ABSTRACT OF THE DISCLOSURE

This specification discloses a marine structure, designed to serve primarily as an offshore drilling platform, comprising a submerged bottom-supported lower portion, an upper portion supported above the surface of the body of water over the lower portion, and an extendable interconnecting portion buoyantly supporting the upper portion above the surface of the body of water and connected by the bottom-supported lower portion. The bottom-supported lower portion of the marine structure is assembled at the site from prefabricated vertical sections while the upper portion, prior to installation, functions as a derrick barge for installing the vertical sections of the lower portion.

This invention relates to a versatile marine structure for drilling or working over exploratory and production wells in subaqueous formations of the continental shelves. More particularly, the invention relates to the design of a bottom-supported platform structure, comprising prefabricated sections which can be assembled at an offshore site so that the marine structure can be utilized over a wide variation of water depths.

Exploration and production efforts in the oil and gas industry are being extended to remote offshore areas through the world as the more accessible and desirable acreage is leased. In the present day, it is necessary to tap hydrocarbon deposits beneath the continental shelves, leases have been obtained in such remote offshore areas as the West Coast of Africa and the coasts of Australia. A single lease may contain areas in which the water depth varies over several hundred feet and a varying incline of the marine bottom or the size of the lease in remote areas. In some of the largely untested remote areas, leases may be obtained for only $100 or $200 an acre, resulting in the obtaining of very large tracts covering a range of three to four hundred feet or more in depth. In water from thirty-five to three hundred feet in depth, the bottom-supported platform has found success. In water over three hundred feet, the floating drilling vessel is usually utilized, due to the almost exponentially rising costs of a bottom-supported platform as the water depth increases.

While floating drilling vessels have the advantage of maximum mobility, they are not as suitable as bottom-supported structures in areas subject to frequent violent storms. Of the more stable bottom-supported structures, the jack-up type of platform is comparatively expensive relative to the template type; but due to range of water depths over which a single jack-up platform can operate, and the relative ease of moving the jack-up platform to a new location, this type of structure is desirable. To date, drilling templates have been built for specific water depths, give or take a few feet, since they are not adaptable for use at, say, fifty feet more or less than the design depth. Furthermore, a jack-up is generally a self-elevating unit and does not require the use of a derrick barge to set it in place at the drilling site. Derrick barges are necessary with prior art templates to at least place the superstructure, including the drilling deck, on the template, once it has been erected on location. The drilling rig and the necessary auxiliary equipment must also be lifted onto the superstructure before drilling can proceed.

Since most of the major oil companies do not own their own drilling platforms and rigs, and must rent them at a per diem rate of, for example, for a deep water jack-up or a self-contained floating transparent platform, as high as $8500 at this time, it is obviously advantageous to keep any marine drilling structure which is under contract in use at all times. Furthermore, it is a practice in this competitive industry to obtain the services of these marine structures far in advance, by contracts extending for several years, and therefore it is not usually possible to rent a marine drilling platform on short notice or over a short indeterminate duration. During a drilling program, particularly at a remote lease, a specific platform may remain idle for days because of its unadaptability to the water depth at which drilling is being conducted at the moment. At the above-cited per diem rates, any unproductive time at the drilling site becomes an important economic consideration.

Accordingly, it is an object of the present invention to provide a marine bottom-supported platform structure which can be used for drilling and maintaining subaqueous wells over the wide range of water depths of the continental shelves.

It is another object of the invention to provide a marine drilling structure combining the attributes of a jack-up platform and a drilling template. It is a further object of the invention to provide a marine drilling structure which can utilize the drilling platform thereof as a derrick barge for setting the supporting portions of the structure and which can be elevated out of the water atop the supporting portions without a supplementary derrick barge when the supporting portions have been set in place.

Other objects and advantages of the invention will be readily apparent from the following description, when taken in conjunction with the accompanying drawings that illustrate useful embodiments in accordance with this invention:

FIGURE 1 is a side elevational view of a marine structure of the present invention erected in relatively deep water for drilling or working over a subaqueous well;

FIGURE 2 is a top plan view of the marine structure shown in FIGURE 1, illustrating more clearly the arrangement of the above-surface deck with respect to the bottom-supported submerged portion of the structure;

FIGURE 3 is a side elevational view of the derrick barge-supercstructure floating in the water prior to being mounted atop the bottom-supported structure as shown in FIGURES 1 and 2;

FIGURE 4 is a cross-sectional view of one of the upper tower sections of the bottom-supported portion of the marine structure taken through line 4-4 of FIGURE 1.

The marine structure of the present invention consists of a bottom-supported completely submerged portion, a completely above-surface superstructure portion, and a partially submerged extensible portion for connecting the above and below surface portions. The bottom-supported submerged portion is assembled at a proposed offshore location or site from a number of prefabricated sections that can be towed to the site.

The bottom-supported submerged portion of the marine structure is prefabricated and, as assembled, has a base foundation section with controlled buoyancy pontoon footings supporting a spacer section thereof and one or more upper tower sections atop the spacer section. A plurality of slidable columns, each consisting in part of a tubular section, form the extensible interconnecting portion of the marine drilling structure, extending from the base foundation section through the spacer section and the upper tower sections, in which they are vertical-
ly guided, to a level above the surface of the body of water. The columns also are designed as prefabricated subassemblies which can be assembled at the site. The upper ends of the columns, as assembled, are adapted to support the above-surface superstructure portion thereon. At the lower ends of each of the slid-
gable tubular sections, within the base foundation and spacer sections, is a tank or chamber section of the superstructure portion thereon, which is also controlled. The column tank sections are used to adjust the height of the columns between a completely submerged position and a position in which the upper ends of the tubular sections extend above the surface of the body of water to support the superstructure portion above the surface. The superstructure of the marine drilling structure, which is designed as a derrick barge for placing the spacer section and the upper tower sections in position on the base foundation section, comprises a buoyant hull and has a turntable with a pair of adjustable stiff-legged cranes thereon forming a derrick for performing the usual functions of a derrick barge during installation and of a drilling rig thereafter.

The assembly of the prefabricated marine structure is accomplished at the site with the assistance of tugs and the barge-superstructure portion only, eliminating the need for supplementary derrick barges. The base foundation section, the spacer section, and each of the upper tower sections are first floated to the location. The base foundation section is then partially submerged by the controlled flooding of the pontoon footings that provided the original buoyancy thereof. Subsequently, the spacer section is lifted by the derrick, onto the barge-superstructure, and set on top of the base foundation section where it is rigidly fixed in place, i.e., by a system of anchor chains, bolting, to the base foundation section beneath. Since the upper end of the base foundation section is just above the surface of the water at this time, divers are not needed to connect the sections. The combined base foundation and spacer sections are then submerged further until just the uppermost end of the spacer section is above the surface of the water. One of the upper tower sections is then lifted up out of the water by the derrick on the barge-superstructure and is set on the upper end of the spacer section where it is fixed in place. The partially assembled marine structure, consisting of the base foundation section, the spacer section, and one upper tower section all fixed together, is further submerged until only the uppermost end of the upper tower section is above the surface. Another upper tower section is placed on the upper end of the first upper tower section by the derrick on the barge-superstructure and is fixed in relation thereto by workmen. This procedure is repeated until all of the necessary upper tower sections are assembled in place, after which the assembled portion of the structure is settled onto the marine bottom. If it is desirable, the vertical corner support columns of each of the spacer and tower sections may be hollow and interconnected, and through the connected conduits in the base foundation section may be connected to the pontoon footings of the base foundation, for providing a fluid passageway for controlling the buoyancy of the foundation without long exterior lines extending all the way from a compressor on the deck of the barge-superstructure portion to the pontoon footings far beneath the surface.

Each of the subassemblies, or short lengths, of the extensible columns is fixed within its respective spacer, and upper tower sections so that they can be connected together to form the complete columns of the extensible interconnecting portion as the sections of the bottom-supported portion of the marine structure are assembled at the side. The extensible columns, when the marine structure is assembled, extend by the use of coaxial circular guides, at least one of which is fixed in each tower section for each extensible column. For purposes of handling, the short lengths of the extensible columns, preassembled in the respective tower sections, can be tack welded in the guides of the respective tower sections to hold them securely fixed. The tack welds can easily be broken later by a hammer blow or a cutting torch. The interiors of the base foundation and spacer sections do not have column guides therein, and the lower ends of the extensible columns thereon, including the column ends that depend on the circular guides in the upper sections, after the columns are assembled in the marine structure, for restricting the entire lengths of each of the columns to a vertical movement within the marine structure. During assembly, the separate lower end sections of the extensible columns are fixed within the base foundation and spacer sections by spars spanning the interiors of the last-mentioned sections and tack welded in place or by removable chains extending between the lengths of the extensible columns and the framework making up the sections. If the weight of a section, and the included short lengths of the columns, exceed the capacity of the derrick being used, the sections of the bottom-supported portion can be assembled without the lengths of columns being fixed therein. Instead, as soon as one of the prefabricated sections is set on a lower one already partially submerged, the derrick assembly would pick up the appropriate length of each of the columns and insert them into the uppermost section. The lengths of the columns are connected rigidly together above the surface as in the case of the sections of the bottom-supported portion of the marine structure. The short lengths of the extensible columns can be rigidly connected together by welding before the respective joints are submerged or can be bolted together at terminal flanges, or by any other appropriate method. The buoyancy tanks on the bottom length of each of the columns are partially flooded to lower the partially assembled columns into the water as the sections of the columns are added.

After the lower bottom-supported portion and the included extensible interconnecting portion of the marine structure have been completely assembled and the lower bottom-supported portion lowered to the bottom, the extensible column portion being submerged until at least the upper end thereof is below the draft of the hull of the portion, the barge-superstructure portion is floated over the uppermost tower section, and the extensible columns are raised by increasing the buoyancy of the tank sections on the bottom of the columns, until the columns are lifted into contact with the barge-superstructure portion. After bolting and otherwise rigidly fastening the upper ends of each of the columns to the lower surface of the barge-superstructure portion, the columns are further raised until the barge-superstructure is at the desired level completely above the water surface. The barge-superstructure portion may be held in this position regardless of the equipment set on the working deck thereof by increasing the positive buoyancy of the tank sections of the extensible columns while limiting the upward movement of the columns by positive stop means coating between the columns and the bottom-supported submerged portion of the marine structure. Alternatively the extensible columns may be bolted or welded in place once the platform has been lifted to the desired height. To be able to adjust closely the height of the barge-superstructure with respect to the surface of the water at a particular site, short jack-up legs may be mounted thereon, the lower ends of the jack-up legs connecting with the upper ends of the columns.

Now looking to FIGURE 1, the marine drilling structure consists of a lower submerged, bottom-supported portion 10, an upper barge-superstructure portion 12, and an extensible interconnecting portion 14. As shown, the entire marine structure is built up of prefabricated sections or subassemblies.
so that it can be used in six hundred feet of water and includes a base foundation section 16, a spacer section 18, and five upper tower sections 20. The construction at the base foundation section 16 is that of an open peripheral framework 22 substantially forming a truncated triangular based pyramid, and pontoon footings 24, fixed to framework 22 at each of the triangular corners thereof to control the depth of submersion of the base foundation section 16. As shown, for six hundred feet of water, the triangular base of the base foundation section 16 is approximately three hundred feet on a side. The base foundation section 16 would be approximately one hundred and seventy feet high.

Secured to the upper end of the base foundation section 16, the spacer section 18 is constructed of an open peripheral framework forming a column of triangular cross section one hundred and sixty feet tall, in this example. Vertical support columns 26, at the apexes of the triangular spacer section, are hollow so as to provide buoyancy in the section during transport and for forming flow passages to the pontoon footings 24 by means of the interconnecting hollow struts (not specifically shown) in the base foundation section 16. The upper and lower ends of each of the vertical support columns 26 have circumferential flanges therearound (not shown) for mating with opposing flanges on the adjoining portion of the lowest of the upper tower section 28 and base foundation 16 beneath, respectively, so that the sections can be securely fastened together.

Each of the upper tower sections 28 is also an open framework construction of supporting struts forming a column of triangular cross section. As shown in FIGURE 4, each of these upper tower sections 28 consists of hollow vertical support columns 28, at each apex of the triangular tower section 20, interconnected by peripheral struts 30 and internal struts 32. The internal struts 32, in turn, adjacent each apex of the triangle, a boxed-in framework within which a circular guide member 34 can be welded. These guide members 34 can also be used to hold short lengths of column, prior to assembly, in conjunction with removable stops fixed for the lengths of the columns. The upper and lower ends of each of the vertical support columns 28 have circumferential flanges 35 for bolting to the above and below upper tower sections 28 or to the spacer section 18 to fixedly assemble the submerged bottom-supported portion 10 of the marine structure. The upper and lower ends of each, in this example, fifty feet tall, allowing the submerged bottom-supported portion 10 of the marine drilling structure to be built up to within a relatively short distance of the surface 38 of the body of water in which the structure is to be used for a particular time. Even narrower upper tower sections may be utilized if it is desirable to fix closely the distance between the surface 38 and the upper end of the submerged bottom-supported portion 10 of the marine structure. Interconnections between the aligned hollow support columns 28, at the apexes of the tower sections 20, the hollow support columns 26 of the spacer section 18, and hollow struts of the base foundation section 16 provide a means for controlling the buoyancy of the pontoon footings 24 from the barge-superstructure portion 12 with only relatively short flexible lines between the above-surface barge-superstructure portion 12 and the upper end of the submerged bottom-supported portion 10 of the marine structure.

The assembled extensible interconnecting portion 14 of the marine drilling structure consists of three parallel tubular sections 40 extending through the circular guides 34 of the upper tower sections 20 and terminating at their lower ends in large diameter buoyancy tank sections 42 contained within the open framework constructions of the base foundation section 16 and the spacer section 18. Chains 44 are attached between points on the base foundation section 16 and each of the buoyancy tank sections 42 to limit the upward travel of the extensible interconnecting portion 14.

The barge-superstructure portion 12, as shown in FIGURES 1 and 3, has a drilling derrick mounted thereon consisting of a pair of stiff-legged cranes 46 fixed on a turntable 48 with a crown block 52 hung from a bridging member 50 between the top of the cranes 46. The cranes 46 are affixed in the attitude shown in phantom at 46' in FIGURE 3 when the barge-superstructure portion 12 is used to assemble the spacer section 26 and the upper tower sections 28 on the base foundation section 16.

When the usefulness of the barge-superstructure portion 12, as a derrick barge, is over, and the submerged bottom-supported portion 10 has been firmly settled on the marine bottom 47, the barge-superstructure portion 12 is floated over the submerged bottom-supported portion 10 and the extensible interconnecting portion 14 (completely submerged as shown in phantom in FIGURE 1) whereupon the buoyancy tank sections 42 of the extensible column portion 14 are evacuated of water and filled with air to drive the columns of the extensible interconnecting portion 14 upward from the submerged portion. As the tubular sections of the extensible interconnecting portion 14 contact the barge-superstructure portion 12, and lift the portion 12 out of the water, they are fastened in place by bolting or welding, or other appropriate manner. The buoyancy of the tank sections 42 then is increased to raise the barge-superstructure portion 12 as far out of the water as permitted by the chains 44 to avoid contact with the waves on the surface 38 of the body of water at high tide. In the particular instance shown, the barge-superstructure portion 12 has been raised forty feet above the surface 38 of the water. This is a height normally used in the Gulf of Mexico, but may not be high enough in other areas.

When a violent storm threatens the marine structure, it may be necessary to release it from the subaqueous bottom 47 to prevent the seven hundred-foot structure from collapsing under the strains caused by the violent surface conditions. The buoyancy of at least the pontoon footings 24 is increased to permit the entire structure to float just clear of the bottom and form an extremely stable spar buoy type of floating unit with a five hundred fifty to five hundred eighty-foot draft, not being susceptible to the extent of damage that a fixed positioned structure would be in violent storms. Due to the possibility that the structure may have to be floated, in case of violent storms, it is necessary that the drilling equipment to be used with the present invention be the type normally utilized in floating drilling operations rather than the type conventionally utilized with fixed bottom-supported platforms. By this it is meant that a mudline suspension with a subsea wellhead should be utilized along with blowout preventers mounted near the bottom, for drilling, connected by a remote-controlled, quick-disconnect marine riser extending to the above-surface deck on the barge-superstructure portion 12. By the use of this equipment rather than having the blowout preventers on the drilling deck as usually is done with fixed platforms, some lateral movement of the entire marine structure can be tolerated after the structure has been raised off the marine bottom and the marine riser is disconnected, without any damage being inflicted on the subaqueous well being drilled.

Although the present invention has been described in connection with details of the specific embodiment thereof, it is understood that such details are not intended to limit the scope of the invention. The terminology employed is used in a descriptive and not a limiting sense and there is no intention of excluding such equivalents, in the invention described, as fall within the scope of the claims. Now having described the method and apparatus herein disclosed, reference should be had to the claims which follow.
What is claimed is:

1. A marine structure for drilling or working over wells in subaqueous formations from an offshore site, said marine structure comprising: a lower portion supported on a marine bottom, fully submerged beneath said surface of said body of water; an upper portion supported fully above the surface of a body of water; and a partially submerged extensible interconnecting portion buoyantly supporting said upper portion above said surface of said body of water while being constrained within said lower portion; said lower portion of said marine structure comprising a base foundation section of open framework construction and having footing means of adjustable buoyancy, said at least one upper tower section of open framework construction supported on said base foundation section for extending the height of said lower portion, depending on the water depth at said offshore site; means for rigidly fixing said at least one tower section on said base foundation section; and guide means within said at least one tower section for constraining said extensible interconnecting portion against lateral movement while permitting vertical movement of said extensible interconnecting portion; and said extensible interconnecting portion having horizontally spaced upper tubular sections for supporting said upper portion thereon; and an adjustable buoyant tank section on the lower end of each of said upper tubular sections, said tank section being contained within an open framework including said base foundation section, said tubular sections of said extensible interconnecting portion being constrained by said guide means in said at least one tower section.

2. The marine structure of claim 1 wherein said upper portion consists of a barge-superstructure having a buoyant hull, adapted to function as a derrick barge prior to the assembly and installation of said bottom-supported portion and said extensible interconnecting portion at said offshore site, and as the superstructure of said marine structure after the installation of said bottom-supported lower portion and said extensible interconnecting portion of said marine structure at said offshore site; and derrick means for adjusting said derrick means between a first position in which said derrick means is utilized to install said lower and extensible interconnecting portions at a marine site, and a second position in which said derrick means is utilized as a drilling or workover rig.

3. The marine structure of claim 1 wherein at least one buoyant tank section of said extensible interconnecting portion is of a larger cross-sectional area than one of said tubular sections.

4. The marine structure of claim 1 wherein there is means coacting between said base foundation section of said lower bottom-supported portion and said extensible interconnecting portion to limit the upward vertical movement of said extensible interconnecting portion with respect to said lower bottom-supported portion in opposition to the buoyancy of said extensible interconnecting portion.

5. The marine structure of claim 1 wherein said base foundation section and said at least one tower section are each of triangular cross-sectional area and said extensible interconnecting portion consists of three parallel tubular sections each having a buoyant tank section connected thereto, each of said tubular sections being vertically slideable within an apex of said at least one triangularly shaped tower section.

6. A method for assembling and installing a marine structure for drilling or working over wells in subaqueous formations at an offshore site, said marine structure comprising: a lower portion adapted to be submerged beneath the surface of a body of water and supported on a marine bottom; an upper portion adapted to be buoyantly supported above the surface of a body of water; and an extensible interconnecting portion adapted to support buoyantly said upper portion above a surface of a body of water while being partially submerged and constrained within said lower portion when said lower portion is submerged and supported on said marine bottom; said lower portion having a base foundation section with footing means of adjustable buoyancy, and at least one upper tower section for adjusting the height of said lower portion with respect to the water depth at an offshore site; means for rigidly fixing said at least one tower section above and in relation to said base foundation section; and means within said at least one tower section for constraining said extensible interconnecting portion against lateral movement while permitting vertical movement of said extensible interconnecting portion; and said extensible interconnecting portion having adjustable buoyant means for adjusting the vertical buoyant positioning thereof, including the following steps:

(a) adjusting the buoyancy of at least said footings at said offshore site to submerge said base foundation section of said lower portion until only the upper end thereof is above the surface;

(b) lifting at least one upper section of said lower portion above said upper end of said base foundation section above said surface and setting said at least one upper section on said upper end of said base foundation section;

(c) rigidly fixing said at least one upper section of said lower portion on said upper end of said base foundation section while only said upper end of said base foundation is above said surface;

(d) assembling said extensible interconnecting portion within said lower portion by rigidly connecting sub-assemblies thereof together;

(e) adjusting the buoyancy of said extensible interconnecting portion during the assembly thereof so that only the very upper end of said column portion, already assembled, is above the surface when connecting an upper subassembly thereto;

(f) readjusting the buoyancy of the assembled lower portion to support said lower portion on the marine bottom at said offshore site;

(g) readjusting the buoyancy of the assembled extensible interconnecting portion to lower the upper end of said extensible interconnecting portion below the surface at least a distance equal to the draft of said upper portion floating on said surface;

(h) floating said upper-surface portion of said marine structure over said assembled lower portion and said assembled extensible interconnecting portion;

(i) increasing the buoyancy of said assembled extensible interconnecting portion to raise said extensible interconnecting portion into engagement with said portion and subsequently to buoy said upper portion to a spaced distance above the surface of said body of water.

7. A method for assembling and installing a marine structure as recited in claim 6 wherein said upper portion consists of buoyant barge-superstructure adapted to function as a derrick barge prior to the assembly and installation of said lower bottom-supported portion and said extensible interconnecting portion at said offshore site, and as the superstructure of said marine structure after the assembly installation of said lower bottom-supported portion and said extensible interconnecting portion; and derrick means on said barge-superstructure adjustable between a first position in which said derrick means is utilized to assemble said lower portion and extensible interconnecting portion; and said derrick means on said barge-superstructure is utilized as a drilling or workover rig, including the following additional steps:

(j) adjusting said derrick means on said barge-superstructure to position said derrick means in said first position;
(k) floating said barge-superstructure to said offshore site; and
(l) utilizing said derrick means in said first position thereof to lift said at least one upper section of said lower portion above said surface and set said at least one upper section on said partially submerged base foundation section.

8. A method for assembling and installing a marine structure as recited in claim 6 wherein there are a plurality of available tower sections for said marine structure, including the following additional step:
   (m) assembling enough additional tower sections above said base foundation section to extend said lower portion so that it will terminate at a predetermined distance beneath the surface of said body of water at said offshore site when said lower portion is submerged and supported on the marine bottom.

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JACOB SHAPIRO, Primary Examiner.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,381,482

William F. Manning

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 64, "controled" should read -- controlled --. Column 4, line 28, "upper most" should read -- uppermost --; line 44, after "the", third occurrence, insert -- barge-superstructure --. Column 5, line 50, "section" should read -- sections --; line 74, "constrictions" should read -- constructions --. Column 6, line 47, "damgage" should read -- damage --; same line 47, "fixed" should read -- fixedly --. Column 7, line 28, "section being" should read -- sections being --.

Signed and sealed this 23rd day of September 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
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