Oct. 27, 1970 P. E. CHANEY 3,535,884

OFFSHORE DRILLING AND PRODUCTION STRUCTURE

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FIG. 1.

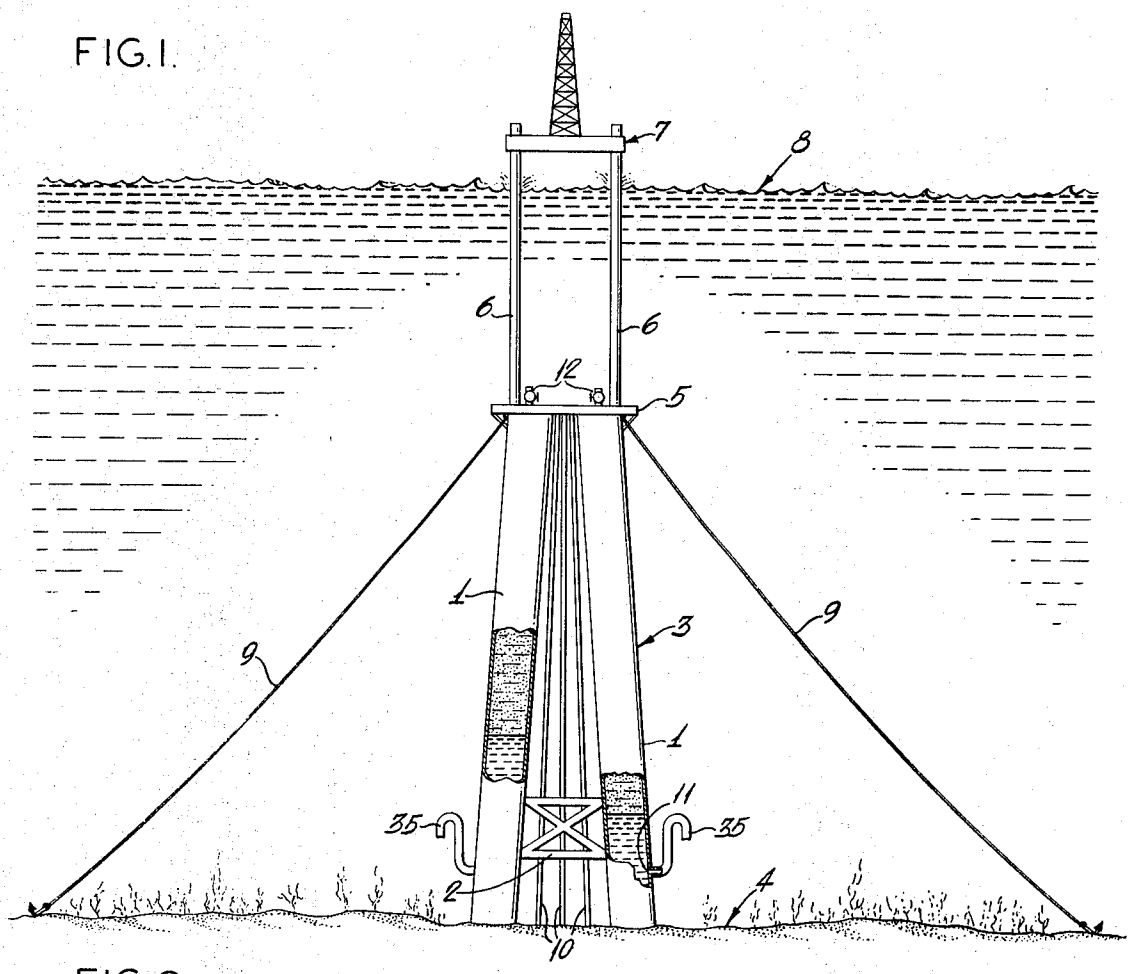
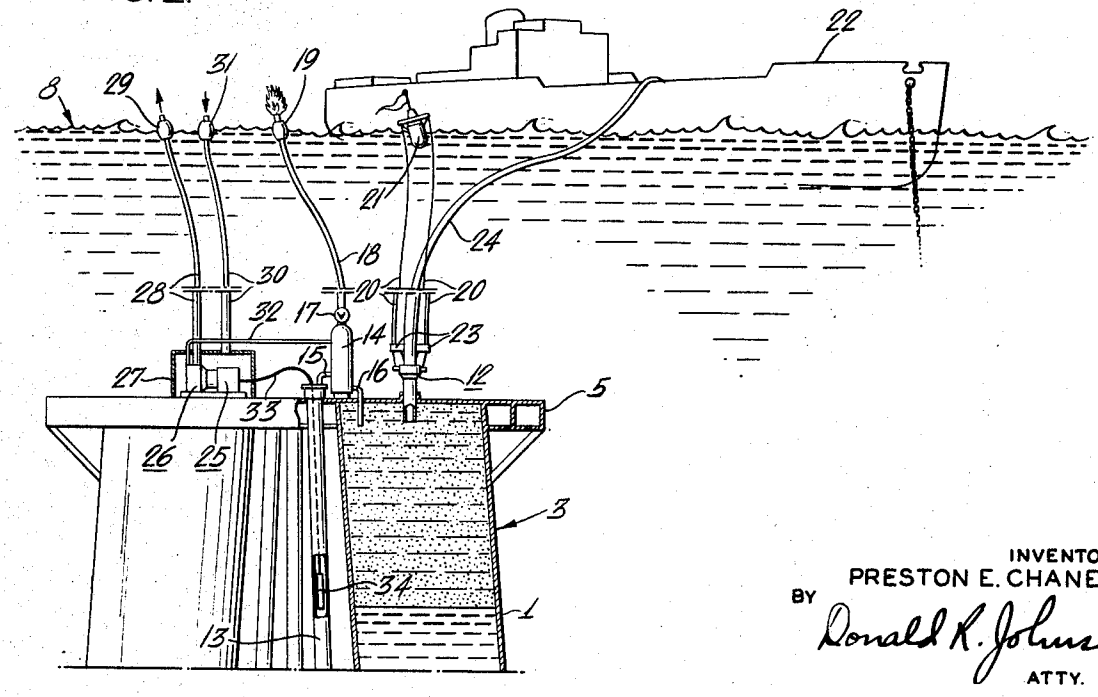


FIG. 2.



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OFFSHORE DRILLING AND PRODUCTION STRUCTURE

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ABSTRACT OF THE DISCLOSURE

For offshore drilling in deep water, a rigid elongated structure having its lower end secured to the ocean floor is utilized. The upper end of this structure comprises a platform which is located 100–200 feet below the sea water surface. For drilling, the legs or columns of a "jack-up" drilling rig rest on and are supported by this platform. The same platform may later be used as a permanent production platform. If wells must be pumped this can be accomplished by mounting an electric generator on the platform for powering downhole electric pumps. Tubular members incorporated into the structure are used as underwater oil storage tanks, and the platform supports marine loading apparatus for transferring the oil stored in the tanks to a tanker.

This invention relates to an offshort structure, particularly suitable for use in deep water drilling and production operations (typically, in water depths of 300 feet to 600 feet), which combines the functions of a drilling platform, a permanent production platform, and underwater oil storage.

Production of oil and gas from offshore locations, in water depths up to 200 feet, is now commonplace in many parts of the world. For offshore oil wells in deeper water, underwater drilling methods have been proposed; however, at present they are very much in the dream stage. All offshore (i.e., underwater) wells completed to date have been drilled with surface drilling equipment, and there is no indication that underwater drilling equipment will be available in the near future. Ocean floor completions, though they have been used, are still generally not the preferred type of completions, even for deeper water.

Three general types of surface drilling equipment (rigs) have been used in the past for offshore drilling operations, to wit, "jack-up" rigs, floating rigs, and drilling platforms. Comparing these types, jack-up rigs are more stable than floating rigs and can be constructed for about one-half the cost. Rigs operating from platforms either with or without a tender ship are comparable in cost to "jack-up" rigs, but the platform cost increases rapidly with water depth.

Also, the use of floating rigs can present a serious problem. One floating rig has been lost, and another barely escaped sinking, because of gas breaking out around the casing at the ocean floor level; the fine gas bubbles rising through the water lowered the effective water density to a value at which the one vessel would no longer float. The other vessel escaped sinking only by cutting loose from the well and leaving the location as quickly as possible; obviously, it is not desirable to leave a well in this manner when it is about to blow out of control. This sinking-rig problem is avoided by the use of jack-up rigs or platforms.

A brief discussion of present practices and procedures in connection with jack-up rigs is now in order. The rotary drilling rig is floated to location, and legs or columns are then lowered to the ocean floor and the rig is jacked-up on these columns, such that all, or a considerable part, of the weight of the drilling equipment is

supported on the ocean bottom, so as to stabilize the drilling rig against horizontal and vertical movement during the drilling operation.

Upon discovery of a field, it is common practice to build a permanent production platform, and subsequent directional wells are often drilled from the platform, in a radial pattern, to drain a relatively large reservoir area. These platforms usually comprise a rectangular truss-like structure composed of hollow tubular sections, which is known as a template. In deeper water, the template may be considerably wider at the bottom than at the top, in order to improve stability. The height of the template is sufficient to reach from the ocean floor to a level thirty or more feet above the surface, to prevent destruction of the floor of the platform in hurricanes. The template is towed to sea, set in position, and then anchored by driving piling through the vertical hollow members of the truss (hence the name template). After driving the pilings to firm footing, they are cut off flush with the tops of the template tubes, and welded to them.

While structures of the type just described have proved satisfactory in shallow water (say, up to 200 feet), the design problems increase rapidly with water depth. In deep water, the overturning moment produced by hurricane wind and wave forces, acting upon the structure several hundred feet above its point of anchorage on the ocean floor, is tremendous. As an alternative, designs are being considered which involve well completion, oil storage, and perhaps even drilling operations, at the ocean floor level (as previously stated, however, underwater drilling operations are as yet only visionary). Experience to date indicates that underwater well completions are possible, but are extremely expensive in water depths below the range of free-swimming divers. The capabilities of robot diving machines are so limited that expensive and restrictive compromises must be made in the design of well-head fittings, in order to permit robot assembly and control.

The underwater storage of oil also presents a serious problem, because of the considerable difference in densities of oil and sea water. For example, 500,000 barrels of 31° (API gravity) oil stored under sea water will exert a buoyant force of 2,680,000 pounds, or slightly over 50 pounds per barrel of oil. To overcome this buoyant force, an underwater storage tank must be quite heavy. If made of steel, the thickness of the material which is called for to provide the necessary weight is much greater than that needed to merely provide adequate strength. Hence, the steel is not used efficiently as a structural material, and the cost of tankage is excessive.

Assume that an oil field is to be drilled and produced in 600 feet of water. Present techniques would require that such wells be drilled with a floating drilling rig, since the legs of jack-up rigs of practical dimensions would buckle under the combined wave forces and weight of the rig at water depths much less than 600 feet. However, the relative instability, high cost, and possibility of sinking of floating rigs, and the unsolved problems of ocean floor well completion, render this approach impractical for such great water depths.

While it might not be impossible to construct a piling-template production platform for use in 600 feet of water, the problems involved in such a design increase exponentially with water depth. The structure must not only extend 600 feet into the water, but must also reach 30 feet to perhaps 100 feet above the surface, to protect the platform floor from hurricane waves. Since the area of the base of the structure must increase as the square of the height in order to maintain stability against overturning by wave action, it is apparent that the steel requirement

and cost of platforms increases very rapidly with water depth.

An object of this invention is to provide a stable, non-floating structure for use in drilling boreholes offshore in deep water, on the order of 300 feet to 600 feet or even more.

Another object is to provide a structure which will support and protect permanent production and storage equipment from wave forces.

A further object is to provide an underwater platform structure which makes double use of the steel by incorporating therein oil storage tanks as integral and structural members of the platform.

A still further object is to provide a single offshore structure which combines the functions of a drilling platform and a permanent production platform, and which embodies therein oil storage and tanker loading facilities.

An additional object is to provide a single underwater structure which can serve as a drilling platform and also as a permanent production platform, and which embodies therein oil storage and tanker loading facilities.

The objects of this invention are accomplished, briefly, in the following manner: A rigid upright structure of substantial vertical length rests at its lower end on the ocean floor, and has a platform at its upper end. This structure is so dimensioned that the said platform is located a considerable distance below the water surface, such that the structure is substantially unaffected by surface wave forces. The platform can support a jack-up drilling rig, and can also be used to support pumping equipment for one well or several wells. A plurality of hollow tubular members providing vertical support for the structure, serve as oil storage tanks, and the platform also carries tanker loading facilities.

As an alternative, an above water drilling and production platform may be erected upon this structure, relying upon the great strength of the cross-braced tubular tank members to provide the necessary resistance to horizontal wave forces, as well as to vertical loads.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front elevation, somewhat diagrammatic, of a structure according to this invention, showing it being utilized in connection with drilling operations; and

FIG. 2 is a view similar to FIG. 1 of the upper portion of the structure of the invention, showing it being utilized for oil storage and as a permanent underwater production platform.

Refer first to FIG. 1. A plurality of relatively large diameter hollow tubular members **1**, which have a substantial vertical length (e.g., about 450 feet) and which extend substantially parallel to each other, are joined together as by means of cross-bracing **2** to form a rigid upright structure denoted generally by numeral **3**. There are a minimum of three, but possibly four or more, members **1**; these members can be considered to be located around the periphery of structure **3**. The members **1** serve as oil storage tanks during production (as will be described more in detail hereinafter), and are constructed to have sufficient strength to form the principal support for structure **3**. The lower end of structure **3** (which is to say, the lower ends of members **1**) rests on the floor **4** of the ocean or other body of water. It will be assumed here, by way of example, that operations are to be carried on at an offshore location wherein the water depth is about 600 feet.

The upper end of structure **3** comprises a platform **5** which is rigidly secured to the upper ends of members **1** and which has an area at least sufficient to accommodate (support) the legs or columns **6** of a jack-up drilling rig of conventional design, denoted generally by numeral **7**. The members **1** have sufficient strength to support the drilling equipment **7**, which rests on platform **5** during the drilling operation.

The structure **3** has a height such that platform **5** is located a considerable distance (say, approximately 100 feet to 200 feet) below the water surface **8**; this distance is such that the structure **3** is never subjected to the force of hurricanes. Hence, large diameter columns suitable for oil storage may be used as legs for the structure. While wind and wave forces are tremendous at the surface **8** of the ocean, it is well-known that these forces decrease very rapidly below the surface. In fact, the wave forces produced by hurricanes are negligible at depths below 100 feet. The principal forces to be dealt with below this depth are the natural ocean currents, tidal currents, and occasional earthquake-induced tidal waves known as "Tsunamis." While these forces may be sizeable, they are of far less magnitude than the maximum surface wave forces.

As previously stated, the range of depths at which the subsurface platform **5** is located is such that this platform is relatively undisturbed by severe surface storms. However, this range is shallow enough to permit installation and servicing of well control equipment by skin divers, when required for the below water completion procedure. This capability of manipulation by free-swimming divers is an important advantage of the invention.

The structure **3** may be braced by several guy lines **9** to increase its vertical stability. The upper ends of guy lines **9** are secured to the platform **5**, while the lower ends of these lines are anchored in the ocean floor **4**. Guy lines **9** are provided with anchors designed like a ship's anchor, to dig into the bottom **4** upon being dragged horizontally. They are dropped and set by tug boats, with the cable running through loosened clamps on the platform **5**. Once the anchor is set and the proper tension is applied to the guy lines, the platform clamp is set and the cable to the ship is removed.

Formed into the structure **3** are a number of hollow tubular well templates **10**, through which can be drilled one vertical well and a pattern of radially spaced directional wells, so as to drain a large reservoir area from the one platform. The templates **10** extend substantially vertically from platform **5** down to the bottom end of structure **3**. Although the templates **10** are schematically illustrated in FIG. 1 as extending between the members (oil storage tanks) **1**, as a practical matter they may run down through the several tanks **1**, near the periphery thereof, in order to contribute maximum resistance to overturning forces on structure **3**. In this case, all or part of the weight of the well casing could be applied to the top of the tanks, to assist in overcoming the buoyancy of the oil stored therein. With the wells drilled through the tanks, the centers of moments for the upward and downward forces would be closer together horizontally, so there would be less bending moment in the structure. The angle of the well templates (with respect to the vertical) is not critical, except that it must be kept small enough to permit the casing and drill pipe to follow the bend without being overstressed, or (in the case of the drill pipe) subjected to fatigue failure during rotation.

Also formed into the structure **3** (but not shown) are a plurality of piling templates, through which piling may be driven to anchor the structure in place. These piling templates are simply hollow tubular members slightly larger in inside diameter than the O.D. of the piling, and are welded into and made a structural part of the structure **3**; they may be located within the tanks **1**, or around their periphery.

It is common practice, on present offshore structures, to provide a rubber seal at the bottom of the piling templates, and to attach a small pipe to the template just above this seal. Once the piling has been set, cement is pumped through the small pipe into the annulus between template and piling. Being prevented from moving downwardly by the rubber seal, the cement rises in the annulus; sufficient cement is pumped to completely fill the annulus. A similar scheme is used on both the piling templates and well templates (for the well casings) of the present structure.

The procedure for drilling a well and making an underwater completion, using the subsurface platform **5** of the instant invention, will now be described. After the structure **3** has been established in place, and guyed at **9**, and anchored by means of the piling templates as previously described, a conventional jack-up drilling rig **7** is floated to location. Then, is legs **6** are lowered to land on the subsurface platform **5**, and the rig **7** is jacked up to operating level, wherein its principal operating parts are located above water surface **8**, as depicted in FIG. 1. The drill pipe and bit for drilling the surface hole are then lowered to the level of platform **5**, and guided into the proper template **10** with the aid of a diver. After drilling to surface casing depth, the casing is set and cemented as above described, but the casing is terminated just above platform **5**. Blowout preventers of conventional type are set at the platform **5** level and mounted to the surface casing, and are connected by hydraulic actuating lines to the drilling rig **7** at the surface **8**. A flexible hose or pipe, having an inside diameter large enough to permit passage of the drill bit, is attached to the top of the blowout preventers; this hose or pipe extends upwardly to the drilling rig **7** to conduct drilling fluid returns from the annulus to the mud circulation system of rig **7**. This hose also serves to guide the drill pipe into the hole after each trip to change bits.

Upon the approach of a severe storm, the drill pipe could be removed from the hole, the blowout preventers closed, and the drilling rig **7** removed to a safe location. After the storm, this procedure would be reversed, and drilling resumed.

Drilling and completion of the well employ essentially the same techniques and equipment used in land-based operations, with the exception that skin divers (free-swimming divers) are required to install well-head fittings on the platform **5**. A hydraulic-powered crane would be installed on the surface platform, to assist the divers in the handling of this equipment.

The tubular members **1** are sealed except for an opening **11** to the sea near the bottom of each member, and are provided with valves such as **12** (described hereinafter) for withdrawing oil from the top of each member. As previously mentioned, these members **1** are adapted to serve as oil storage tanks. Pipes **35** are connected to openings **11** to supply sea water to the bottoms of tanks **1**; these pipes may be of goose-neck shape, as illustrated, to forestall clogging of the pipes by mud or sediment. Since sea water is freely admitted to the bottoms of the tanks, the oil therein is at all times stored over sea water, and when oil is withdrawn from the tanks, sea water replaces it.

After the offshore well or wells have been completed (by using the structure **3**, as above described), the same structure can be used as a permanent production platform, as well as to provide oil storage. This is illustrated in FIG. 2, to which reference will now be made.

After drilling is completed, the jack-up rig **7** is removed from platform **5**. Assuming that the well has been completed and is either flowing or is being pumped through well pipe **13**, the crude oil produced is fed to a gas-oil separator **14** of conventional type which is mounted on the subsurface platform **5**. The mixed stream (containing oil, gas, and perhaps water) is fed through a pipe **15** from well pipe **13** to separator **14**. Pipe **15** enters the side of separator **14** aproximately one-third of its length above the bottom. The separated oil is withdrawn from the bottom of separator **14**, and is fed into the tops of storage tanks **1** by means such as pipes **16**, one of which is shown. The separated gas is removed from the top of separator **14** through a back-pressure valve **17** which maintains sufficient pressure on the separator to displace the oil into the storage tank system. The gas flowing through valve **17** is vented to the surface **8** through a pipe **18** which is supported at the surface by a float **19**, and is generally flared or burned at the surface, since ordinarily the volume of gas available from oil wells would not justify a pipeline to shore. However, if the gas is available in sufficient volume, it could be transported to shore by an underwater pipeline.

Chemical emulsion treating of the oil, if called for, would be straightforward and conventional.

The oil stored in tanks **1** will be under pressure, because of the low density of oil relative to sea water. This hydrostatic pressure difference can be used advantageously to transfer the oil to a tanker, without pumping, for transportation to market. FIG. 2 illustrates one means whereby this can be accomplished.

Each one of the storage tanks **1** is equipped with an hydraulically-operated valve **12** (previously referred to) for withdrawing or discharging oil from the top of the respective tank. The hydraulic control lines **20** for each valve **12** extend upwardly to a respective marker buoy **21** at the surface **8**. A tanker **22** to be loaded is pulled up alongside buoy **21**, and guides **23** on the filler hose **24** are slidably engaged with the hydraulic lines **20** in such a way that the lower end of the hose is guided into position so as to engage and seal to discharge valve **12** when the hose is lowered to the proper depth. In this connection, it will be recalled that valve **12** is located adjacent the surface platform **5**. The filler hose **24** is then locked into position by a hydraulically-operated locking means (not shown), after which valve **12** is opened; oil then flows from tank **1** to ship **22** under the urging of the natural buoyant force of the oil.

Asume first that the wells are flowing. Well tests such as bottom hole pressure measurements can be run by skin divers using conventional wire line equipment, with hydraulic drive power furnished from a tender ship.

Now assume that the wells must be pumped through well pipe **13**. In this case, a gas-turbine-driven generator **25** may be installed at the platform **5** level. Generator **25**, and the gas turbine **26** driving the same, are installed in a water-tight compartment or chamber **27**. The exhaust from turbine **26** is discharged through a snorkel tube **28** supported by a buoy **29** at the surface **8**, while the intake air is furnished to compartment **27** through a snorkel tube **30** supported by a buoy **31** at the surface. A part of the gas separated from the produced oil can be used to operate the turbine **26**; a pipe **32** carries this gas from separator **14** to the turbine. If there is not sufficient gas for this purpose available at separator **14**, the turbine **26** can be of a different type, and can be operated on crude oil.

The electricity generated by generator **25** can be used to power a standard downhole electric pump, such as a so-called Reda downhole pump; pumps of this type are in common use in the industry. Thus, an electrical power cable **33** is connected from generator **25** to a downhole electric pump **34**, which for convenient illustration only is shown horizontally related to tanks **1**; actually, of course, the pump **34** would be located adjacent the producing formation penetrated by well pipe **13**.

It would probably be possible to pump the oil from well pipe **13** by utilizing a conventional rod pump, operating exposed on subsurface platform **5**, such a rod pump being actuated pneumatically or hydraulically.

For minor maintenance of the well, a floating coring vessel may be used. However, for major workovers, a full scale jack-up rig would probably be the most practical.

Recapitulating, the present invention greatly reduces the cost and hazards of drilling in deep water, and makes it possible to drill and complete such wells with essentially the same drilling techniques already proved practical by extensive use.

One of the main ideas behind the present invention is to make multiple use of the steel, and to reduce the maximum loading on the structure **3** by keeping its upper face **5** below the level of hurricane wave forces. To explain further, if the structure **3** is heavy enough and strong enough to provide the required oil storage, it can be designed (with little or no additional steel) to serve also as

an underwater producing platform and as a base for jack-up rig drilling operations, or to support an above water drilling and production platform constructed of relatively small diameter members. It is pointed out that the construction and operating costs of jack-up rigs or platform supported rigs are roughly half the corresponding costs for floating rigs (which would otherwise be required in the deep-water depth range, on the order of 600 feet). Also, by supporting the well pipe **13** from the platform **5**, the weight and tensile strength of the well pipe **13** can supplement the weight of the structure **3** in overcoming the buoyancy of the oil.

The structure of the present invention reduces deep-water drilling costs by nearly 50%, and also provides a permanent producing platform and underwater oil storage, at a cost about equal to the present cost of providing underwater oil storage alone.

The invention claimed is:

1. In offshore well apparatus, a rigid upright structure of substantial vertical length having its lower end resting upon the floor of the body of water and having its upper end located a distance below the water surface such that the structure is substantially unaffected by surface wave forces, the upper end of said structure comprising a subsurface platform adapted to support well equipment, said structure including a plurality of spacially interconnected hollow tubular elongated upright members adapted to serve as fluid storage tanks, each of said tanks having, near the lower end thereof, an opening providing communication between the interior of the respective tank and the surrounding water, and well pipe connected to said upright members.

2. In offshore well apparatus, a rigid upright structure of substantial vertical length having its lower end resting upon the floor of the body of water and having its upper end located a distance below the water surface such that the structure is substantially unaffected by surface wave forces, the upper end of said structure comprising a subsurface platform adapted to support well equipment, said structure including a plurality of structural hollow tubular elongated upright members adapted to serve as fluid storage tanks, each of said tanks having, near the lower end thereof, an opening providing communication between the interior of the respective tank and the surrounding water, and further including pumping equipment for said well, said pumping equipment including means for delivering well fluid to the upper end of said tanks.

3. Apparatus for drilling boreholes in the earth at offshore locations comprising a rigid substantially prismoidal structure of substantial vertical length having its base resting upon the floor of the body of water and having its upper face located a distance below the water surface such that the structure is substantially by surface wave forces, said prismoidal structure including at least three large diameter vertical tubular members for supporting said upper face, the upper face of said structure comprising a subsurface supporting platform; a jack-up drilling rig having relatively small diameter legs which are supported by said platform and extend upwardly therefrom with the principal operating parts of said rig located above the water surface; and means for introducing well fluids into said large diameter tubular members.

4. Apparatus for drilling boreholes in the earth at offshore locations comprising a rigid substantially prismoidal structure of substantial vertical length having its base resting upon the floor of the body of water and having its upper face located a distance below the water surface such that the structure is substantially uneffected by surface wave forces, the upper face of said structure comprising a subsurface supporting platform; a jack-up rotary drilling rig the legs of which are supported by said platform and extend upwardly therefrom with the principal operating parts of said rig located above the water surface, said structure including a plurality of structural hollow tubular elongated upright members adapted to serve as fluid storage tanks, and each of said tanks having, near the lower end thereof, an opening providing communication between the interior of the respective tank and the surrounding water, and also having a valved connection at the top thereof.

5. In combination, a plurality of substantially vertical hollow tubular elongated members spacially coupled together to form a rigid substantially prismoidal structure of substantial vertical length, the base of said structure resting upon the floor of a body of water and the upper face of said structure being located a distance below the water surface such that the structure is substanitally unaffected by wave forces, said hollow members being adapted to serve as fluid storage tanks; well pipe connected to said hollow members; means for introducing well fluids into said tanks; means providing a platform at the upper face of said structure; and marine loading apparatus, for transferring fluid stored in said tanks to a tanker, associated with said platform and coupled to said tanks.

6. Combination set forth in claim **5** wherein each of said tanks has, near the lower end thereof, an opening providing communication betwen the interior of the respective tank and the surrounding water.

7. In combination, a plurality of substantially parallel hollow tubular elongated members coupled together to form a rigid substantially prismoidal structure of substantial vertical length, the base of said structure resting upon the floor of a body of water and the upper face of said structure being located a distance below the water surface such that the structure is substantially uneffected by wave forces, said hollow members being adapted to serve as fluid storage tanks; means providing a platform at the upper face of said structure; marine loading apparatus, for transferring fluid stored in said tanks to a tanker, associated with said platform and coupled to said tanks; and a valved connection at the top of each of said tanks.

8. In combination, a plurality of substantially parallel hollow tubular elongated members coupled together to form a rigid substantially prismoidal structure of substantial vertical length, the base of said structure resting upon the floor of a body of water and the upper face of said structure being located a distance below the water surface such that the structure is substantially unaffected by wave forces, said hollow members being adapted to serve as fluid storage tanks; means providing a platform at the upper face of said structure; and well pumping apparatus carried by said platform and coupled to said tanks.

9. Combination set forth in claim **8**, wherein each of said tanks has, near the lower end thereof, an opening providing communication between the interior of the respective tank and the surrounding water.

10. Combination set forth in claim **8**, wherein each of said tanks has, near the lower end thereof, an opening providing communication between the interior of the respective tank and the surrounding water, and also has a valved connection at the top thereof.

11. In combination a plurality of substantially parallel hollow tubular elongated members coupled together to form a rigid substantially prismoidal structure of substantial vertical length, the base of said structure resting upon the floor of a body of water and the upper face of said structure being located a distance below the water surface such that the structure is substantially unaffected by wave forces, said hollow members being adapted to serve as fluid storage tanks; means for transferring well fluids to and from said tanks; and drilling apparatus supported by said upper face of said prismoidal structure, the upper portion of said drilling apparatus extending above the water surface.

12. In combination, a plurality of substantially parallel hollow tubular elongated members coupled together to form a rigid substantially prismoidal structure of substantial vertical length, the base of said structure resting

upon the floor of a body of water and the upper face of said structure being located a distance below the water surface such that the structure is substantially unaffected by wave forces, said hollow members being adapted to serve as fluid storage tanks; means for transferring well fluids to and from said tanks; drilling apparatus supported by said upper face of said structure, the principal operating parts of said apparatus being located above the water surface; and a plurality of hollow tubular templates fixed to said structure and extending in a substantially vertical direction downwardly from said platform, to serve as well templates for said drilling apparatus.

13. In an offshore well structure, a first underwater portion of said structure adapted for being supported by the ocean floor and having at least one large diameter hollow member arranged to extend upwardly from the ocean floor and forming a fluid petroleum storage tank, well pipe extending downwardly into producing formations from said hollow member and connected to said hollow member and having at least a prtion of its weight supported by said hollow member, a second portion of said structure including means for communicating fluids within said tank to a fluid receiving means on the water surface, and at least one opening in said tank for providing communication between the interior of the lower end of said tank and the surrounding water to permit the entry of water into the lower end of said tank.

14. In an offshore well structure, a first underwater portion of said structure adapted for being supported by the ocean floor and having at least one large diameter hollow member arranged to extend upwardly from the ocean floor and forming a fluid petroleum storage tank, a second portion of said structure including means for communicating fluids within said tank to a fluid receiving means on the water surface, at least one opening in said tank for providing commuication between the interior of the lower end of said tank and the surrounding water to permit the entry of water into the lower end of said tank, and including connection means for introducig petroleum fluids under pressure into the upper end of said tank, said opening in the lower end of said tank permitting the expulsion of water therefrom as said well fluids displace such water.

15. The apparatus of claim 14 wherein said means for communicating fluids from said tank to the surface has a substantially smaller cross-sectional area than said fluid storage tank.

16. Offshore well apparatus comprising, a first upright structure having its lower end adapted for resting on the floor of a body of water and arranged to have its upper end located a distance below the water surface such that the structure is substantially unaffected by surface wave forces, said first structure having at least one large diameter hollow member sealed at its upper end to form a fluid storage tank; a second structure supported by said first structure and arranged to extend above the water surface, said second structure being considerably smaller in cross-section than said first structure, means for admitting sea water into said tank in the absence of petroleum fluids therein, means for introducing petroleum fluids under pressure into said tank to displace the sea water therefrom, and well pipe extending downwardly into producing formations from said hollow member wherein said well pipe is at least partially supported by said hollow member.

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JACOB SHAPIRO, Primary Examiner

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