Aug. 25, 1970 J. J. BARDGETTE 3,525,224

METHOD AND APPARATUS FOR INSTALLING ANCHOR PILES

Filed March 5, 1969 2 Sheets-Sheet 1

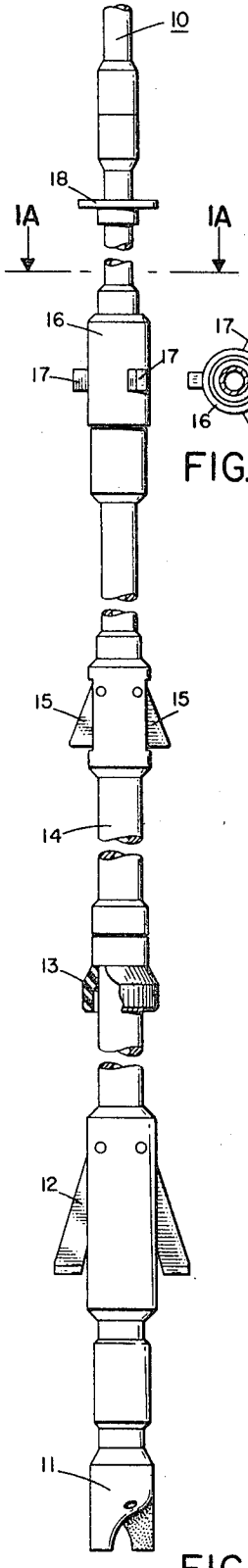


FIG. 1.

FIG. 1A.

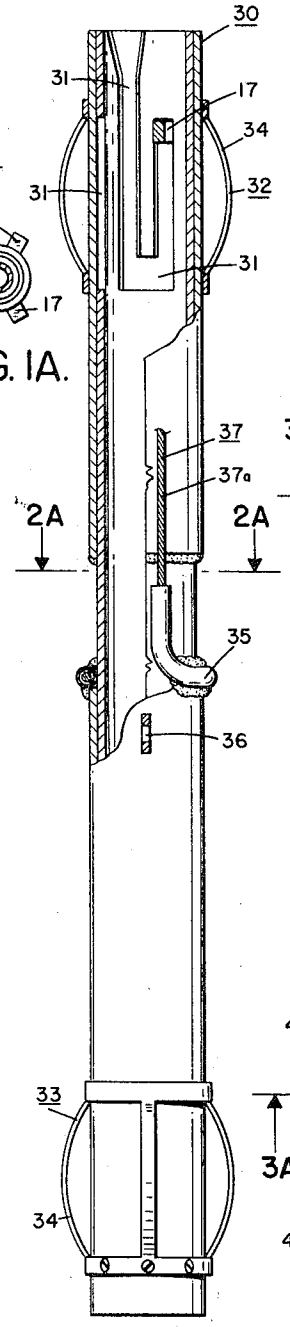


FIG. 2.

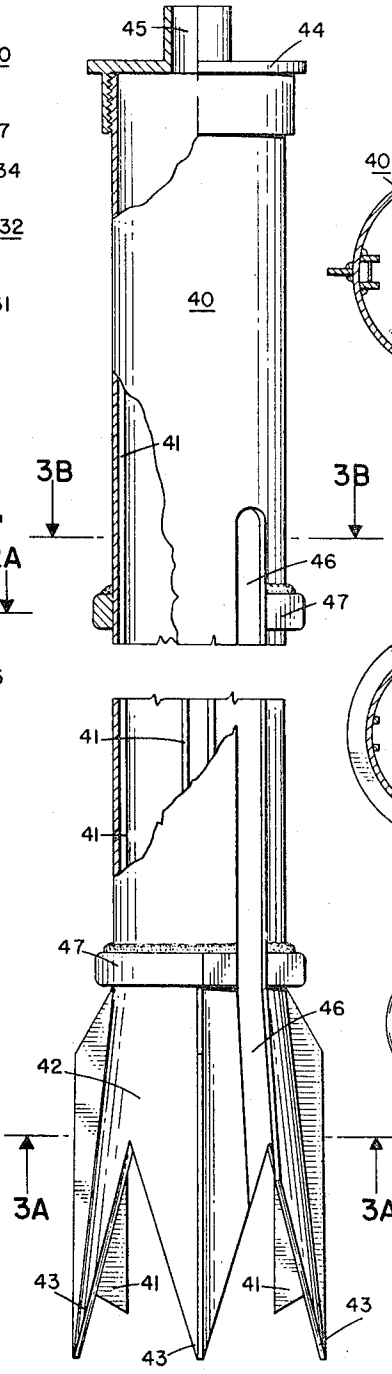


FIG. 3.

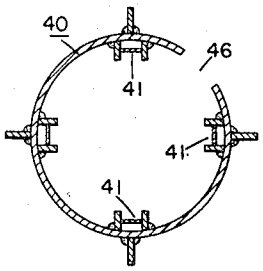


FIG. 3A.

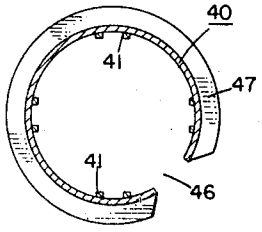


FIG. 3B.

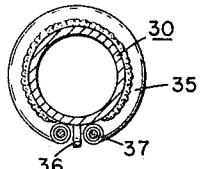


FIG. 2A.

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METHOD AND APPARATUS FOR INSTALLING ANCHOR PILES

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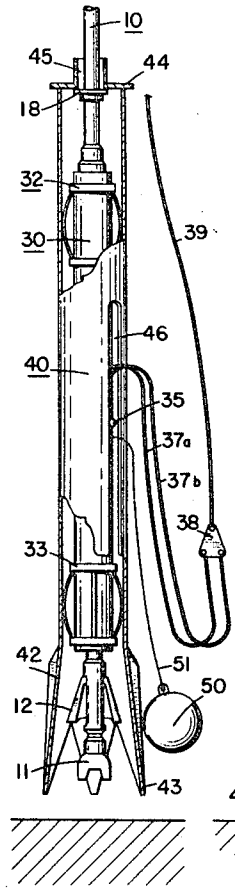


FIG. 4.

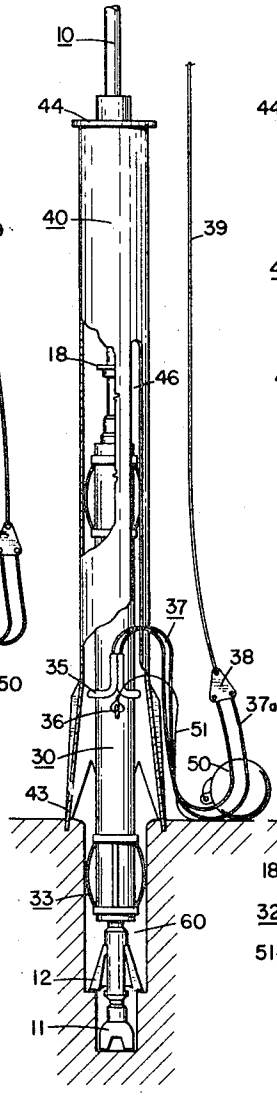


FIG. 5.

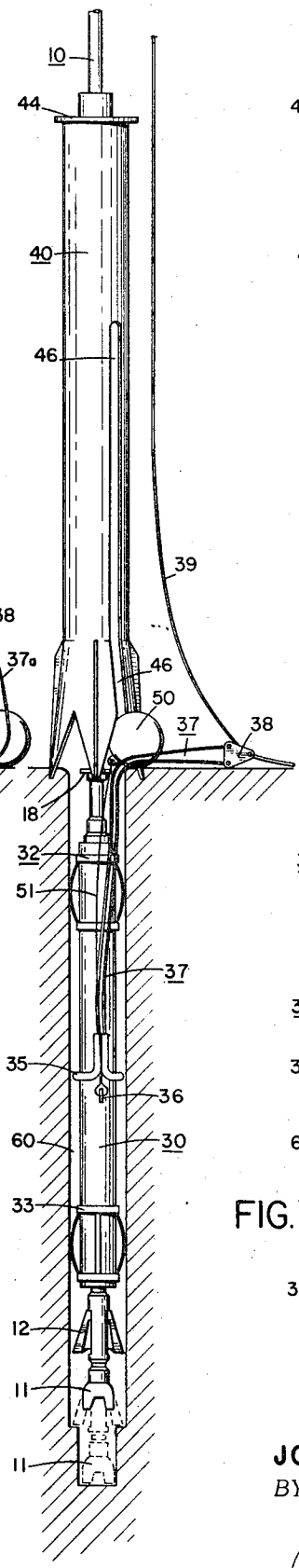


FIG. 6.

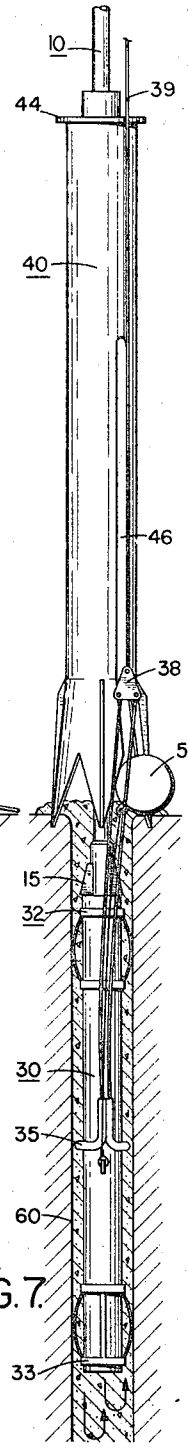


FIG. 7.

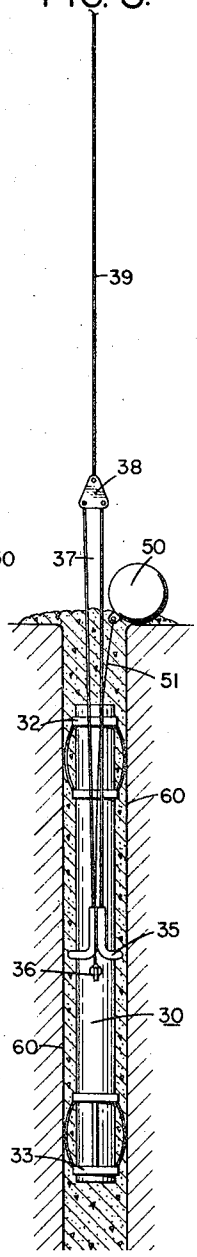


FIG. 8.

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METHOD AND APPARATUS FOR INSTALLING ANCHOR PILES

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Int. Cl. B63b 21/00; E02d 5/54; E21b 7/12
U.S. Cl. 61—46 17 Claims

ABSTRACT OF THE DISCLOSURE

Installation of piles for mooring floating rigs used in conducting offshore oil and gas drilling and production operations. A drill string having a drill bit on the lower end is suspended from a floating rig. The drill string extends through and is releasably attached to an anchor pile to be installed in the ocean floor. An antirotation sleeve arranged on the drill string surrounds and releasably engages the anchor pile. While so engaged and after the antirotation sleeve contacts and grips the ocean floor, rotation of the anchor pile is inhibited or prevented. An anchor cable connects the anchor pile to the drilling rig. Means connected to the anchor pile limits the depth reached by the anchor pile in the drilled hole. The drill string is lowered until the antirotation sleeve contacts the ocean floor. The drill bit and drill string are then rotated and the anchor cable is paid out from the floating rig as the hole is drilled by the drill bit and the anchor pile is carried deper into the drilled hole. When the anchor pile is located at a desired depth, cement is pumped through the drill string into the hole. The drill string is then released from its attachment to the anchor pile and the drill string and antirotation sleeve are raised to the floating rig, leaving the anchor pile cemented in the hole.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention generally concerns the installation of permanent anchor tubes or piles for mooring floating rigs (semisubmersibles or ships), and in particular, drilling a hole and setting and cementing such anchor piles in the drilled hole in one continuous sequential operation.

In one known method of installing anchor piles, setting and cementing of anchor piles are performed in one continuous sequential operation. Such a method is described in Drilling Magazine. Offshore Section, Jan. 19, 1968, in an article entitled, "Problem: Tack a Floater to the Ocean Floor." In this method, a hole is drilled with a bit on a rotary drill string which extends through an anchor pile. An expandible reamer above the bit expands and enlarges the drilled hole sufficiently to allow the anchor pile to be lowered into the drilled hole as it is made. After the hole is drilled and the anchor pile is lowered into place, cement is circulated around the anchor pile while it is held in place by the drill pipe. The drill pipe is then separated from the anchor pile and removed from the drilled hole. An anchor cable is connected to the anchor pile before drilling starts. One disadvantage of this procedure is that it does not prevent rotation of the anchor pile during drilling. Rotation of the anchor pile occurs as a result of torque transmitted from the drill pipe to the anchor pile. If the anchor pile rotates while drilling in, the anchor cable would wrap around the drill pipe. Although wrapping of the anchor cable around the drill pipe may not prevent drilling of the required hole or prevent subsequent cementing operations, it would hinder or prevent retrieval of the drill pipe and could result in pulling the anchor pile out of the drilled hole when the drill string is removed from the drilled hole.

The present invention permits drilling in, setting and cementing of the anchor piling in one continuous sequential operation, and at the same time, prevents the anchor pile from rotating with subsequent wrapping of the anchor cable around the drill string.

SUMMARY OF THE INVENTION

The present invention, briefly summarized, includes apparatus for use in installing anchoring means for mooring floating rigs which comprise an anchor pile; means for releasably connecting the anchor pile to a drill string and including a swivel to permit the anchor pile to remain stationary when the dill string rotates; an antirotation sleeve member surrounding the anchor pile and suspended on the drill string and having one end adapted to contact and grip the ocean floor and inhibit rotation thereof; means linking the sleeve member and the anchor pile together, preventing rotational but permitting vertical movement of the anchore pile relative to the sleeve member; an anchor cable connected to the anchor pile; and means cooperating with said sleeve member for limiting the depth of the anchor pile in the drilled hole. The procedure for installing the anchor pile is as follows. The drill string is inserted through the anchor pile and the drill string and anchor pile are releasably attached to each other in a manner which permits the anchor pile to remain stationary while the drill string rotates. The antirotation sleeve member is placed around the anchor pile and engages it such that when the sleeve member contacts the ocean floor, rotation of the anchor pile is prevented. An anchor cable is connected to the anchor pile. Means are provided to limit the depth of the anchor pile in the drilled hole. The drill string with the assembled apparatus attached is lowered through the water from the floating rig until the sleeve member contacts the ocean floor. A hole is then drilled in the ocean floor and as the hole is made, the anchor cable is paid out as the anchor pile is carried deeper into the drilled hole. Drilling operations are halted when the anchor pile is located at a desired depth in the drilled hole. The hole is then flushed out and cleaned. Thereafter, cement is pumped through the drill string into the hole. The drill string is released from its attachment to the anchor pile and then the drill string and antirotation sleeve member are raised to the floating rig.

Thus, the present invention makes use of the ocean floor to supply a required resisting torque for the anchor pile. Holding the anchor pile by an outside force prevents its rotation but does not prevent it from following the bit as the bit drills ahead and drilling, setting and cementing operations proceed without wrapping the anchor cable around the drill string.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view partly in section of a drill string and components associated therewith;

FIG. 1A is a view taken on lines 1A—1A of FIG. 1;

FIG. 2 is a view partly in section of the anchor pile to be installed;

FIG. 2A is a view taken on lines 2A—2A of FIG. 2;

FIG. 3 is a view partly in section of the antirotation sleeve;

FIG. 3A is a view taken on lines 3A—3A of FIG. 3;

FIG. 3B is a view taken on lines 3B—3B of FIG. 3; and

FIGS. 4–8 illustrate installation of an anchor pile in accordance with the teachings of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the apparatus includes a drill string **10** which extends to a floating rig at the water surface (not shown). Drill string **10** is provided with a drill bit **11**, an underreamer **12**, a downwardly facing cup

packer **13**, a spacer pipe **14**, spring biased spacer dogs **15**, a marine swivel housing **16** provided with outwardly extending lugs **17**, and above swivel **16**, a fixed stop plate **18**. Drill string **10** extends through the swivel housing and is free to rotate while the housing is held stationary.

FIG. 2 shows a tubular anchor pile **30** provided with a plurality of J-slots **31** machined in an inner wall at the upper end thereof, each of which is adapted to engage a lug **17** when drill string **10** extends through the anchor pile. The outer wall of anchor pile **30** is equipped with vertically spaced-apart centralizers **32** and **33**, each of which is provided with bow springs **34**. The lower band of each centralizer is fixed to the wall of the anchor pile while the upper band of each is free to slide up and down according to action of the bow springs **34**. Also provided on the anchor pile is a wrap-around cable tube **35** adapted to receive ends **37***a*, **37***b* of anchor cable **39**. An eye bracket **36** is provided on the outer wall of anchor pile **30** for connection to a stop cable **51**. (See also FIGS. 4–8.)

Lugs **17** of swivel housing **16** are in sliding engagement with the J-slots **31** of anchor pile **30**. Bow springs **34**, when engaged in the guides of an antirotation sleeve, prevent rotation of the anchor pile but do not prevent it from following bit **11** as it drills ahead into the ocean floor. In this manner, drilling, setting and cementing operations proceed without wrapping anchor cable **39** around the drill assembly.

As seen in FIG. 3, an antirotation sleeve **40** is equipped with centralizer grooves or guides **41** to receive and restrain each bow spring **34** in a manner such that any rotation of the anchor pile structure transmits torque or rotation through the centralizer bow springs to the antirotation sleeve guides **41**. The lower end **42** of the antirotation sleeve is expanded and formed to provide a serrated or sawtoothed surface **43** or other surface that will dig into the ocean floor under the weight of the antirotation sleeve and prevent rotation of the sleeve during rotation of the drill string while drilling. The upper end of the sleeve is capped with a plate member **44** provided with a hole **45** through which the drill string **10** is to extend. Hole **45** is smaller than stop plate **18** so that the weight of antirotation sleeve **40** is suspended from plate **18** when the complete assembled apparatus is lowered to the ocean floor. A cable slot **46** is formed in the wall of sleeve **40** and extends a major portion of the length thereof through the lower expanded section **42**. Anchor cable **37** extends from the floating rig at the water surface through slot **46** and the ends **37***a*, **37***b* thereof are looped around anchor pile **30** through tube **35** (see FIG. 2). Sleeve **40** is reinforced adjacent the cable slot by split ring members **47** welded about the sleeve.

As shown in FIGS. 4–8, cable ends **37***a*, **37***b* are attached to a "sister plate" **38** to which cable **39** is also attached and a stop sphere **50** is connected to eye bracket **36** by cable **51**.

In assembling the apparatus, drill string **10** is inserted through anchor pile **30** and connected to the pile by means of lugs **17** on marine swivel **16** and J-slots **31** in the inner wall of the anchor pile. Antirotation sleeve **40** is slipped over anchor pile **30** with centralizer bow springs **34** compressed and in guides **41** formed on the inner surface of antirotation sleeve **40**. Cable ends **37***a*, **37***b* and **51** all extend outwardly through cable slot **46** with sphere **50** attached to the end of cable **51**.

As illustrated in FIG. 4, the entire assembly, including drill string **10**, is lowered to adjacent the ocean floor. Antirotation sleeve **40** is the first component to contact the ocean floor upon continued lowering of the drill string, closely followed by bit **11**. After contact with the ocean floor is made and before rotation of the drill string has been started, some of anchor cable **39** is paid out and laid on the ocean floor, as illustrated in FIG. 5. Rotation of drill string **10** is then started and any rotation imparted to antirotation sleeve **30** through marine

swivel lugs **17** and anchor pile centralizer bow springs **34** is resisted by the teeth or serrated edge **43** of the antirotation sleeve digging into the ocean floor and also by the drag of anchor cable **39** lying on the ocean floor. These teeth furnish required torque resistance and prevent rotation of the antirotation sleeve. Thus, the anchor cables are prevented from wrapping around the lower end of drill string **10**. As bit **11** and underreamer **12** drill ahead, lugs **17** in the JAY-slots **31** of anchor pile **30** force the anchor pile out of the antirotation sleeve and into the drilled hole.

As shown in FIG. 5, a hole **60** has been partially dug into the ocean floor with about one-fourth of the anchor pile structure in the hole. As the lower centralizer bow springs **34** contact the wall of the drilled hole, the anchor pile will start to resist rotation through such contact, as well as through engagement of upper centralizer **32** with the guides **41** of antirotation sleeve **40**. When the top bow springs **34** disengage from antirotation sleeve **40**, the entire required torque resistance is obtained from contact of the lower centralizer **33** and the hole wall. As illustrated in FIG. 6, as drilling continues, top centralizer **32** enters hole **60** and both centralizers are then available to furnish torque resistance.

Sphere **50** attached to anchor pile **30** by stop cable **51** is used to stop descent of the anchor pile and allow drill string **10** to drill ahead.

As shown in FIG. 7, the anchor pile may be installed completely below the ocean floor dependent upon the length of stop cable **51**. Contact of centralizers **32** and **33** with the walls of hole **60** resist any rotation of the anchor pile structure which might be imparted from drill string **10** through outer housing of marine swivel **16**. Anchor cable **37** is attached to the anchor pile with the wrap-around tube in order to minimize the size of the connection therebetween so that such connection is capable of entering the drilled hole.

When sphere **50** attached to cable **51** is pulled into contact with the lower end of antirotation sleeve **40** by downward movement of the anchor pile **30**, it stops further descent of the anchor pile. If the anchor pile **30** has been pushed down into the hole by lugs **17**, then these lugs are in releasing position so that rotating the drill string counterclockwise brings them into vertical alignment with the releasing portion of the J-slots **31**. However, if the anchor pile slides down into the hole under its own weight, lugs **17** would remain in the upper end of the locking portion of J-slots **31**, as shown in FIG. 2. In that event, the drill string continues to drill until lugs **17** are brought into releasing position; i.e., into contact with the lower end of J-slots **31**.

Circulation down the drill string and up the annulus between the drill string-anchor pile and the borehole wall is continued after drilling is completed. This continued circulation down the drill string and up around the outside of the anchor pile causes the remaining cuttings to be dumped on the ocean floor. In this manner, the hole is circulated clean. After cleaning the hole, counterclockwise torque is applied to drill string **10**. This movement causes swivel lugs **17** to un-J from slots **31** in the anchor piling, thus freeing inner drill string from the anchor piling. Then the drill string is slowly picked up a few feet. Proof of separation can easily be confirmed on the rig by reading the weight indicator.

Drill string **10** is raised a distance sufficient to place the spacer dogs **15** above the top of anchor pile **30**. The string is again lowered until spacer dogs **15** contact the top of the anchor pile. This places the downwardly facing packer cup **13** at a position in the bore of the anchor pile below J-slots **31**. By calculated volume, the hole is then filled with cement by pumping down the drill string and up the annulus between the anchor pile and the borehole wall until the cement spills over onto the ocean floor.

While continuing to pump cement, inner drill string **10** is slowly elevated. As illustrated in FIG. 8, in this manner, the entire bore of the anchor piling is filled with cement as the bit is withdrawn therefrom. The bit is pulled back to the drilling rig at the surface along with the entire drill string and antirotation sleeve.

The anchor piling is now set and by unreeling anchor cable **39** attached thereto and connecting it to a buoy on the surface, the floating rig is free to move to the next position to set another piling. By using this one-trip operation, the required number of pilings may be quickly set and the floating rig securely anchored for the drilling operation.

Various modifications may be made in the preferred embodiment of the invention which has been described without departing from the spirit and scope thereof. Thus, instead of a spherical member attached to the cable to limit movement of the anchor pile in the drilled hole, any other configuration for such member may be used so long as it lodges against the lower portion of the antirotation sleeve or top of the drilled hole and prevents further movement of the anchor pile down the drilled hole.

Having fully disclosed the nature, objects, apparatus and operation of my invention, I claim:

1. Apparatus for use in installing anchoring means for mooring rigs floating on the surface of water compising:

a drill string for drilling a hole in the ocean floor;

an anchor pile adapted to be positioned in a hole drilled by said drill string;

means for releasibly connecting said drill string to said anchor pile including means permitting said anchor pile to remain stationary upon rotation of said drill string;

a sleeve member suspended on said drill string and surrounding said anchor pile and having one end adapted to contact and group the ocean floor to inhibit rotation of said sleeve member;

means releasibly engaging said anchor pile and sleeve member for preventing rotational and permitting vertical movement of said anchor pile relative to said sleeve member, said sleeve member also having a slot extending along the length thereof;

an anchor cable connected to said anchor pile adapted to extend through said slot to the water surface; and

means for limiting the depth of said anchor pile in said drilled hole.

2. Apparatus as recited in claim **1** wherein said means releasably engaging said anchor pile and said sleeve member includes guide means formed on the interior surface of said sleeve member and resilient means arranged on the outer surface of said anchor pile for engagement with said guide means.

3. Apparatus as recited in claim **2** wherein said guide means comprise a plurality of longitudinally extending, radially spaced-apart grooves and said resilient means comprise vertically and radially spaced-apart bow springs for engagement in said grooves.

4. Apparatus as recited in claim **1** wherein said means for limiting the depth of said anchor pile in said drilled hole includes obstruction means connected to said anchor pile for engaging the lower end of said sleeve member to prevent movement thereof to the top of and into said drilled hole.

5. Apparatus as recited in claim **4** wherein said obstruction means includes a stop cable connected to said anchor pile and adapted to extend through said slot in said sleeve member.

6. Apparatus as recited in claim **5** wherein said obstruction means comprises a sphere.

7. Apparatus as recited in claim **1** including a wrap-around tube arranged on said anchor pile for receiving said anchor cable.

8. Apparatus as recited in claim **1** in which said sleeve member includes a serrated and flared end to aid in gripping said ocean floor.

9. In apparatus for use in installing anchoring means for mooring rigs floating on the surface of water using an anchor pile system comprising a drill string, an anchor pile and means releasably connecting the drill string to the anchor pile including means permitting the anchor pile to remain stationary while the drill string rotates, the improvement comprising:

a sleeve member adapted to be suspended on said drill string and to surround said anchor pile, one end of said sleeve member being adapted to contact and grip the ocean floor and inhibit rotation of said sleeve member; and

means formed on said sleeve member for releasably connecting said sleeve member to said anchor pile to prevent rotational but permit vertical movement of said anchor pile relative to said sleeve member, said sleeve member also having a slot extending along the length thereof to permit an anchor cable connected to said anchor pile to extend through said sleeve member to the water surface.

10. Apparatus as recited in claim **9** in which said sleeve member includes a serrated and flared end to aid in gripping said ocean floor.

11. Apparatus as recited in claim **10** including means for limiting the depth of said anchor pile in said drilled hole.

12. Apparatus as recited in claim **11** wherein said means for limiting the depth of said anchor pile in said drilled hole includes obstruction means connected to said anchor pile for engaging the lower end of said sleeve member to prevent movement thereof to the top of and into said drilled hole.

13. Apparatus as recited in claim **12** wherein said obstruction means includes a stop cable connected to said anchor pile and adapted to extend through said slot in said sleeve member.

14. Apparatus as recited in claim **13** wherein said obstruction means comprises a sphere.

15. A method for installing means for use in mooring a floating rig comprising the steps of:

inserting a drill string through an anchor pile, said drill string and said anchor pile being releasably attached to each other in a manner to permit said anchor pile to remain stationary while said drill string rotates;

arranging an antirotation sleeve member about said anchor pile and engaging with each other such that when said sleeve member contacts the ocean floor, rotation of said anchor pile is inhibited;

connecting an anchor cable to said anchor pile and extending it through a slot formed in said sleeve member to the floating rig;

connecting said stop means to said anchor pile to limit the depth of said anchor pile in the hole to be drilled;

lowering said drill string together with said anchor pile, sleeve member, anchor cable and stop means through the water from the drilling rig until said sleeve member contacts the ocean floor;

drilling a hole in the ocean floor and paying out said anchor cable as said anchor pile is carried deeper into said drilled hole;

said anchor pile being restrained from rotational movement during drilling by said sleeve member;

halting drilling operations when said anchor pile is located at a preselected depth in said drilled hole;

releasing said drill string from said anchor pile; and

then raising said drill string and sleeve member suspended thereon from said drilled hole to the floating rig.

16. A method as recited in claim **15** including the step of pumping cement through said drill string into the an-

nulus surrounding said anchor pile following the step of halting drilling operations when said anchor pile is located at a preselected depth in said drilled hole and prior to the step of releasing said drill string from said anchor pile.

17. A method as recited in claim **16** including the step of pumping cement through said drill string while raising said drill string and sleeve member suspended thereon from said drilled hole until said anchor pile and drilled hole are filled with cement.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

52—156; 61—53.52, 63; 114—206; 175—171