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Hubby

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[54] **ANCHORING METHOD FOR OFFSHORE MARINE STRUCTURES**

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[52] **U.S. Cl.** **61/53.6,** 61/46, 61/53.62

[51] **Int. Cl.** **E02d 5/44**

[58] **Field of Search** 61/53.52, 53.58, 61/53.6, 53.62, 53.64, 53.68; 175/286

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[57] **ABSTRACT**

The invention relates to a method for forming an anchoring or foundation base for an offshore marine structure. Said method includes the embedment of an elongated support member lower end, which extends downwardly into the substratum and upwardly through the body of water. The lower end of said member is firmly fixed in the substratum by the application of a cement jacket thereabout which terminates at the lower end of the column in an outwardly projecting, partially bulbous cement base.

The apparatus for achieving said foundation includes an open structured anchoring cage which depends from the support member to form a firm engagement with the cement base.

4 Claims, 6 Drawing Figures

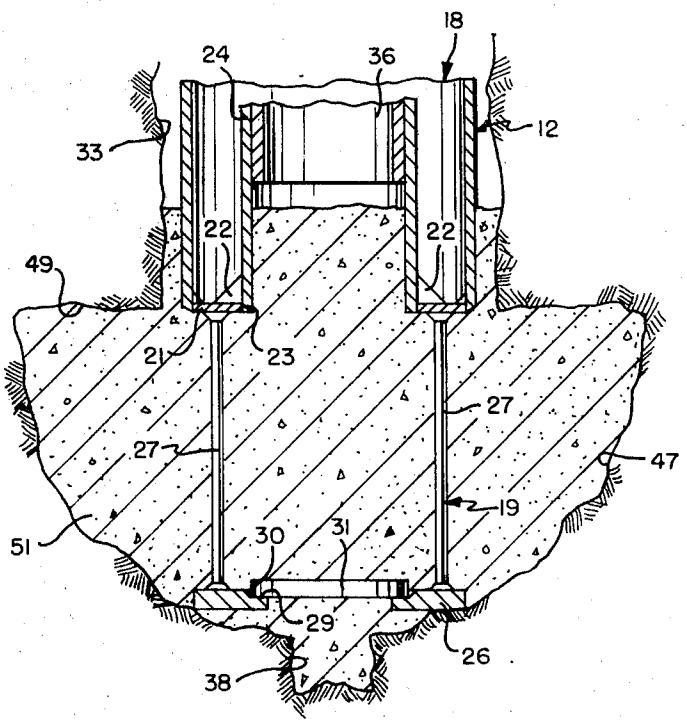


FIG. 1

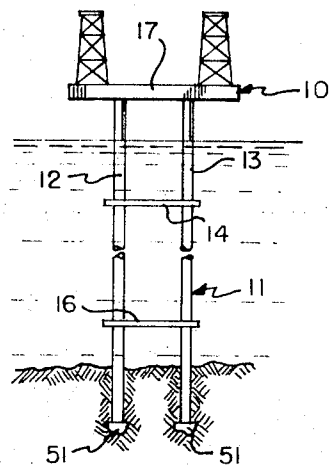


FIG. 2

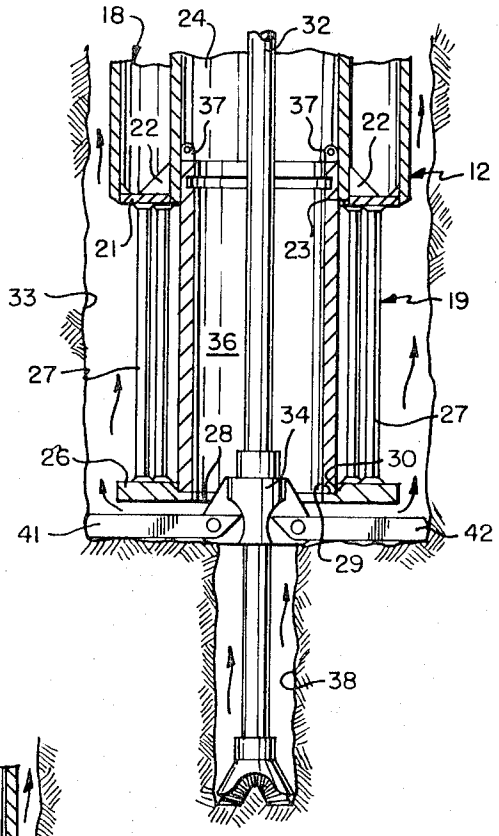
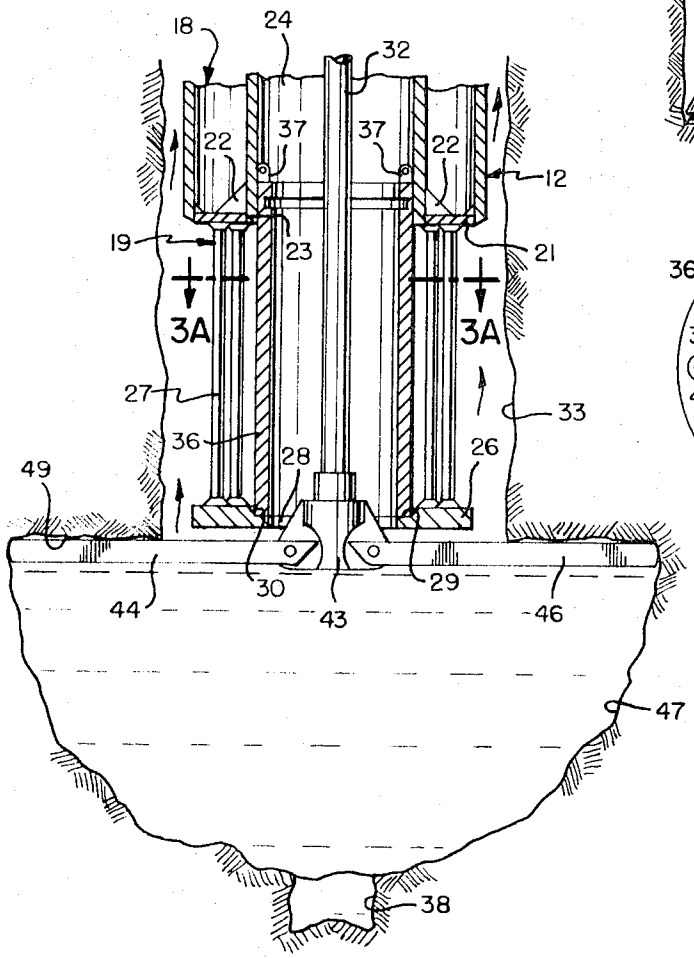


FIG. 3



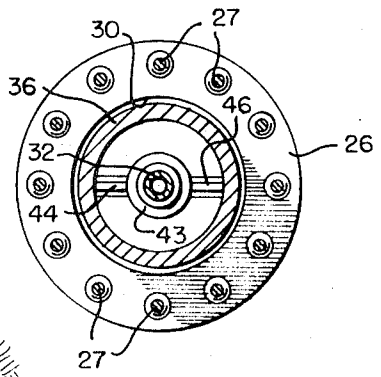


FIG. 3A

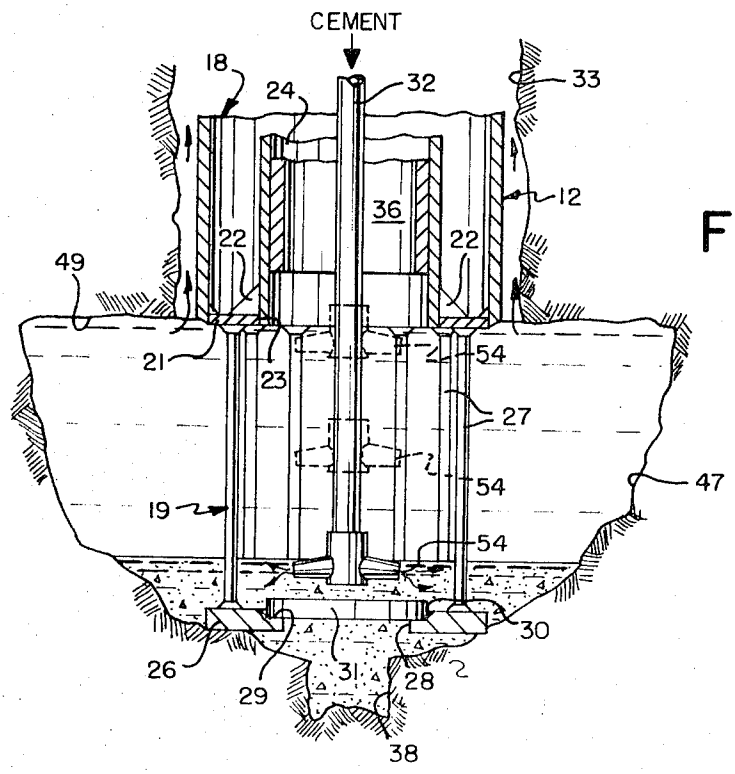

CEMENT
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FIG. 4

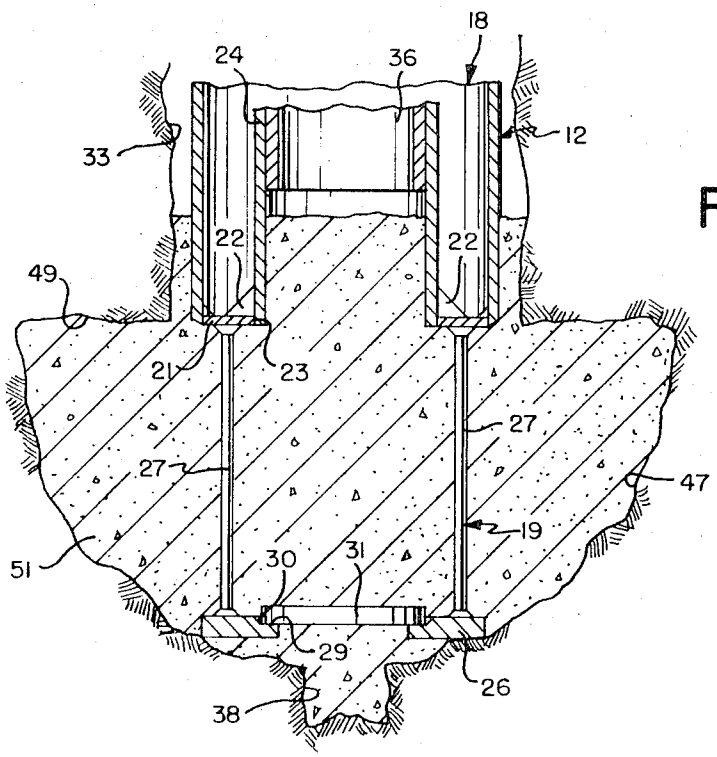

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FIG. 5

ANCHORING METHOD FOR OFFSHORE MARINE STRUCTURES

BACKGROUND OF THE INVENTION

In the positioning of a floatable or semi-submersible marine structure at an offshore body of water, the method normally followed is to anchor the structure by use of anchors and lines which radiate downwardly from the structure. In the instance of self-supporting or buoyant structures for deep water use, it has been found feasible to mount the entire unit on a single upstanding column-like member that is controllably buoyant in the water such that the upper end projects beyond the water's surface. The lower end of such a buoyant member however must be firmly anchored such that the column will, under the influence of wind, waves and other elements, be permitted only a limited degree of oscillatory movement about a fixed lower end.

To achieve such a purpose, although the entire marine structure is free to oscillate through the water, the lower or base end must be so firmly embedded or weighted into the ocean floor to in effect tether the mobile column. Adequate anchoring can assume a number of efficient forms presently known and including primarily, permanent piling, removable anchor piles, or the like. These pile forms are characterized by being normally embedded downwardly into the substratum a sufficient distance to be firmly held in position by the subsoil. The piles can thus resist any withdrawing forces imposed by lateral movement of either the buoyant column or the abovesurface structure.

While the pile type anchoring system is satisfactory in most locations, in many instances the character of the substratum is such that it possesses only minimum qualities for pile retention in resistance to a withdrawing force. Substrate of this nature are found in many parts of the world and are characterized by a deltaic or underconsolidated consistency that prohibits a firm grip on relatively smooth surfaced pile sides.

The anchoring pile or piles could if necessary be driven to an extent that they pass beyond the deltaic layer or layers and enter a more firm substratum. However, long underwater piles can be expensive in view of the equipment required for this type of piling operation and the length of pile required. Further, in relatively deep waters, today's technology is not advanced to the point where such a process can be economically achieved. For example, while deep water piling can be satisfactorily achieved through the judicious use of stingers and other members interposed between the pile and the pile hammer, the greater the length of such a stinger member the less efficient will be the operation due to the tendency of the stinger to absorb the pile driver's blow.

Toward overcoming or minimizing the stated problems, the present arrangement provides an improved foundation means for a pile type anchor member which is embedded into the substratum of an offshore body of water. The pile anchored member and its superstructure, for the purpose of the disclosure will be assumed to extend from the ocean floor in a generally vertical direction, terminating at a point above the water's surface. A work deck is supported on the superstructure, which in turn holds drilling or producing equipment normally characteristic of such offshore structures.

Normally, a plurality of support piles or columns can be utilized as the understructure for any one marine platform. The piles when so employed, are usually interconnected and constitute in the aggregate an elongated column possessing a degree of flexibility in response to lateral displacement, but being firmly anchored at the lower end into the substratum.

The anchoring portion of the instant column comprises at least a part of the pile or piles, being embedded into the underconsolidated substratum in a manner to form a firm gripping engagement with the latter to resist being withdrawn upwardly. The pile however, is further provided with at least one outwardly protruding cement base member, so arranged to afford not only additional downward pull but also to present a greater resisting area at such time as the pile is subjected to a withdrawing or upward force.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical elevation view of an offshore marine platform shown anchored into the substratum. FIG. 2 is a segmentary veiw taken on an enlarged scale, of an initial step in the forming of the instant foundation as seen at the platform end. FIGS. 3, 4 and 5 are similar to FIG. 2, illustrating the sequence of steps followed as the method proceeds. FIG. 3A is a view in cross-section taken along 3A—3A in FIG. 3.

FIG. 1 illustrates a marine structure 10 of the type contemplated, located in a body of water. An elongated support column 11 extends from a point adjacent the ocean floor, in a generally vertical direction, to a predetermined distance above the ocean's surface. Column 11 comprises a plurality of elongated cylindrical casing members 12 and 13 which are optionally interconnected at spaced apart intervals by lateral braces 14 and 16 to afford a degree of cross rigidity and mutual support to the column uprights. The column lower end terminates at the ocean floor and is there maintained in a relatively fixed arrangement by the upright members being partially embedded into the substratum.

Column 11 functions not only as a vertical support for deck 17, but also as a fixed cantilever. Thus, the entire unit can oscillate about the lower fixed end, the stress of displacement being absorbed by the respective column members.

Support column 11 is provided with controllable internal and/or external buoyancy at the upper end to maintain the column in a generally vertical disposition in the water. Buoyancy is usually regulated through use of internal, controlled buoyancy tanks. However, in the alternative, one or more externally positioned removable tanks can depend from the column upper end at or adjacent the water's surface.

Referring to FIG. 2, a segment of column 11 lower end is illustrated to show specific details thereof with respect to a single casing element 18 which is equivalent to uprights 12 or 13 of FIG. 1. Said casing 18 comprises in effect an elongated cylindrical member formed of a plurality of discrete pipe-like sections. The latter are sequentially end welded one to the other during assembly or installation to afford the necessary overall length for a particular water depth. The number and bulk of casing 18 will be contingent to a large part on the magnitude and character of equipment carried on deck 17 at the column upper end. However, as a practical matter such casings 18 are usually 30 to 60 inches in diameter, having a wall thickness up to about

2 inches whereby to offer the necessary resistance to flexural and tensional strains imposed on the column.

The lower end of casing 18 is further provided with an open structured cage 19 which constitutes an axially oriented extension to the column lower end. To facilitate its being gripped by the substratum, the exterior of casing 18 can be provided with a surface that has been preconditioned by the application of a roughened or discontinuous pattern. For example, although not presently shown, the casing exterior surface can be provided with discretely placed upstanding protrusions or even indentations formed into the surface to be readily gripped by the subsequently inserted cement mass.

Cage member 19 as shown, comprises in one embodiment an upper transverse plate 21. Said plate extends across the lower end of casing 18, being peripherally welded to the latter to form a tight seal therewith whereby to retain subsequently inserted drilling mud or cement. Plate 21 can also be provided with peripherally spaced reinforcing brackets 22 or similar members, connected along one side thereof to casing 18 wall. An opening 23 is formed substantially centrally of said plate 21, being of a sufficient diameter to slidably accommodate an elongated conduit or cylindrical riser 24 welded therein.

A transverse panel 26 is spaced downwardly from said plate 21 and comprises a disc-like, flat member having a relatively substantial thickness. The respective plate 21 and transverse panel 26 are interconnected by a plurality of intermediate columns or radially disposed vanes 27 fixedly positioned to and extending therebetween in a direction generally longitudinally of riser 24. Intermediate columns 27 serve the dual functions of rigidly spacing the respective plate and panel whereby to form a solid foundation for casing 18. They also provide a firm engaging footing about which the subsequently poured cement will harden, thereby establishing a firm bond between the poured cement and casing 18.

Panel 26 is provided with a central aperture 28 extending therethrough formed with a peripheral shoulder 29 adapted to receive a circular plug or cap 31, on a frusto conical seat 30.

While the foregoing description represents a specific embodiment of casing 18 lower end, it is understood that an essential function of the cage-like structure 19 is to form an appropriate connection for embedment into subsequently poured and hardened cement. Thus, upon hardening the cement will tend to completely enclose lower panel 26 as well as a part of the upstanding columns 27, thereby becoming an integral part of column 11.

Riser 24 extends from the casing 18 upper end, downwardly to cage 19. As above noted, the lower edge of riser 24 is preferably welded into central opening 23 of transverse plate 21 to form a fluid tight connection with the latter. Riser 24 serves the function of enclosing and guiding the lowered drill string 32 whereby to properly register with and excavate well bore 33 wherein casing 18 is slidably received. Riser 24 is preferably formed of a series of end welded pipes or tubing lengths of sufficient diameter to slidably receive drill string 32 as well as drill bit 34.

A steel, cylindrical liner 36 is received within cage 19, being adapted to slidably register with the inner wall of riser 24. Liner 36 comprises a relatively short, metallic member of sufficient length to permit the lower end thereof to seat against shoulder 29 within opening 28 in lower panel 26. Thus, liner 36 when in the lowered or extended position, defines an open ended passage means extending through cage 19. Said liner is slidably positioned within cage 19 and riser 24 respectively to permit the liner to be displaced completely from the cage 19 or removed to the surface of casing 18 as required. Toward this end liner 36 is provided with attaching lugs 37 or a similar gripping means such as a circular groove, at the upper end. Said lugs or groove are adapted to receive and engage the end of a lifting tool normally lowered from the riser 24 upper end whereby the said lifting tool will permit longitudinal placement of the liner.

When liner 36 is displaced to the upward position within riser 24, the cage section 19 will be entirely open and in a condition whereby lower plate 26 and intermediate columns 27 will become embedded in fluid cement. When in the lowered position, liner 36 will extend between the respective plate 21 and panel 26, being registered in the center opening of the latter, to form a guide passage for the drill bit and drill string. Further, when in the lowered position, liner 36 will permit drilling mud passed downwardly through the rotating drill string 32 and bit 34, to flow outwardly and remove cuttings normally formed as the drill bit 34 advances.

In the usual practice of the invention, cage 19 is arranged with liner 36 in the downward position to define a central passage which will permit insertion of drill string 32. Casing 18 will, in the usual manner be lowered into the substratum of an offshore body of water for a distance due to its own weight. Thus, for a sufficiently long casing, the latter would tend to bury itself depending on the consistency of the soil, quite deeply into the substratum. During the insertion step, liner 36 will as mentioned, be in the down position at the casing lower end. However, plug 31, adapted to be received on shoulder 29, is retained at the water's surface such that opening 28 defines an open passage extending through riser 24 and the liner 36.

Drill string 32 with bit 34 carried at the forward end thereof, is lowered through riser 24 to eventually engage the substratum. Toward facilitating the drilling operation, the relatively wide well bore 33 is preceded by the formation of a pilot bore 38 in advance of and coaxial with the casing.

The main well bore 33 into which casing 18 is lowered, is formed by rotation of said drill string at work deck 17 by means of a driven rotary table or the like. As shown in the figures, bit 34 includes a plurality of radially extendable arms 41 and 42 in contrast to the normal drill bit which includes only stationary cutters rotatably mounted to the bit lower end. Such extendable arm bits are known in the art and serve the function of forming an enlarged opening or undercut within a compatible substratum by being rotated therein to shear and displace layers of substratum as the bit is advanced.

In the normal manner, a pressurized flow of drilling mud or similar fluid is directed through drill string 32, which mud passes outwardly into the drilled or reamed portion of the bore to carry away cuttings formed by the rotation of blades 41 and 42. The cuttings are borne away on a mud vehicle which passes upwardly along the sides of casing 18, through the annulus formed intermediate casing 18 and bore 33.

As the bore opening 33 progresses deeper, casing 18 is sequentially lowered to maintain the integrity of the bore and also to maintain and guide the rotating bit within the liner 36 lower end.

Referring to FIG. 3, at a predetermined bore depth, when it is determined that the substratum is of a nature to support a cement foundation anchor, the initial forming of bore 33 is discontinued. Thereafter, drill string 32 is withdrawn from the well and drill bit 34 is removed. A second bit 43, characterized by further expandable blades 44 and 46 is replaced on the drill string 32 lower end. The latter is then lowered the length of casing 18 and registers within pilot bore 38.

Drill bit 43, similar to bit 34 normally functions by causing the respective arms 44 and 46 to be urged to an outwardly extending position, eventually reaching a position normal with the longitudinal axis of drill string 32. The blades 44 and 46 are thus rotated from an initially vertical disposition, to gradually broaden and increase the opening thereabout. The downward flow of drilling mud through drill string 32 is continued such that as cavity 47 is being formed, the cavity will be concurrently filled by a substantially slurry-like fluid mixture. The latter comprises in essence drilling mud from the water's surface which is intermixed with and emulsifies the cuttings loosened from the cavity walls.

Underreaming or cutting of the cavity 47 at the bore 33 end continues until the respective blade arms 44 and 46 achieve a substantially horizontal disposition. At this point the blade tips extend beyond the outer periphery of the bore 33 to form a peripheral lip 49 about the latter. The degree and the configuration of cavity 47 is substantially hemispherical due to the pivoting action of the blades as they advance to form the cavity and to promote formation of the slurry therein. In such condition, cavity 47 will maintain its integrity, being not of the deltaic or underconsolidated consistency but rather of a normal or more consolidated soil structure.

Referring to FIG. 4, formation of cement anchor 51 is initiated by first withdrawing both the drill string 32 and cutting bit 43 upwardly through riser 24. Toward this end, the radial blades 44 and 46 of the drill bit are retracted to a closed or generally vertical disposition. Thereafter withdrawal of drill string 32 raises the cutting bit to the water's surface.

The entire casing 18 is then lowered into the mud filled hemispherical cavity 47 to rest on plate 26 on the cavity floor. Disc-like plug or plate 31 is inserted from the surface downwardly, through riser 24 and seated within the recessed shoulder 29. Liner 36 is then raised to its upward position beyond cage 19. In such condition, cavity 47 is in condition for cementing.

A stream of fluidized cement preferably under pressure, is thereafter introduced from the water's surface to form a bulbous inverted mushroom shaped foundation anchor. The cement flow is introduced through drill string 32 from which the drill bit has been removed, or it can alternatively be introduced through a separate conduit passed downwardly through the casing to the lower end. As shown in FIG. 4, a cement carrying conduit 32 can comprise an elongated tubing string or a non-rigid conduit which is provided with a nozzle 54 at the lower end to properly distribute the fluidized flow as to form the desired cement anchor.

Thus, cement is passed downwardly to the lower end of the cage 19. The cement, having a greater specific gravity than the mud in cavity 47, is preferably introduced at the lower end to facilitate urging the drilling material upwardly whereby to fill cavity 47.

The cement injection is continued and the cement conduit 32 is gradually raised to permit the distribution of progressive levels throughout cavity 47 whereby to facilitate the filling of the latter. Eventually the cement will rise to the point of completely displacing mud from the cavity, in which instance the cement will have reached the overhanging shoulder 49 of the cavity 47 and further completely embed the respective lower plate 26 and intermediate support columns 27. Thereafter the cement is permitted to flow upwardly through riser 24 as well as through the annulus intermediate the wellbore 33 and the wall of casing 18.

The hardened or set cement will thus not only define a mushroom shape weighty anchor 51 at the lower end of casing 18, but it will also form a partial sleeve at the outer side of the casing along the surface of the latter.

Thereafter the cement conducting apparatus is withdrawn from the casing 18 and the cement permitted over a period of time to set into a firm body completely encasing anchoring cage 19.

In the practice of the instantly disclosed method, normally columns 12 and 13 are lowered from a surface vessel in a generally vertical direction. The column can of course be prefabricated and floatably transported by virtue of its own buoyancy to a desired spot or it may be carried by barge or other suitable means to points of embedment. Further the column is preferably made up in its entirety in advance of the installation operation such that the entire unit may be lowered completely into place and cemented in a minimum of time whereby to avoid complications which may arise with inclement weather.

Other modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. Method for embedding an elongated cylindrical casing into an underconsolidated offshore substrate, which casing includes; an open structured reinforcing cage at the lower end thereof, said cage having a longitudinally displaceable liner element disposed axially thereof and displaceable between upper and lower positions to form a longitudinal passage through said reinforcing cage, which method includes the steps of,

urging said elongated casing downwardly into said substrate to form a borehole in the latter approximately the diameter of said casing outer diameter, said displaceable lining being positioned axially of said reinforcing cage to define a drill guide passage through the latter,

forming a cavity at the lower end of said borehole, said cavity having a portion thereof extending outwardly beyond said borehole diameter,

withdrawing said liner from its lower position in said cage while maintaining the latter within said cavity,

introducing a stream of fluidized cement through said bore and into said cavity to substantially occupy the latter and to immerse said reinforcing cage whereby to subsequently solidify and unitize said cylindrical casing with said solidified cement in said cavity.

2. In the method as defined in claim 1, wherein said cavity is formed generally hemispherical in shape, hav-

ing an upper wall extending generally in a plane normal to the longitudinal axis of said bore and said reinforcing cage extends downwardly to engage the lower curved wall of said hemispherical cavity.

3. In the method as defined in claim 1, including the step of forming a closure across the lower end of said reinforcing cage while the latter is within said cavity and prior to the introduction of fluidized cement into the latter.

4. In the method as defined in claim 1, including the step of, forming a pilot bore within said substrate prior to the formation of said cavity, and thereafter closing said pilot bore to preclude entry of fluid cement thereinto as said cement enters said cavity.

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