This invention relates to offshore oil and gas wells and particularly pertains to an underwater housing or protector for protecting an underwater Christmas tree.

General objects of the invention are to provide improved protection for underwater Christmas trees and to simplify the structure and installation procedures for protecting such Christmas trees.

Offshore wells are becoming increasingly important as a source of petroleum, and considerable progress is apparent in techniques and equipment for underwater drilling. Particularly difficult have been encountered, however, in providing suitable protection for the Christmas tree of underwater wells. It is necessary that, for maintenance purposes, the Christmas tree be readily accessible, but the corrosive effects of water, particularly salt water, make for rapid deterioration of exposed parts. Casings have heretofore been suggested to enclose the Christmas tree in an air-filled chamber, but such casings have not been satisfactory because of difficulties of installation and high cost, and because access to the Christmas tree is impeded.

Specific objects of this invention, accordingly, are to provide a simple, inexpensive, easily installed, permanent protective structure for a Christmas tree, and to provide in such structure a convenient arrangement for gaining access to the Christmas tree.

A further specific object of the invention is to improve the security and stability of mounting or foundation means for housing for an underwater Christmas tree.

The novel features which are believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a sectional side view of an offshore oil well Christmas tree protection system in accord with this invention;

FIG. 2 is a side view on reduced scale and partially in section and broken away of protecting apparatus applicable to the system of FIG. 1 and showing details thereof;

FIG. 3 is a top view of the installed apparatus of FIG. 2, portion being broken away to disclose further details of the apparatus; and

FIG. 4 is a side view of the underwater but above-ground portions of the installed protective apparatus.

As shown in FIG. 1, the protective system for a Christmas tree comprises in part a hollow cylindrical tubular casing 1 formed preferably of iron or steel or of similar material, and having an outwardly extending continuous annular flange at its upper end. Welded internally of the casing are anchor means 3, while the open top of the casing is closed by a cover plate or cap 4 bolted, as by through bolts 5, to flange 3.

In accord with the protective system of this invention, the lower open end 6 of the casing 1 is, during installation, passed down over Christmas tree 7 and forced down into the sand, mud or other material 8 which forms the floor 9 of the body of water in which the well has been drilled. After being so forced down into the bottom material 8 an appropriate distance below the bottom level 9, a quantity of the bottom material within the casing 1 is removed, thereby to lower the water level of the bottom material within the casing to the level shown at 10 in FIG. 1.

Anchor means 11 are welded, by welds 12, to extend outwardly from the well casing 13 at a position at least several inches and up to a foot or two below the top 14 of the well casing 13. Anchor means 3, welded by welds 15 to the protective casing or housing 1 and anchor means 11 of the well casing 13 are disposed at approximately the same level and two or three or more inches above the level 10 of the mud or sand or other bottom material inside casing 1. A quantity of grout is piped in or otherwise placed in position on the internal bottom material surface 10 and is permitted to set into a solid block 16. Sufficient grout is pumped into casing 1 to fill the casing to a level well above anchor means 3 and 11, whereby the anchor means become rigidly embedded in block 16. As shown, the hardened or set grout becomes an annular seal completely filling the area between the outer surface of well casing 13 and the inner surface of protective casing 1. In a typical installation, the block of grout 16 may be approximately one foot in thickness, although in deep water, or if the bottom is soft mud, a greater thickness may be desirable, while for shallow water or for installations on firm sand or rock bottom materials, the block may be less than one foot thick. The size of casings 1 and 13, the depth below bottom level 9 at which lower end 6 of casing 1 is disposed, the strength of currents in the body of water, the desired permanence of the installation and other factors will also govern in part the thickness of block 16.

The upper end 14 of conductor casing 13 is preferably sealed by turning in the upper end to meet well pipe 17 and by welding at 18 between the top of casing 13 and the pipe, although the seal may be made by pouring grout into the conductor casing around pipe 17 and permitting the grout to harden therein.

To install the protective casing, divers may perform the welding at 18 to join the conductor casing to pipe 17 below Christmas tree 7, and they may also weld anchor ears 11 to casing 13. If anchor means 3 have not been welded to the cylindrical protective casing member 1 before installation, these means 3 may also be welded under water by divers.

A petroleum supply conduit, preferably a flexible tube 19, is connected to Christmas tree 7 and carries the petroleum fluid produced by the well through connection 20 which is sealed through the metal seal of the protective casing. Since casing member 1 is permanently installed in a fixed position, connection 20 is preferably made through its side wall rather than through the removable upper wall or cover 4.

Grout is poured into position to form block 16 before the cover 4 is placed in its final position and while the top of the protective casing is open to the body of water. An external grout counterweight such as is shown at 21 may be desired, and such counterweight may take the form of several blocks anchored to casing 1 by ears 22 welded at 23 to the casing, as shown at the left hand side thereof, or the form of a continuous ring similarly anchored as shown in FIG. 2 hereafter described and as indicated in FIG. 3. Such counterweighting will offset the natural buoyancy of the casing when and if air filled and will increase the permanent stability of the casing, but it will be understood that the counterweight 21 may normally be omitted, since the casing 1, when installed, may be filled with water until the last steps of the installation procedure, at which time it will be, in accord with this invention, filled with oil.

Assuming the block 16 to have been formed and conduit 19 to have been connected, cover 4 is placed in position, a neoprene or similar oil and water tight sealing gasket 24 being preferably disposed under cover plate 4 and above flange 2, and nuts and bolts 5 are installed and tightened to make the chamber above block...
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16, under cover 4 and within casing 1 into a liquid impervious chamber 32, which contains Christmas tree 7. Through connections into the dued chamber 33 is provided through top cover 4, one such opening comprising a short length of pipe 25 extending downwardly just through cover 4 and having above the cover a closure valve 26, or a suitable plug, permitting attachment of an external hose or pipe 27 when desired and operable to seal the opening into the chamber. The second opening is provided through a pipe 28 sealed through the cover and terminating in an open lower end 29 disposed immediately above the upper surface of block 16. The external upper end of pipe 28 carries a valve 30, or a suitable plug, and is adapted for attachment to an external hose 31. With the cover in place, protective oil is pumped in through connection 25, and, being lighter than water, the oil fills the protective chamber from the top as water flows out of the chamber through conduit 28. The pumping in of protective oil is continued until oil, or substantially all of the water has been displaced by oil, whereby the Christmas tree 7 becomes completely encompassed in a body 34 of protective oil. It will be apparent that, if desired, water may be pumped out of pipe 28 and oil drawn in through pipe 25 to fill the chamber, rather than pumping the oil in under positive pressure as suggested above. An alternative air may be supplied through pipe 25 and water withdrawn through pipe 28 to fill the chamber 32 with air, and thereafter oil may be pumped in through either pipe to fill the chamber.

From time-to-time gas may accumulate within chamber 32, leaking from Christmas tree valves or gas vents from other sources. Such gas, being lighter than oil, will collect at the top of the chamber 32. A pressure relief valve 35 is provided communicating through cover plate 6 with the upper end of chamber 32, and this valve is set to open when the pressure within casing 1 exceeds the external water pressure by more than a few pounds per square inch, closing automatically as the pressure differential drops below a safe limit. Thus valve 35 operates to prevent excessive pressures within the casing by permitting the escape of gas accumulations which might otherwise cause excessive pressures.

In a typical installation, the cubic content of the chamber 32 within the casing member 1, under cover 4 and above block 16 may be approximately 100 cubic feet, and the buoyant force on a chamber of this size when filled with air is of the order of 3 tons. This buoyant force would normally be only partially compensated by the aggregate weight of the block 16 and of the cover 4 and of casing member 1, but is completely, or at least, substantially completely compensated by the aggregate weight of the contained protective oil body and of the block, cover and casing member. In other words, the net buoyancy of the oil alone, assuming 100 cubic feet as the chamber capacity, would be substantially 1,000 pounds, and the excess of weight of the cover, casing member and block over the weight of water displaced by these elements will normally be in excess of 1,000 pounds. Accordingly, the provision of the protective system of this invention to the oil well will not impose a buoyant or upward force on the well pipe 17 or on the conductor casing 13 which might otherwise tend to pull these well members out of the ground. On the other hand, some resistance to floating up of the well members 13 and 17 is provided by the system of this invention. The relatively small net downward weight of the oil, casing member 1, cover 4 and block 16 will normally be supported by the earth under block 16 and around and under portions of casing member 1 adjacent its lower edge 6, but any tendency of conductor casing 13 to rise would be opposed not only by the weight of the casing 1 and other parts of the protective system but also by the resistance to upward displacement of casing member 1 which is embedded in the earth for most of its height and particularly by the cup-like, earth filled cavity existing under block 16. As shown in FIG. 2, the protective casing member 1 is embedded, as in FIG. 1, in the ground or earth below the floor 9 of the body of the protective system 3, the Christmas tree 7 and the inner portion of casing 1, as is Christmas tree 7. The cover 4 is sealed in place to close the upper end of the casing.

Because of the buoyancy of the casing member 1 when it is air filled, if it is expected at any time to fill the chamber 32 with air, and since it is usually not desired to fill up this impermeable casing, the Christmas-tree containing chamber 32 and the inner portion of casing 1 may be affixed externally of casing member 1. Such counterweight preferably takes the form of a ring or annulus surrounding the casing member and embedding anchor lugs 22 which are welded to and extend outwardly from the casing member. The size of counterweight 21 is such that the weight of the embdedded member is necessary to limit the upward force on conductor casing 13 to the desired maximum. Preferably a trough is dug or pumped out around casing member 1 to receive counterweight 21, and the upper outer edge of the counterweight may be rounded or bevelled as at 23 to provide clearance for net guards hereafter described.

Following the pouring of grout block 16 and the completion of installation operations connected with the Christmas tree and with the connection of conduit 19, cover 4, previously described, is bolted across the top of casing member 1, and to the Christmas-tree-containing chamber 32 to complete the installation. Pipe 33 is connected in place to conduct the oil or other fluid supplied by the well to desired external pumping, storage or utilization facilities. Counterweight 21, after completion of the installation, provides a useful firm and permanent foundation for the casing member 1 and serves to reduce seepage of water down along the casing member and to reduce the effects of currents which might tend otherwise to wash soil from around the casing member. It will be apparent that the added weight of counterweight 21 may permit a substantial reduction in the required weight of the embdedded member 16 and may, accordingly, permit the block 16 to be reduced to the thickness required merely to insure an unbreakable seal and bond between casing member 1 and conductor casing 13.

FIG. 2 is a partially sectional side elevation of a completed installation of a system including a counterweight 21. In FIG. 2, casing member 1 is seen to be for the greater portion of its length embedded in the earth material 8 of the floor of the body of water, that is below floor 9. The casing member surrounds and encloses, in its upper portions of block 16 and of the cover 4 and of upper end portions of well pipe 17 and of conductor casing 13. Cover 4 is in place to close the chamber, and connection valves 26 and 30 are available for exhausting water from and supplying protective oil to the chamber, while pressure relief valve 35 is arranged to exhaust excess gas into the body of water. Counterweight 21 is seen to be rounded off or bevelled at its upper outer edge at 46. Net guards 47, of steel pipe elements or the like, have end portions 48 embedded in the earth material 8 outwardly of the counterweight 21 and the guards are formed to extend in a gradual arc over and across the cover 4. The guard members may be joined into another at the center of cover 4 as shown at 49, or they may merely pass over another at the center. The purpose of guards 47 is to lift fishing or shrimp nets safely over the top of casing member 1. The guards 47 are also effective to reduce the likelihood of an anchor or cable becoming entangled with the protective system and, while they should be sufficiently firmly mounted by its embdedded ends 48 normally to stay in place, it can be pulled up by an anchor which may become entangled, and it should be remov-
able by a diver without difficulty. Such intentional removal by a diver may be necessary from time-to-time, for example, to permit removal of cover 4 for servicing, checking, or maintenance operations on the Christmas tree.

A particular problem encountered with heretofore suggested protective arrangements for underwater Christmas trees has been their susceptibility to damage from or to nets, cables, anchors, boat keels and the like. The arrangement of this invention, wherein the cover 4 is positioned not higher than a foot or two above level 9, and, where necessary, as low as floor level 9, and in which the installation is preferably guarded by net guards 47, is very unlikely to be damaged by or to inflict damage on nets, boat bottoms, anchors, cables or other moving objects which might approach or pass over the installation.

It will be understood that the net guard is a relatively inexpensive and easily replaced assembly, and that damage to the guard, or inadvertent displacement or removal of the guard, does not make the protective system ineffective, and the guard may be replaced at slight expense.

In FIG. 2, as in other figures of the drawings, several elements have been designated by numeral but, to avoid repetition, without specific description. Numerical designations throughout the drawings have been consistently applied and the description of each element in connection with any one figure is equally applicable to the element identified by like numeral in any other figure.

FIG. 3 is a top plan view of the completed installation. Cover 4 is seen to be bolted down by bolts 5 to casing member 1, indicated in broken lines. Net guard members 47 extend over the cover 4 and tend to prevent external objects from catching on the cover 4, valves 26, 30 or 35 or on other parts of the system.

Counterweight 21 is indicated in broken lines, in that it may be included or omitted as heretofore explained.

As seen in full side view in FIG. 4, the upper end of casing member 1 protrudes above floor 9 a relatively short distance, and net guards 47 are arranged to cause objects moving across floor 9 or through the water to pass over cover 4 and over valves 26 and 30 and the other portions of the installation on which such objects might catch.

It will be understood that the water level 42 of the ocean or other body of water 49 is in an exemplary relation only and that the depth of water in which the herein described system may be advantageously employed will vary between only a foot or two at high tide to any depth at which well drilling is possible.

This application is a continuation of my co-pending application Serial No. 543,523, entitled Underwater Christmas Tree Protector, filed October 28, 1955, and now abandoned.

While only certain preferred embodiments of this invention have been shown and described by way of illustration, many modifications will occur to those skilled in the art and it is, therefore, desired that it be understood that it is intended in the appended claims to cover all such modifications as fall within the true spirit and scope of this invention.

What is claimed as new and what it is desired to secure by Letters Patent of the United States is:

1. In an offshore petroleum well wherein an underwater Christmas tree is disposed above the upper end of the well casing, a removable covering disposed approximatelv at the level of the floor of the body of water, an elongated vertically disposed tubular protective casing extending downwardly a substantial distance into the earth below said floor level and a substantial distance below the top of said well casing to a lower end, said casing extending downwardly a substantial distance above said Christmas tree and a substantial distance above said floor level and terminating in an upper edge below the water level, inwardly directed anchor means affixed internally to said protective casing spaced above its said lower end and spaced below the level of said top of said casing, outwardly directed anchor means affixed externally to said well casing and positioned at substantially the level of said first mentioned anchor means, said level of said anchor means being substantially below said floor level, said protective casing having therein a quantity of earth extending upwardly above said lower end of said protective casing and terminating in an upper surface below said level of said anchor means and below said floor level, a block of grout set upon said upper surface within said protective casing and completely filling the space between said well casing and said protective casing from said surface upwardly to a level substantially above said anchor means but below said top of said well casing, said block embedded said anchor means of said well casing and of said protective casing, a removable cover plate affixed and hermetically sealed to said upper edge of said protective casing, two conduit connections through said cover plate for filling and draining said protective casing, one said connection terminating internally of said protective casing adjacent said cover plate and the other said connection terminating internally of said casing immediately above the upper surface level of said block, valve means respectively connected to said connections externally of said protective casing, said valve means being respectively operable to seal off said connections, and at least one conduit connected to said Christmas tree to receive petroleum from said well, said conduit for petroleum being sealed through said protective casing below said upper edge thereof.

2. In an offshore petroleum well having a petroleum well pipe extending into the earth and terminating in a Christmas tree at approximately the level of the floor of the body of water and a well casing surrounding said pipe and terminating adjacent and below said Christmas tree, the protective system which comprises a protective casing surrounding said Christmas tree and extending upwardly thereabove and extending downwardly to a level substantially below said floor level and substantially below the level of and surrounding the terminal upper end of said well casing, earth extending upwardly internally of said protective casing to an internal earth surface substantially below said floor level and below said level of said terminal upper end of said well casing, anchor means disposed internally of said well casing and affixed to the inner surface of said protective casing and to the outer surface of said well casing at a level between and spaced from said internal earth surface and said level of said terminal upper end of said well casing, a solid grout block positioned on said internal earth surface and embedding said anchor ears and filling completely between said well casing and said protective casing to a level below said Christmas tree, means sealing between said well pipe and said upper end of said well casing, a removable cap hermetically sealed across the open upper end of said protective casing, two conduits sealed through said cap adapted and arranged selectively to fill said protective casing with oil, means to seal off said conduits, and a plurality of annular members passing over said cap and anchored at their respective ends in said floor externally spaced on opposite sides of said protective casing.

3. In an underwater oil well having an oil well pipe, a conductor casing and a Christmas tree, an oil-filled protective housing for the Christmas tree, comprising a vertically disposed hollow cylindrical casing means affixed to said Christmas tree and a cylindrical side wall
of said housing, and a removable plate sealed to and covering the upper end of said member forming the upper wall for said housing at position in an annulus surface through said plate for filling and draining protective oil from said housing, a conduit for oil from said well connected to said Christmas tree in said housing and sealed through said side wall, and means sealing between the upper end of said conductor casing and the oil well pipe. 4. In an under-water Christmas tree, a removable plate sealed to and covering the upper end of a conductor casing, said protection comprising an annular block of grout sealed to said conductor casing and extending outwardly therefrom at a level below said floor level and disposed upon the surface of underlying earth material, a body of oil encompassing said upper end of said conductor casing and said Christmas tree and supported on the upper surface of said block, a cylindrical vertically extending wall laterally enclosing said body of oil said wall being sealed to and laterally surrounding said block and having anchor means integral therewith extending into said block, and a removable plate sealed to the upper end of said wall above said Christmas tree and completing with said wall and block a sealed chamber filled with said body of oil.

5. Protection for an offshore petroleum well wherein an under water Christmas tree is disposed above the upper end of the conductor casing, and said upper end is disposed approximately at the level of the floor of the body of water, an elongated vertically disposed cylindrical protective casing having a diameter at least twice the diameter of said conductor casing and extending downwardly a substantial distance into the earth below said floor level and a substantial distance below the top of said conductor casing and extending upwardly a substantial distance above said Christmas tree and at a substantial distance above said floor level and terminating in an upper edge below the water level, said protective casing being disposed substantially coaxially surrounding said conductor casing, inwardly directed anchor means affixed internally to said protective casing spaced above its said lower end and spaced below the level of said top of said conductor casing, outwardly directed anchor means affixed externally to said conductor casing and positioned at substantially the level of said first mentioned anchor means, said level of said anchor means being substantially below said floor level, said protective casing having therein a quantity of earth extending upwardly above said lower end of said protective casing and terminating in an upper surface internally of said casing below said level of said anchor means and below said external floor level, a block of grout set upon said internal upper surface within said protective casing and completely filling the space between said conductor casing and said protective casing from said surface upwardly to a level substantially above said anchor means but below said top of said conductor casing, said block embedding said anchor means of said conductor casing and of said protective casing, a removable cover plate bolted and hermetically sealed to said upper edge of said protective casing, two conduit connections through said cover plate adapted and arranged to supply and remove fluids to and from the interior of said protective casing, one said connection terminating internally of said protective casing adjacent said cover plate and the other said connection terminating internally of said casing immediately above the upper surface level of said block, means externally of said protective casing selectively to seal off said connections, a third conduit connection through said cover plate communicating with the interior of said圣诞 tree at a portion inside said Christmas tree below said cover plate, a pressure-responsive relief valve closing said third conduit connection externally of said casing above said cover plate, and at least one petroleum supply conduit connected to said Christmas tree to receive fluid from said well sealed through said cylindrical protective casing below said upper edge thereof.

6. In an under-water Christmas tree extending through the earth and terminating in a Christmas tree as substantially as the lower floor level of the body of water and a well casing surrounding said pipe and terminating adjacent below said Christmas tree, the protective system which comprises a protective casing surrounding said Christmas tree and extending upwardly therefrom and extending downwardly to a level substantially below said floor level and substantially below the level of and surrounding the terminal upper end of said well casing, earth extending upwardly internally of said protective casing to an interface with said surface substantially below said floor level and below said level of said terminal upper end of said well casing, a solid grout block positioned on said internal earth surface and filling completely between said well casing and said protective casing to a level below said Christmas tree, anchor means for said grout block imbedded therein and fixedly attached to and extending into said block from the outer surface of said well casing and fixedly attached to and extending into said block from the inner surface of said protective casing, means sealing between said well pipe and said upper end of said well casing, a removable cap hermetically sealed across said upper end of said protective casing, two conduits sealed through said cap and arranged selectively to fill said protective casing with oil, and means to seal off said conduits.

7. Protection for an offshore oil well of the type having adjacent the floor level of the body of water an under water Christmas tree and the upper end of a conductor casing, said protection comprising an annular block of grout sealed to said conductor casing and extending outwardly therefrom and disposed upon the surface of underlying earth material, a cylindrical vertically extending wall laterally enclosing said Christmas tree and said upper end of said conductor casing, said well being sealed to and laterally surrounding said block and having anchor means integral therewith extending into said block, and a removable plate sealed to the upper end of said wall above said Christmas tree and completing with said wall and block a sealed chamber.

8. Protection for an offshore oil well of the type having adjacent the floor level of the body of water an underwater Christmas tree and the upper end of a conductor casing, said protection comprising an annular block of grout sealed to said conductor casing and extending outwardly therefrom and disposed upon the surface of underlying earth material, a cylindrical vertically extending wall laterally enclosing said Christmas tree and said upper end of said conductor casing, said well being sealed to and laterally surrounding said block and having anchor means integral therewith extending into said block, anchor means integral with said conductor casing extending outwardly therefrom and embedded in said block, and a removable plate sealed to the upper end of said wall above said Christmas tree and completing with said wall and block a sealed chamber.

9. In an underwater oil well having a conductor casing, an oil well pipe and a Christmas tree, an oil-filled protective housing for the Christmas tree, comprising a vertically disposed hollow cylindrical casing member embedded in the bottom material of the body of water and surrounding an upper end portion of the conductor casing, the Christmas tree of said well, a block of grout imbedded within said casing member and sealing between said conductor casing and said casing member and forming a lower wall of said oil filled housing, said block being disposed upon the surface of underlying earth material, the walls of said casing member above said block forming the cylindrical wall of said housing, and a removable plate sealed to and covering the upper end of said member forming the upper wall for said housing, at least two conduit means opening through said plate for filling
and draining protective oil from said housing, a conduit for oil from said well connected to said Christmas tree in said housing and sealed through said side wall, and means sealing between the upper end of said conductor casing and the oil well pipe.

10. Protection for an offshore oil well of the type having adjacent the floor level of the body of water an underwater Christmas tree and the upper end of a conductor casing, said protection comprising an annular block of grout sealed to said conductor casing and extending outwardly therefrom at a level below said floor level and disposed upon the surface of underlying earth material, a body of oil encompassing said upper end of said conductor casing and said Christmas tree and supported on the upper surface of said block, a cylindrical vertically extending wall laterally enclosing said body of oil, said wall being sealed to and laterally surrounding said block and having a portion extending below said block, and a removable plate sealed to the upper end of said wall above said Christmas tree and completing with said wall and block a sealed chamber filled with said body of oil.

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