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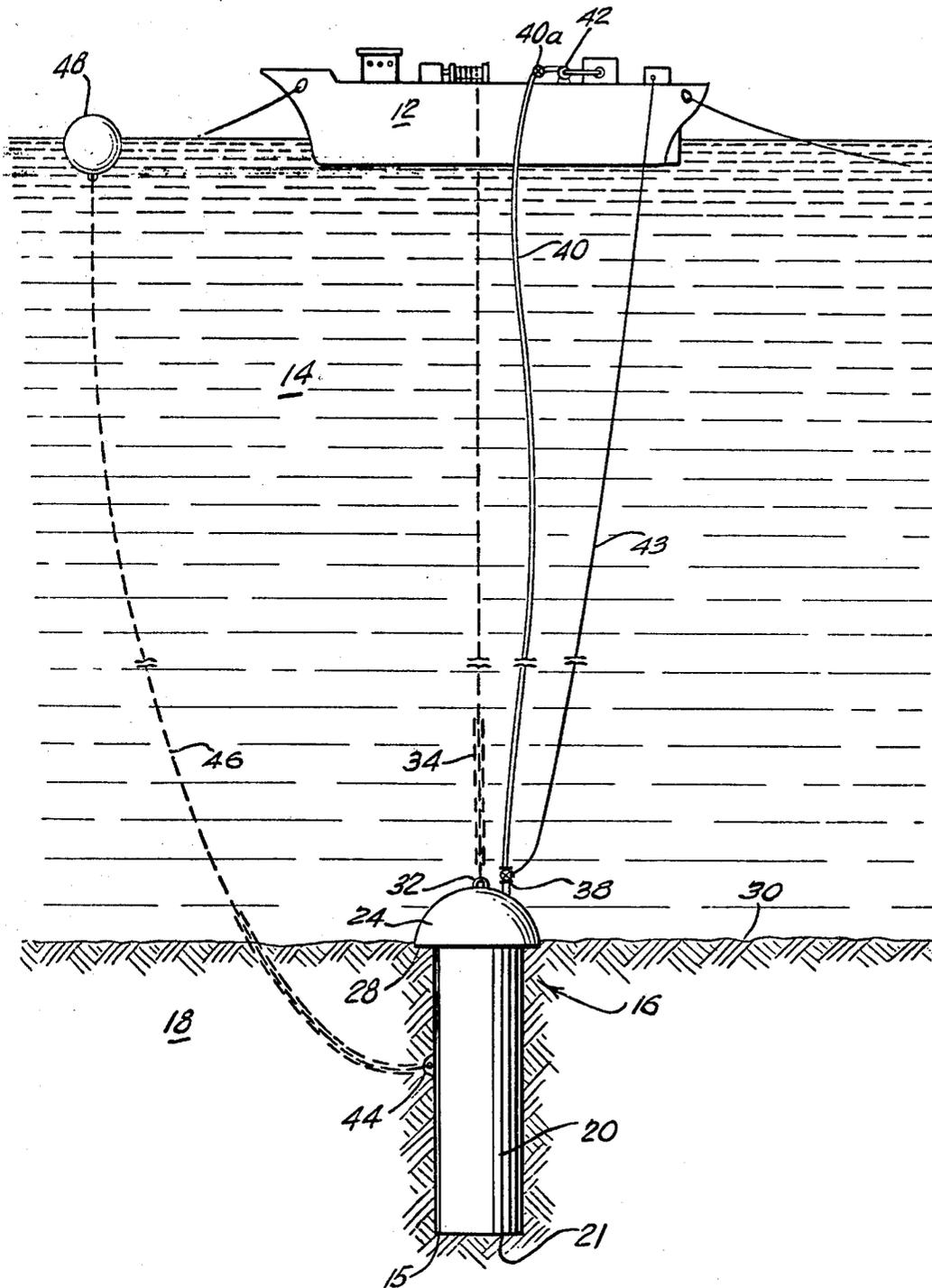
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METHOD FOR INSTALLING A DEEP WATER ANCHOR

Filed May 23, 1968

3 Sheets-Sheet 1

Fig. 1.



Feb. 24, 1970

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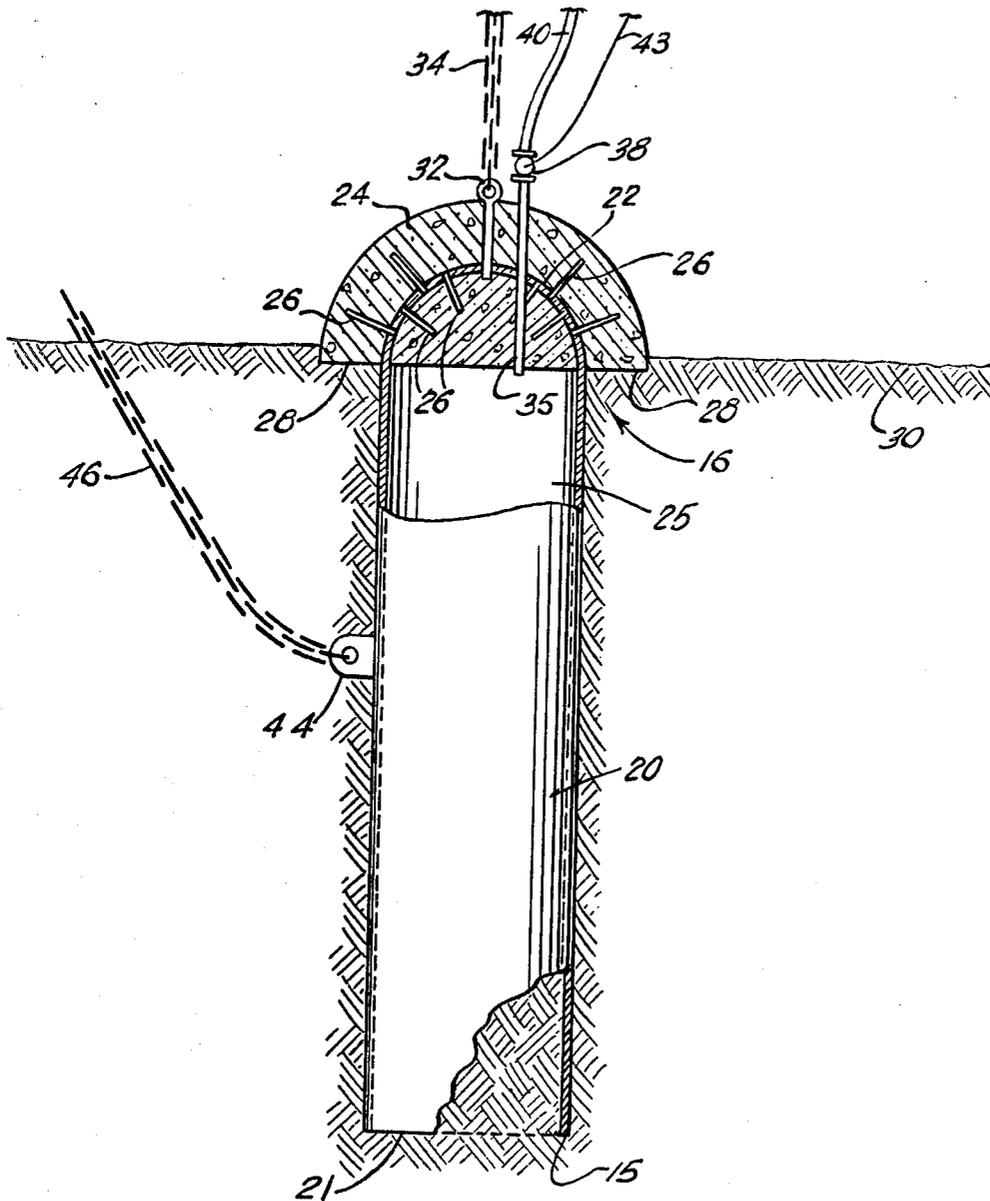
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Filed May 23, 1968

3 Sheets-Sheet 2

Fig. 2.



Feb. 24, 1970

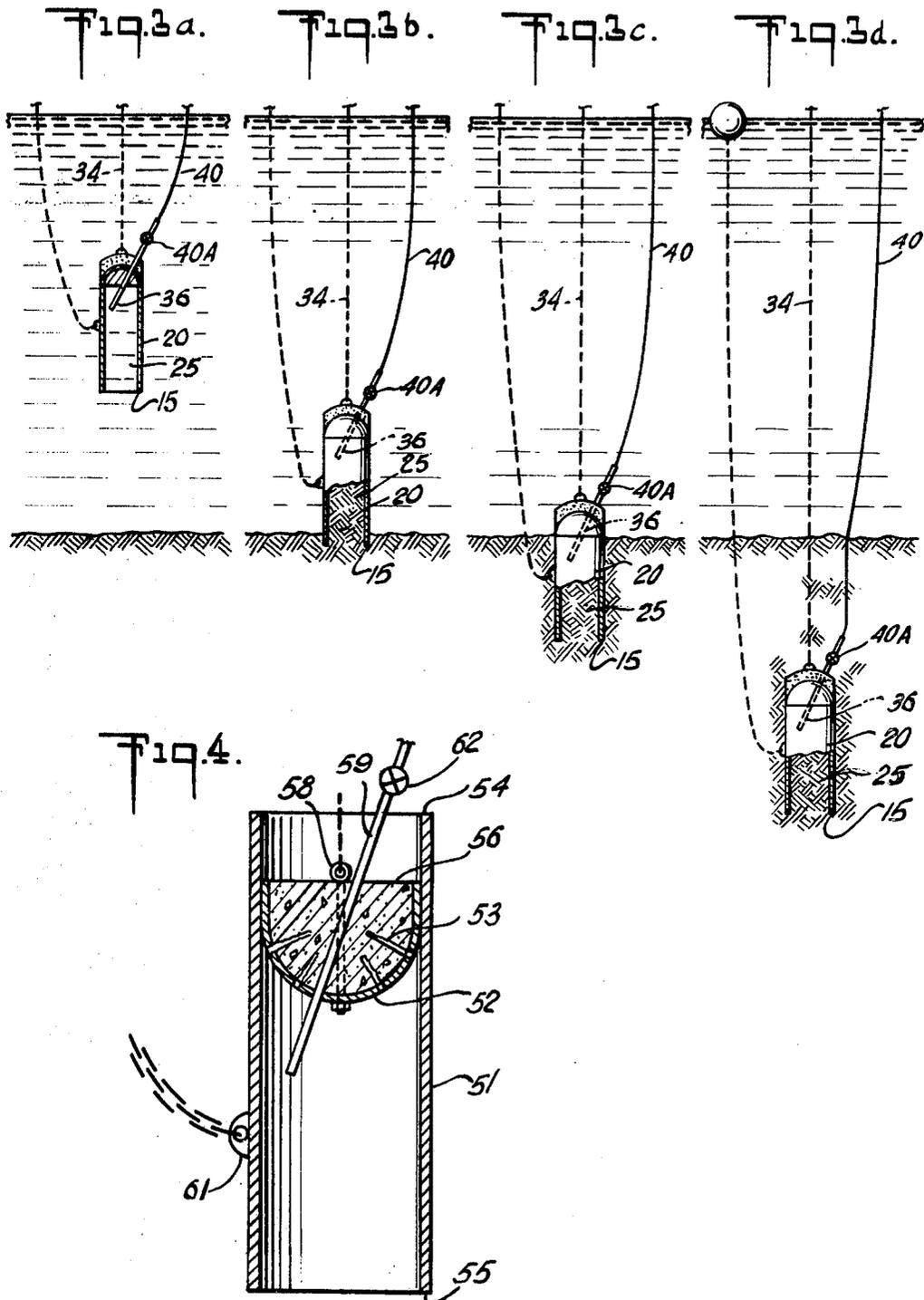
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Filed May 23, 1968

3 Sheets-Sheet 3



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METHOD FOR INSTALLING A DEEP WATER ANCHOR

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Int. Cl. B63b 21/26

U.S. Cl. 114—206

4 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to a method for controllably imbedding an anchor into a relatively soft ocean floor. The method comprises lowering the anchor in such manner to permit water and mud to enter the lower end of an evacuable chamber. The chamber is then maintained in a condition of partial evacuation by the controlled removal of said mud and water whereby pressure differential is established with the surrounding atmosphere. The said pressure differential urges the anchor downwardly, which downward progress is maintained so long as the received mud and water are removed, or until the consistency of the substratum permits no further entry.

This is a continuation-in-part of our copending application Ser. No. 602,706, dated Dec. 19, 1966, now Patent No. 3,411,473 and entitled "Deep Water Anchor."

BACKGROUND OF THE INVENTION

This invention also relates to an anchor for use in deep water and more particularly, to an anchor which is capable of resisting both horizontal and vertical loads without corresponding movement, and which may be inserted in a relatively soft ocean bottom utilizing a simple work vessel rather than a pile driving or drilling barge.

The anchoring of supply vessels, crew boats, drilling vessels and floating drilling platforms for drilling offshore wells, can be readily seen to be critical in that lateral movement of the vessel to any substantial extent cannot be tolerated. In the situations requiring minimal lateral displacement of the floating structure, the well known fluke type anchors are generally designed for specific bottom conditions, i.e. sand or soft clays. Anchors designed for one set of soil condition are not always efficient in different soil conditions. Accordingly, it has been the general practice in industry to use steel piles driven into the bottom in cases when anchor slippage could be expensive and/or disastrous.

Anchor piles have been proven efficient in widely ranging soil conditions. In the fluke type anchoring system for example, cable or chain lengths are usually 5 to 15 times the water depth depending on the magnitude of the mooring loads and the weight of the chain or cable. Such lengths are required to keep vertical force components from being transferred to the fluke type anchor since the holding power of such anchors is radically reduced with application of vertical loads. The cost of a mooring system utilizing fluke type anchors becomes extremely high in deep water applications.

Shorter chains and cables can be utilized in a mooring system, if anchor piles are driven into the ocean bottom. Such anchor piles can take some vertical loads. However, the cost of driving pilings into the ocean bottom in deep water is extremely expensive.

There is presently described an underwater anchor of the pile type which is capable of effectively maintaining its imbedded position in an ocean bottom when subjected to strong lateral and/or vertical pull. The invention dis-

closed provides a method for controllably installing the anchor in an underwater substrate without the need to utilize a conventional derrick barge or pile driving vessel and for subsequently salvaging the same for relocation.

It is therefore an object of the invention to provide a deep water anchor capable of maintaining an embedded position within the ocean bottom under heavy lateral or vertical pulls. Another object is to provide a method for controllably regulating the descent of the anchor into an ocean floor and the subsequent disengagement and raising of the same from the floor. It is another object to provide a method for inserting an anchor a sufficient depth into an ocean floor to be in a relatively firm environment. A still further object is to provide a method whereby the above mentioned anchor can be controllably imbedded into a penetrable yet firm strata of the ocean floor to achieve efficient holding ability.

An anchor of the type utilized in the disclosed method is provided with an elongated tubular body member having an open lower end defined by a relatively thin edge adapted for controllable insertion into the ocean bottom. The other end, or top of the tubular member is provided with a closure member to which is bonded a weight-cap. An elongated cavity extends substantially the length of the body defined by fluid tight body walls. A pad eye forming a first connection means is provided extending from the top of the weight-cap so that the anchor can be vertically suspended. A valved suction-fill pipe is provided extending from the outside, to the interior of the tubular member.

A suction-discharge line is adapted for removable connection to the suction-fill pipe and extends to the water surface. A quick opening connector may be carried at the outer end of said suction-fill pipe by means of which the suction-discharge line can be remotely disconnected, if desired, from the suction-fill pipe. Pumping means at the water surface is adapted to attach to the suction-discharge line for evacuating or pressurizing the cavity of the tubular member thereby controllably regulating the character of the latter. A second pad eye or connection means depends from the outer wall of the tubular member, part way down the length thereof for connection to a mooring line so that lateral forces exerted on the mooring line by a surface vessel can better be withstood without displacement of the anchor.

According to the invention, there is provided a method of controllably inserting and removing the salvageable anchor particularly at deep water locations. The open ended tubular body has a closed upper end and is capable of withstanding both vertical and horizontal pulls when inserted into an ocean floor characterized by a consistency or density sufficient to retain the anchor against dislodging forces.

For imbedding, the anchor is lowered from the water surface in a vertical attitude so that the thin edged open end of the tubular body first contacts the ocean bottom to form a partial seal. To insert or further imbed the anchor into a penetrable substratum, the interior of the tubular member is at least partially evacuated to create a pressure differential between the cavity and the surrounding substratum, which condition will sink said tubular member into the ocean bottom by utilizing the weight of the water thereabove.

To controllably remove the anchor, an upward pull is applied to the anchor connection from the water surface. In addition, the cavity of the tubular body is pressurized concurrently with the vertical lifting to dislodge the anchor from the holding substratum.

The above mentioned, and other features and objectives of this invention, and the manner of obtaining them will become more apparent and the invention itself will be best understood by reference to the following description

of the embodiments of the anchor taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a schematic representation showing the anchor in place in the ocean bottom after having been lowered from a working vessel;

FIGURE 2 is a partial vertical cross sectional view of the anchor of FIGURE 1;

FIGURE 3 is a diagrammatic illustration of the sequential steps identified as 3a through 3d, followed for inserting an anchor of the type shown into a penetrable substratum, in accordance with the described method, and

FIGURE 4 illustrates an alternate embodiment of an anchor adapted to the present purpose and which may be imbedded in the substratum of a body of water.

FIGURE 1 illustrates a work boat 12 anchored in position in a body of water 14 over the location where anchor 16 is to be inserted in the penetrable ocean bottom 18. The anchor structure 16 may be, and is preferably, fabricated at an on-shore location and brought to the mooring site. The vessel to be moored may be a drilling vessel or barge which necessarily has to be maintained at a predetermined floating position within relatively close tolerances, for example, when drilling a well. Accordingly, a number of such anchors 16 would be spaced around the vessel or structure to provide the stable mooring.

Anchor structure 16 consists of a normally uprightly positioned, elongated tubular member or body 20 made preferably of fluid tight steel or concrete walls. Said body includes an open lower end 21 defined by a relatively thin peripheral lip or edge 15. The latter normally is formed of a thickness equivalent to the thickness of the metallic tubular member 20 wall for easy penetration into the ocean bottom 18. Referring now to FIG. 2, tubular body 20 includes an elongated internal cavity 25 extending coaxially thereof, being open at one end, and closed at the opposite end by a plate. In the shown structure, plate 22 comprises a convex dish-shaped member made preferably of steel or concrete. If steel is used for tubular member 20 and convex member 22, the latter is welded or joined to the upper edge of elongated tubular member 20. The pressure resisting plate is then embedded in a concrete cap 24 to add additional weight to the anchor 20. Concrete-weight cap 24 is bonded to the dish-shaped closure member 22. Short metal bars 26 are connected to and extend from the dish-shaped closure member 22 into the concrete to improve the bond therebetween. The concrete-weight cap 24 need not assume a specific configuration, but as shown, the illustrated embodiment is hemispherical in shape with the curved portion facing upwardly toward the ocean surface when anchor 16 is in place in the ocean bottom 18.

The diameter of hemispherical concrete-weight cap 24 may be equal to or greater than the diameter of the tubular member 20; the latter case, having at least a portion thereof overhanging tubular member 20 and extending radially therefrom to serve as a seat 28 on the mud line 30 when the anchor 16 is in place in a relatively dense ocean floor. However, in less dense floors, or in cases where deeper imbedment is desired, an alternate head and cap arrangement can be used to afford a minimal effect in deterring passage of the anchor through substrata having a less solid consistency.

The upwardly facing spherical configuration of the concrete-weight cap 24 provides a strong structural shape to better withstand extreme pressures applied thereto at deep water locations. It will be appreciated that the weight of concrete-weight cap 24 at the top of tubular member 20 causes the lower thin edge of the tubular member, when in contact with the ocean bottom 18, to readily penetrate the latter, rather than to support the anchor on the bottom. Such initial penetration thus forms a partial fluid seal which is necessary for the subsequent partial or full evacuation of the chamber defined by

elongated cavity 25, closure member 22, and the ocean floor.

A pad eye is attached to and extends into the concrete-weight cap 24, and to the dish-shaped closure member 22 where it is attached by welding or other suitable means. Pad eye 32 extends from the middle of the outer surface of the upwardly curved concrete-weight cap 24, such that the entire anchor 16 can be hung from a chain or cable 34 attached thereto in a vertical position, that is, with the tubular member 20 vertical. Also, imbedded in the concrete-weight cap 24 and passing through the dish-shaped closure member 22 is a suction-fill pipe 36 which communicates the interior of the tubular member 20 with the exterior thereof.

Mooring chain 46 is shown connected to a pad eye 44 and to float 48. However, it will be appreciated that the chain 46 is normally connected to a floating structure such as a drilling vessel along with possibly other chains from anchors of the same design to maintain the structure in a predetermined location so that the drilling etc. can be carried on. The top pad eye 32 can be used not only for lowering the anchor 16 into the ocean bottom 18 position but may also be utilized as a mooring connection.

Suction-fill pipe 36 is communicated with means for controllably regulating the character of cavity 25 thereby to regulate the disposition of the anchor during imbedment as well as during retrieval. Pipe 36 may be communicated by line 40 and valve 40A, to pumping means 42. The latter is representative of a suitable pumping system including pumps, manifolds, etc. for handling water, mud, air and other fluids drawn from the anchor or injected into the anchor cavity. In the instance where the anchor is imbedded such that the concrete cap 24 is normally disposed at the ocean floor, connection 38 may be detachable and only fastened to line 40 for manipulating the anchor. Where, however, the anchor is buried as shown in FIGURE 3d to a particular depth into the substratum, connection 38 may remain communicated with the line 40 for subsequent use.

FIGURE 4 illustrates an alternate embodiment of an anchor adapted to the present purpose and which may be imbedded in the substratum of a body of water. The anchor comprises basically an elongated shell 51, being preferably, although not necessarily, of uniform diameter. When disposed in a normally upright position, body 51 includes opposed upper and lower ends, the latter of which comprises a relatively narrow penetrating lip 55 which defines the inlet to the anchor interior cavity 50.

The upper end is closed by plate 52 which assumes a generally hemispherical or concave configuration, being peripherally welded to an inner wall or body 51 at a position spaced from the body upper end. The cavity formed by the body upper end and plate 52 encloses a weight member 56 formed of concrete or similar relatively heavy material. Inwardly extending bars 53 are buried in the concrete and fastened to plate 52 to firmly anchor the weight member in place.

The specific configuration of cavity 50 permits the volume of weight cap 56 to be varied in accordance with the composition of the ocean substratum. Thus, the shape of said weight cap may be hemispherical, or extend upwardly as shown from a hemispherical base toward the anchor upper edge, defining a generally cylindrical configuration.

As with the previously described embodiment the anchor body 51 is provided with means 61 to hold one or more chains and cables. A similar holding device 58 extends from the upper end of weight cap 56 and through plate 52, where it is fastened in place. A communicating pipe 59, together with valve 62 is passed through the weight cap and provides communication with body cavity 50 whereby the content of the latter may be controllably regulated to determine the disposition of the anchor when being imbedded and removed.

Referring to FIGURE 3, and in brief, the method for inserting and removing the described pile type anchor includes the following steps designated 3a to 3d inclusive.

(3a) Supportably lowering the anchor through a water mass in such manner to assure the unit maintains a substantially vertical disposition with the body lower peripheral lip at the lowermost position. During the lowering, the surface connection including pipe 36, connection 38 and valve 40A might be open to the atmosphere such that cavity 25 will be substantially full of water.

(3b) Upon contact with the ocean floor, peripheral lip 15 is permitted to penetrate the substratum surface. The penetration will vary in degrees depending on the consistency of the floor and upon the weight of the anchor together with its weight cap 24. Under normal circumstances, even in the instance of a relatively hard ocean floor, the upper layer will be covered with a film of mud into which the anchor will sink by its own weight thereby to establish the desired partial seal about the anchor body.

Initial penetration of edge 15 will in any event, establish a partial seal or at least engagement with the ocean floor. As the anchor is further lowered, the mass of water held in cavity 25 will be displaced through pipe 36 by the more dense mud in the ocean floor as the latter rises through the cavity 25.

(3c) The anchor's descent is now controllably regulated by actuation of the pumping system connected to line 40 and tube 36 to at least partially evacuate the cavity. Both water, and flowable mud will be removed from the cavity to effect a pressure differential between the exterior of the anchor and cavity 25. The resulting downwardly acting force, will force the anchor further into the substratum.

(3d) The anchor's descent will continue into the substratum so long as the consistency of the latter permits passage of the same through the pumping system whereby the above noted pressure differential is maintained. By maintaining a slightly upward tension on line 34 the attitude of the anchor will be continued in an upright position. Controlled regulation of the rate of mud and/or water removal from cavity 25 will permit a controlled descent of the anchor through the substratum. During the descent, the path defining the anchor's progress through the soft mud will be filled, at least in part, by water and/or mud. However, downward pressure acting against the anchor top will nonetheless continue.

The imbedment is continued until a predesired depth is reached or until the density of the substratum and the capabilities of the pumping equipment, prohibit further removal of fluid from cavity 25. At such point the pressure in the cavity is stabilized to equal the ambient about the anchor thereby fixing the anchor's location.

The character of cavity 25 may be maintained in a condition of partial vacuum by closing the pumping system at valve 40A thereby maintaining at least a partial vacuum in the cavity to stabilize the position of the anchor.

As mentioned, a primary virtue of the presently described invention is its ability to be readily removed as well as inserted from an imbedded position in the penetrable substratum. This of course permits the salvaging of the anchor or anchors from a location that has been determined to be unprofitable and from which drilling or producing equipment is to be moved. For salvaging or removing the present anchor from its imbedded position, it will be presumed that the anchor itself is in a substantially upright position although this may not be a true representation since lateral pull against the anchor body over a period of time might have caused it to assume a non-vertical attitude. However the unit is dislodged from its resting place by reversing the procedure followed during the imbedment process.

This comprises primarily of connecting pipe 36 and

valve 40A with a source of compressed air, gas, or water as to regulate the condition of cavity 25. As the pressure in the cavity 25 is increased by the forced introduction of compressed gas or water, the latter will tend to displace both water and mud which have filled the cavity. In doing so the water and mud will be urged downwardly through the cavity and out into the substratum. Because of the downwardly exerted pressure, the reaction of the anchor in response to the pressurized cavity will cause the latter to be forced upwardly against the holding forces maintaining the anchor in its imbedded position.

Evacuation of cavity 25 is supplemented by an upward pulling of the anchor through chain 34 attached to a derrick barge or similar equipment at the water surface.

As gas or water continues to be forced into the cavity 25, it gradually replaces water and/or mud, the injection is continued, the gas or water will be forced into the areas adjacent the body 20 thus in effect tending to break the hold of the clay on the anchor body in the imbedded position.

As the anchor becomes dislodged the rate of forced gas or water introduction will be regulated to control the rate of ascent by the physical lifting and by the lifting as achieved through the pressurized medium.

After the anchor has been completely dislodged from its imbedded position and is again in the water mass, the lifting mechanism comprises primarily the physical hoisting of the anchor which may be then removed or placed upon the barge for transportation to a new location.

Obviously many modifications and variations of the invention as herein set forth may be made without departing from the spirit and scope thereof.

We claim:

1. Method for imbedding a pile type anchor into a penetrable substratum comprising mud and flowable fluids at the floor of a water mass, said anchor including a generally elongated cylindrical body formed with fluid tight walls and having opposed closed and open ends, said anchor being communicated with fluid pumping means (42) disposed remotely therefrom, a weighted member carried at said body closed end, means forming an internal cavity extending substantially the length of said elongated body, a relatively thin edge at the body open end defining an inlet to said means forming said cavity, and means communicated with said internal cavity for controllably regulating the character thereof, which method comprises the steps of;

(a) supportably lowering said anchor through said water mass, said elongated body being disposed in a substantially vertical attitude with said edge in the lowermost position;

(b) penetrating the surface of said substratum with said thin edge to provide a peripheral, partial seal therewith, and to form an evacuable chamber within said means forming said cavity;

(c) at least partially evacuating said means forming said cavity to establish a pressure differential between said cavity and said water mass, by pumping mud and flowable fluids from said cavity through said remotely disposed pumping means as said elongated cylindrical body penetrates further into said substratum, to be completely embedded therein,

whereby, external pressure exerted against the said body closed end will controllably urge the anchor further into said substratum.

2. In the method as defined in claim 1 including the step of:

stabilizing said partially evacuated cavity to a pressure substantially equal to the pressure external to said cylindrical member for maintaining the embedded position of said anchor in said substratum.

3. In the method as defined in claim 1 including the step of:

maintaining an upward tension on said elongated body

3,496,900

7

during penetration thereof into said substratum for sustaining the substantially vertical attitude of said body.

4. In the method as defined in claim 1 wherein said step of evacuating said means forming said cavity includes the regulated pumping of said mud and flowable fluid therefrom to control the rate of penetration of said anchor into said substratum.

8

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TRYGVE M. BLIX, Primary Examiner