which may have overall dimensions on the order of 100 feet by 100 feet and a height of 15 or 20 feet, may be used as storage tankage for the crude petroleum, by displacement of ballast water from buoyancy tanks 25.

While various modifications and changes in the method of constructing or disassembling the underwater drilling platform at its original location, as well as in the exact construction of the various units comprising that structure, will occur to those skilled in the art, all such modifications and changes which fall within the scope of the appended claim are intended to be included therein.

We claim:

The method of establishing an underwater drilling platform in a body of water which comprises the steps of floating a buoyant foundation pontoon to the underwater drilling site, stabilizing said foundation pontoon on the surface of the water by a plurality of anchor barges laterally disposed with respect to said pontoon, lowering a guide caisson through a central portion of said foundation pontoon into engagement with the underwater bottom, anchoring said guide caisson on the underwater bottom in a substantially vertical position, supporting said pontoon from the upper end of said guide caisson, decreasing the buoyancy of said foundation pontoon by admitting water to said pontoon so that the effective weight of said pontoon is substantially supported by said guide caisson, sequentially erecting on said foundation pontoon a plurality of buoyant framework assemblies, controlling the water level in said foundation pontoon to substantially a constant elevation relative to the bottom of said pontoon by supplying compressed air to the buoyancy chambers of said pontoon as each of said framework assemblies is added and secured to said structure and lowered along said guide caisson, sequentially lowering along said guide caisson said foundation pontoon and the said sequentially erected buoyant framework assemblies comprising the structure until said structure extends from a point above the water's surface to a position such that said foundation pontoon engages the underwater bottom, and erecting a drilling platform on the uppermost framework assembly.

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