

Jan. 15, 1957

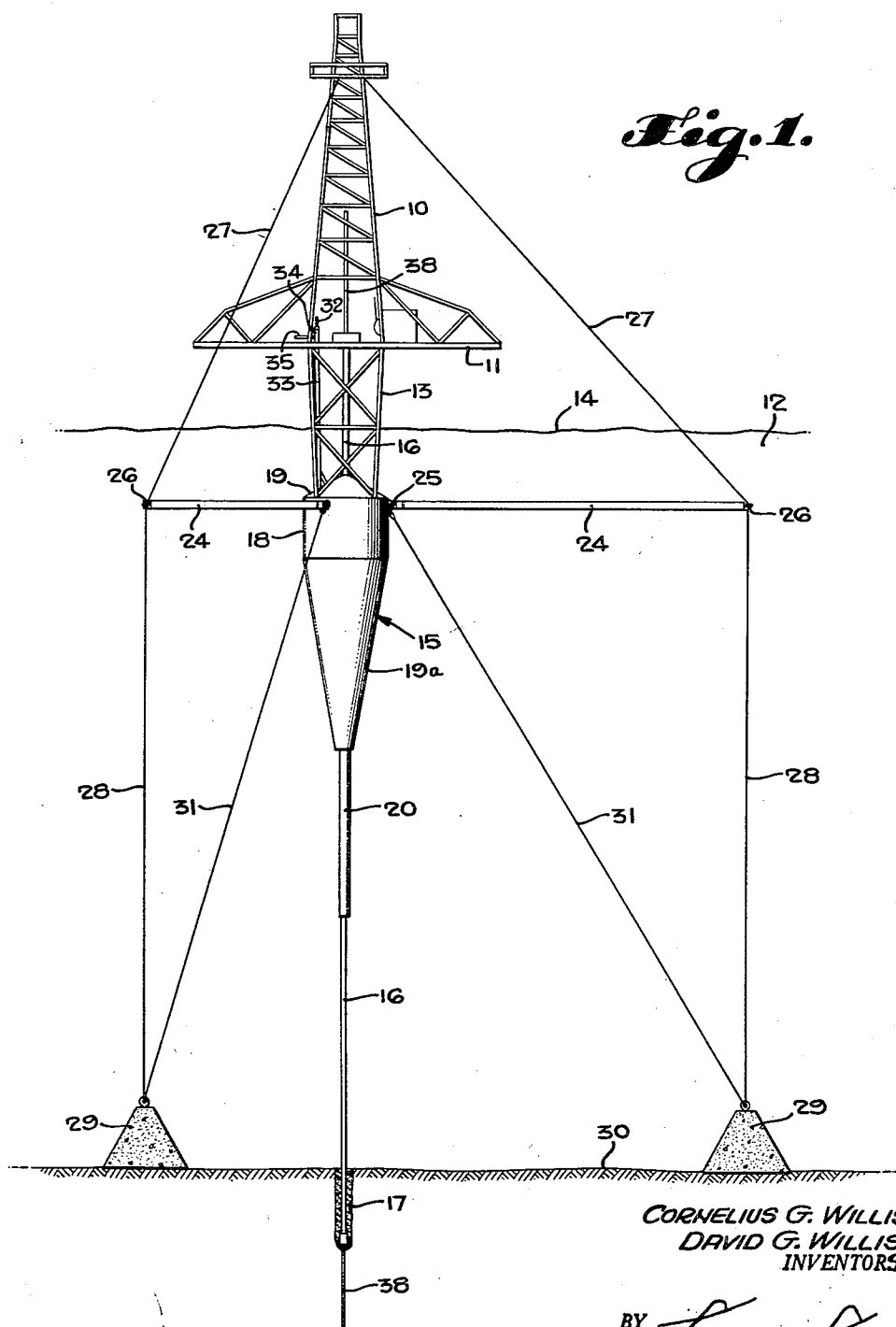
C. G. WILLIS ET AL

2,777,669

MARINE WELL DRILLING APPARATUS

Filed Dec. 27, 1948

5 Sheets-Sheet 1



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5 Sheets-Sheet 2



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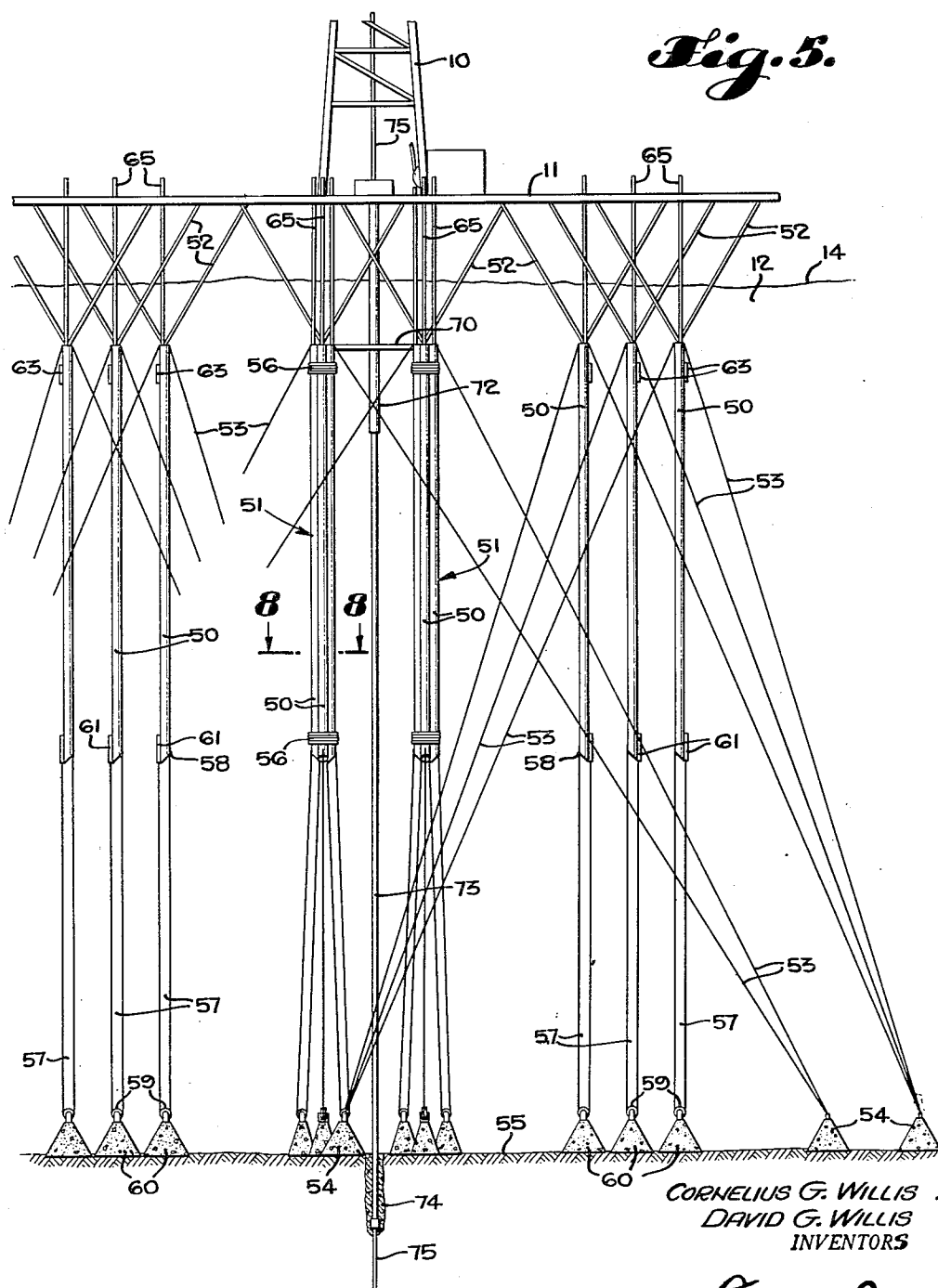
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5 Sheets-Sheet 3



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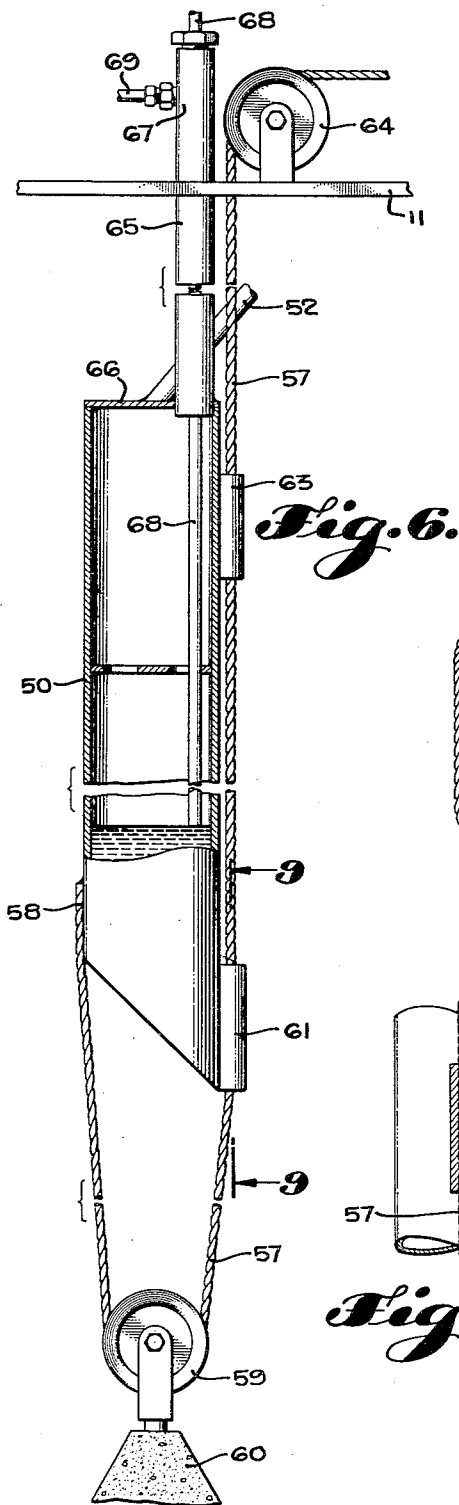


Fig. 6.

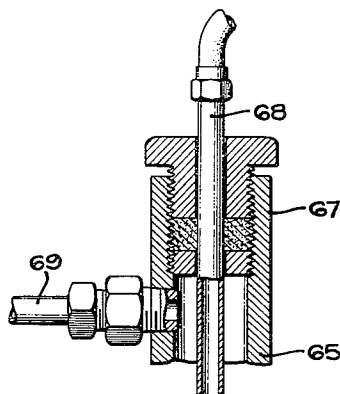


Fig. 7.

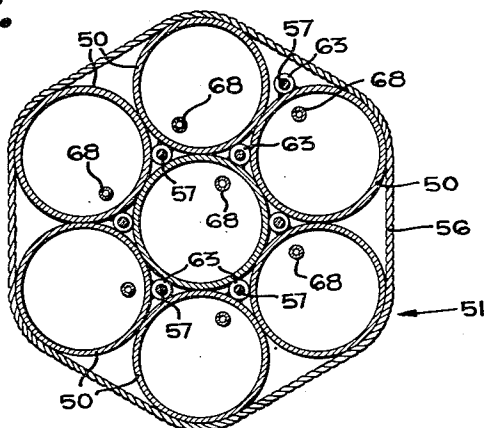


Fig. 8.

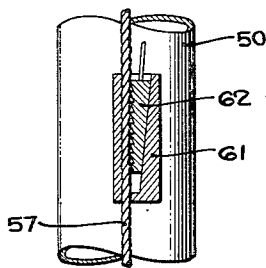


Fig. 9.

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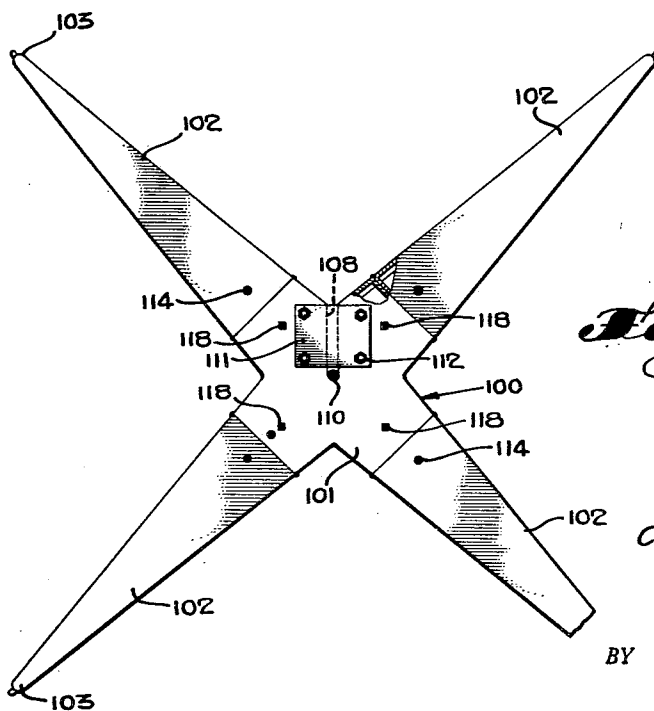
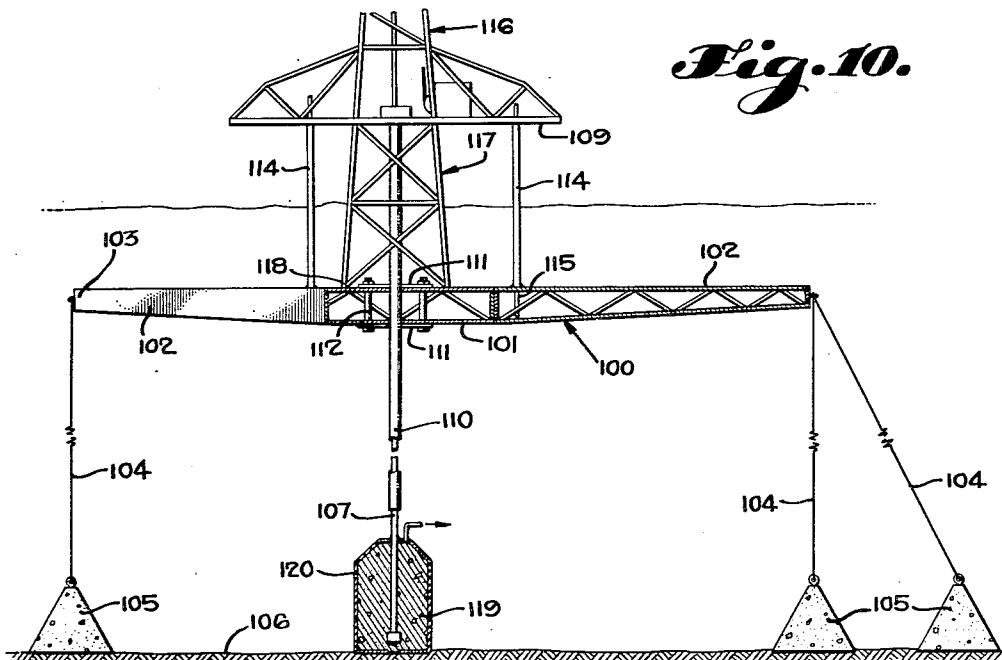
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5 Sheets-Sheet 5



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MARINE WELL DRILLING APPARATUS

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8 Claims. (Cl. 255—2.5)

This invention relates to a submerged buoyant support and is particularly directed to supporting devices for use in the ocean or other large bodies of water, which devices may be used for oil well drilling or production operations or for other purposes requiring rigid artificial supports such as, for example, floating docks or air dromes. While various types of submerged buoyant supports are described hereinafter in connection with oil well drilling operations, it will be understood that the advantageous features of our invention are not confined to this particular use.

A primary object of our invention is to provide a support for marine oil well equipment which may be employed in relatively deep water.

An important object of this invention is to provide an artificial submerged or partly submerged island, platform or false bottom which has sufficient buoyancy to support conventional rotary drilling equipment, casing, etc., and which may be maintained below its normal floating position by means of the plurality of cables, chains or other elements attached to the ocean bottom. Our submerged buoyant support differs from a barge or boat floating on the surface because such a vessel must rise and fall with the tide and is affected by wave action. Our submerged buoyant support differs from barges which may be sunk to rest on the bottom in relatively shallow water, because such barges are not useable in deep water for well drilling operations.

Another object of our invention is to provide a submerged buoyant support for well drilling apparatus, the support being positioned below the surface for a sufficient distance to avoid adverse effect of wave action and tides.

Another object is to provide a novel form of marine well drilling support utilizing laterally extending compression members to which guy wires from the derrick structure and ocean bottom may be attached for obtaining lateral stability.

Another object is to provide novel means for varying the buoyancy of the submerged support.

A related object is to provide supporting structure including a plurality of relatively long vertical buoyant pilings, each having a high center of buoyancy and a low point of attachment for a guy wire extending to the ocean bottom, whereby each of the pilings has inherent lateral stability.

A further object is to provide a submerged buoyant support having relatively great horizontal dimensions as compared to its vertical dimensions, depending for lateral stability upon its width and rigidity and being tied to the ocean bottom by a plurality of tension members.

Other more detailed objects and advantages will appear hereinafter.

In the drawings:

Figure 1 is a side elevation in diagrammatic form illustrating a preferred embodiment of our invention.

Figure 2 is a side elevation partly broken away shown on an enlarged scale and illustrating the details of construction of the buoyant member.

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Figure 3 is a sectional side elevation showing constructional details of anchoring the upper and lower ends of the tubular tension element.

Figure 4 is a plan view partly broken away taken substantially on the lines 4—4 as shown in Figure 2.

Figure 5 is a side elevation in diagrammatic form showing a modification.

Figure 6 is a side elevation partly in section showing details of construction and anchorage of the buoyant members shown in Figure 5.

Figure 7 is a sectional detail showing the construction of the upper end of the buoyancy control extensions employed in connection with each of the buoyant members shown in Figure 6.

Figure 8 is a sectional plan view taken substantially on the lines 8—8 as shown in Figure 5.

Figure 9 is a sectional elevation taken substantially on the lines 9—9 as shown in Figure 6.

Figure 10 is a side elevation in diagrammatic form showing a further modification.

Figure 11 is a plan view of the buoyant member illustrated in Figure 10.

Referring to the drawings, the rotary well drilling apparatus includes a derrick 10 and drilling platform 11 adapted to be supported over a body of water 12. The derrick 10 is carried on a substructure 13 which extends downwardly below the water level 14 and rests on the upper end of the floating or buoyant member 15. This buoyant member displaces a relatively large amount of water in comparison to its weight and would normally float almost completely out of the water. The buoyant member 15 is maintained in a submerged position below its normal free floating position by means of a tension element 16 which may comprise a conductor casing made up of a plurality of joints connected end to end. The conductor casing 16 extends downwardly from a location adjacent the drilling platform 11 through the buoyant member 15 and is secured to the ocean floor by the cement body 17. The buoyant member 15 may include a cylindrical portion 18 having a conical cap 19 at its upper end and a frusto-conical lower projection 19a extending downwardly therefrom. A center pipe 20 extends axially through the buoyant member 15 and is fixed at the upper and lower ends thereof by any convenient means such as by welding. As shown in Figure 3 the center pipe 20 is secured to the conductor casing 16 by means of a pipe slip assembly generally designated 21. This slip assembly includes a plurality of wickered slip elements 22 constrained to move on a tapered mandrel 23 and to move into engagement with the inner wall of the conductor casing 20. The slip assembly 21 therefore tensions the conductor casing 16 and enables it to hold the buoyant member 15 below its normal free floating position.

A plurality of struts 24 extend radially outwardly from the buoyant member 15. These struts 24 preferably are submerged below the water level 14 and may be attached to the buoyant member 15 by means of fittings 25. The outer end of each strut is provided with a terminal fitting 26. A guy wire 27 extends from each terminal fitting 26 to the upper portion of the derrick 10. Hold-down cables 28 also extend from the fittings 26 to the anchor blocks 29 resting on the ocean floor 30. Inclined hold-down cables 31 also extend from the anchor blocks to the buoyant member 15 for stability against lateral movement.

It is contemplated that the drilling equipment to be employed on the platform 11 and in the derrick 10 shall be of conventional form. In such case the total weight carried by the substructure 13 varies over a wide range. Thus, in the operation of setting casing a very heavy load may be supported by the derrick 10, whereas during initial stages in the drilling operation the load on the derrick 10

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may be very low. If the buoyancy of the member 15 were constant the tension in the casing 15 and in the hold-down cables 31 would vary over a wide range. The tension would be at a maximum when the load on the derrick was at a minimum, and vice versa. In order to avoid this wide variation in tension and in order to reduce the required size of the cables and casing 16 means are provided for varying the buoyancy of the member 15 to compensate for the variation in weight carried by the derrick 10. As shown in the drawings this means includes a spear tube 32 which extends downwardly through the pipe 33 which is fixed in the cap 19 of the buoyant member 15. A stuffing box 34 of the type shown in Figure 7 is mounted at the upper end of the pipe 33 to permit the tube 32 to be drawn axially therethrough. A side outlet 35 is provided which may be connected to any convenient source of air pressure. When it is desired to decrease the buoyancy of the member 15, water is pumped into the upper end of the tube 32 so that it is delivered into the interior of the member 15. When it is desired to increase the buoyancy, air pressure is admitted from the side outlet 35. The pressure within the member 15 then forces water upwardly through the spear tube 33. By moving the tube 32 to position the lower end thereof at the desired level, the amount of water remaining in the interior of the buoyant member 15 may be accurately controlled. I prefer to taper the lower end 19 of the buoyant member 15 so that the collapse strength of the member increases as the depth of water increases. This simplifies the construction of the vessel and permits the use of uniform thickness of material for the wall thereof.

Internal bracing struts 36 may be provided for stiffness, and additional internal framework or struts may be utilized if desired. In operation the buoyant member 15 with its integral center pipe 20 is floated to position while partly filled with water to reduce its buoyancy. The anchor blocks 29 are placed in position on the ocean floor and the guy wires 31 are installed to hold the member 15 against lateral movement. The horizontal struts 24 are placed in position and the guy wires 27 and hold-down cables 28 installed. The rotary drilling equipment on the derrick platform 11 or on an attendant barge (not shown) is then utilized in a conventional manner to lower the conductor casing 16 through the center pipe 20. A drill bit 37 is carried on the lower end of the casing 16 and when it reaches the ocean floor 30 the casing 16 is turned by means of the rotary drilling equipment to cause the drill bit to cut into the ocean floor. If necessary, mud fluid is delivered under pressure to the interior of the casing 16 to carry the cuttings away from the bit. After the bit has entered the formation for a predetermined distance, cement is pumped down through the interior of the casing 16 to fill the drilled hole with the cement body 17. This serves to anchor the casing 16 relative to the ocean floor.

The member 15 is reduced in buoyancy by adding water to the interior thereof through the spear tube 32 so that the center pipe 20 is lowered slightly with respect to the conductor casing 16. The slip assembly 21 is then actuated to secure the lower end of the center pipe 20 to the casing 16. The buoyancy of the member 15 is then returned to its proper value by forcing water from the interior thereof out through the spear tube 32. A drill pipe 38 is then run into the conductor casing 16, and this drill pipe is provided with a metal cutter 39 at its lower end which cuts a hole through the bit 37. The drill pipe 38 and metal cutter 39 are then withdrawn in order that a conventional formation drilling bit (not shown) may be installed on the lower end of the drill pipe. The drilling operation then proceeds in the conventional manner.

The buoyant member 15 is preferably maintained at a level below wave and tide action so that a stable foundation mounting is provided for the substructure 13 and derrick 10. The substructure 13 is preferably formed so that it offers a minimum of resistance to wave action.

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The drilling platform 11 is located well above the high water level and out of reach of waves at high tide. The buoyancy of the member 15 may be varied to compensate for changes in weight supported on the derrick 10.

The modification shown in Figures 5 to 9 supports the derrick 10 and drilling platform 11 above the action of waves at high tide as set forth above. Instead of employing a single buoyant member, however, a large number of hollow pilings 50 are employed and are distributed under the platform 11 and clustered in groups 51 under the legs of the derrick 10. Suitable substructure 52 including angular braces supports the platform and derrick 10 from the upper ends of the pilings 50 which are positioned below wave and tide action. Inclined guying cables 53 are connected to the upper ends of the pilings 50 and are attached to concrete blocks 54 resting on the ocean floor 55. As shown in Figure 8 the groups or clusters 51 may each include a plurality of individual buoyant pilings 50 each comprising a length of pipe sealed at its ends. The groups may be lashed together by suitable cable 56.

Means are provided for anchoring the lower end of each of the buoyant piling 50 with respect to the ocean floor 55, and as shown in Figure 6 this means may include a hold-down cable 57 secured to the lower end of the piling at 58 passing around a pulley 59 anchored to the concrete block 60. The cable then passes upwardly through the slip housing 61 also carried at the lower end of the buoyant piling 50. A tapered slip 62 within the housing acts to prevent upward movement of the buoyant piling 50 with respect to the stationary cable 57. The cable may extend upwardly through a guide 63 near the upper end of the buoyant piling 51 and pass over a pulley 64 on the derrick platform 11. Suitable means (not shown) are provided for securing the upper end of the cable 57 with respect to the platform 11. Suitable means are provided for varying the buoyancy of each of the buoyant pilings 50, and as shown in the drawings this means includes an extension pipe 65 welded to the upper closure 66 of the piling 50 and extending upwardly to the derrick platform 11. A stuffing box assembly 67 is located on the upper end of the pipe 65 to permit the spear tube 68 to be moved vertically therein while preserving a seal at the point where the spear tube enters the pipe 65. Compressed air admitted through the lateral inlet 69 is effective to force water from the interior of the piling 50 out through the spear tube 68 in the same manner as described in connection with the embodiment of our invention shown in Figure 2. Water may be added to the interior of the piling through the spear tube 68 if desired. Crossbracing 70 may be provided to connect the upper end of the clusters 51 and to provide lateral support for the center pipe 72 which extends upwardly adjacent the level of the drilling platform 11. The conductor casing 73 may be installed and anchored by means of the cement body 74 in the same manner outlined above. The conventional drill string 75 operates through this conductor casing 73.

In the modification shown in Figures 10 and 11 the buoyant member 100 comprises a central buoyant body section 101 having a plurality of horizontally radiating arms 102 attached thereto. Each of the arms 102 may taper if desired from a relatively large cross-section adjacent the body 101 to a relatively small cross-section adjacent its outer end 103. Hold-down cables 104 are attached to the outer end 103 of each of the arms 102 and are secured to concrete blocks 105 resting on the ocean floor 106. In this form of our invention lateral stability is afforded by the width and rigidity of the buoyant member itself. The hold-down cables 104 and the conductor pipe 107 maintain the member 100 in horizontal position and hold it submerged below wave and tide action. The arms 102 may be attached to the central body 101 by any convenient means such as, for example, by bolting or by welding. A slot 108 may be provided on the body for reception of the center pipe 110 which extends down-

wardly from the drilling platform 109. Companion plates 111 connected by bolts 112 extend across the slot 108 to compensate for the loss of stiffness occasioned by the slot 108. The plates 111 may be removed if desired after completion of the well in order that the buoyant member 100 may be removed laterally from the center pipe 110.

Means are provided for varying the buoyancy of the arms 102 and body 101, and as shown in the drawings this means may include the stationary upright pipes 114 having movable spear tubes 115 mounted concentrically within them. The manner of introducing and discharging water from each of the buoyant units making up the member 101 may be substantially similar to that described above. The derrick 116 rests on the substructure 117 which in turn is supported on the body 101. The legs of the substructure 117 are preferably positioned as shown at 118.

The conductor pipe 107 extends downwardly through the center pipe 110 and is anchored in the concrete block 119 which rests on the ocean floor 106. This block may be conveniently formed by placing a shell 120 on the ocean floor and then pumping it full of concrete delivered through the conductor pipe 107. The conductor pipe 107 may be anchored with respect to the center pipe 110 by means of a slip assembly (not shown) which may be similar to that illustrated in Figure 3. After the concrete forming the block 119 has "set" a drill string is run in through the conductor pipe 107 to drill out the cement plug and drill into the formation below the ocean floor 106 in the conventional manner.

While we have described the device in connection with the rotary drilling apparatus, it will be understood that any form of well drilling apparatus may be employed.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. A buoyant load-carrying support floating in a body of water in a submerged position, the support including a plurality of horizontally extending buoyant arms radiating from a central body, structural elements carried on the body and extending upwardly above the water level to carry a load, and hold down cables at the ends of the arms engaging means on the floor of the body of water for maintaining the support in submerged position.

2. A support for a marine oil well installation including a derrick, comprising in combination a plurality of submerged horizontally extending buoyant arms radiating from and secured to a central body, structural elements carried on the body and extending upwardly above the water level to carry the oil well derrick, and hold down means at the outer ends of the arms engaging means on the ocean floor for maintaining the support below wave and tide action.

3. A support for a marine oil well installation including a derrick, comprising in combination a plurality of submerged horizontally extending buoyant arms radiating from and secured to a central body, the arms tapering from a relatively large cross-section adjacent the body to a relatively small cross-section at their outer ends, structural elements carried on the body and extending upwardly above the water level to carry the oil well derrick, and hold down means at the outer ends of the arms engaging means on the ocean floor for maintaining the support below wave and tide action.

4. A support for a marine oil well installation including a derrick, comprising in combination a buoyant member having a plurality of submerged horizontally extending arms, means for maintaining the support below wave and tide action, said means including hold-down cables at the outer ends of the arms engaging means on the ocean floor,

said means also including a tubular tension element secured relative to the body and having its lower end fixed in a block resting on the ocean floor.

5. Supporting apparatus for a marine oil well installation including a derrick, comprising in combination: a floating member adapted to support the derrick, a plurality of tension elements secured to the ocean floor and adapted to maintain the floating member at a level below its free-floating position, a plurality of submerged compression struts radiating outwardly from the floating member, guy wire means attached to the derrick and extending to the outer ends of said struts, and cable means extending from the outer ends of the struts and secured to the ocean floor.

6. Supporting apparatus for a marine oil well installation including a derrick, comprising in combination: a submerged floating member adapted to support the derrick, a plurality of tension elements secured to the ocean floor and adapted to maintain the floating member in a submerged position below wave and tide action, a plurality of submerged compression struts radiating outwardly from the floating member, pivot means connecting the inner ends of the compression struts to the floating member, guy wire means attached to the derrick and extending to the outer ends of said struts, and cable means extending from the outer ends of the struts and secured to the ocean floor.

7. A buoyant load carrying support floating in a body of water in a submerged position, a support including a plurality of horizontally extending arms radiating from a central body, structural elements carried on the body and extending upwardly above the water level to carry a load, and hold down cables at the ends of the arms secured relative to the floor of the body of water for maintaining the support in submerged position.

8. In combination: marine oil well apparatus including a platform and a derrick mounted upon the platform, a fully submerged floating member constituting the sole supporting means for said apparatus and positioned directly below the derrick, the member having a centrally positioned vertical opening extending therethrough, structural framework means extending upwardly from the submerged floating member to maintain the said apparatus above water level, means providing a vertical conductor conduit for well tools extending from above water level and axially insertable centrally through said vertical opening in the submerged floating member to the ocean floor, and inclined tension elements secured to means on the ocean floor and to said floating member for maintaining said floating member in submerged position and for minimizing lateral movement thereof.

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