United States Patent

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[54] **METHOD OF AND APPARATUS FOR SETTING AN UNDERWATER STRUCTURE**
7 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **166/.5,** 61/53.68, 175/171, 285/282
[51] **Int. Cl.** **E21b 7/12,** E21b 33/035
[50] **Field of Search** ..... 175/5–10, 171, 325, 257, 258, .5; 166/286, 290; 285/18, 272–282, 91, 92, 94, 402; 61/53.68

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ABSTRACT: A method of and apparatus for setting an underwater structure in which the structure is lowered on a drill string into the hole as it is being drilled, cement is delivered through the drill string and placed to secure the structure in the hole and the drill string is recovered. This abstract is neither intended to define the invention of the application which, of course, is measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

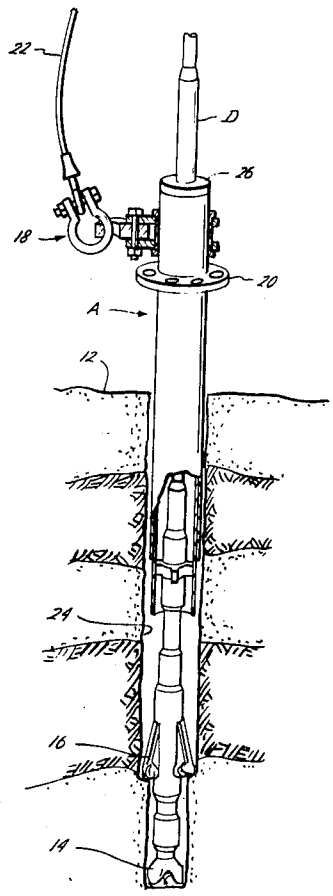
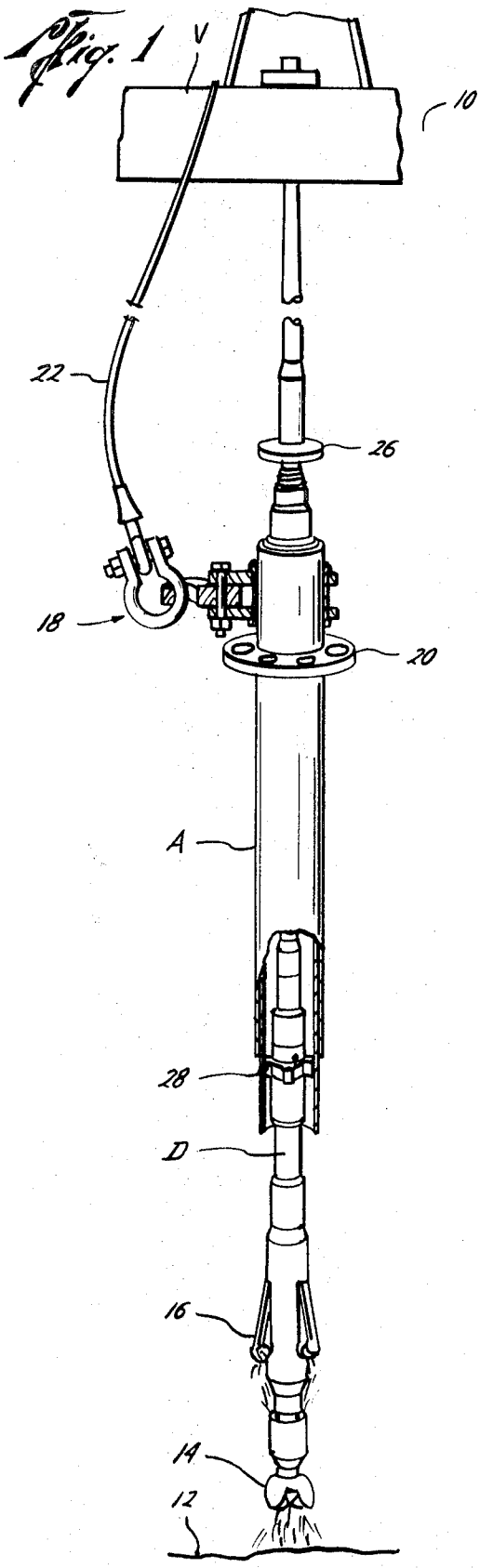


Fig. 1



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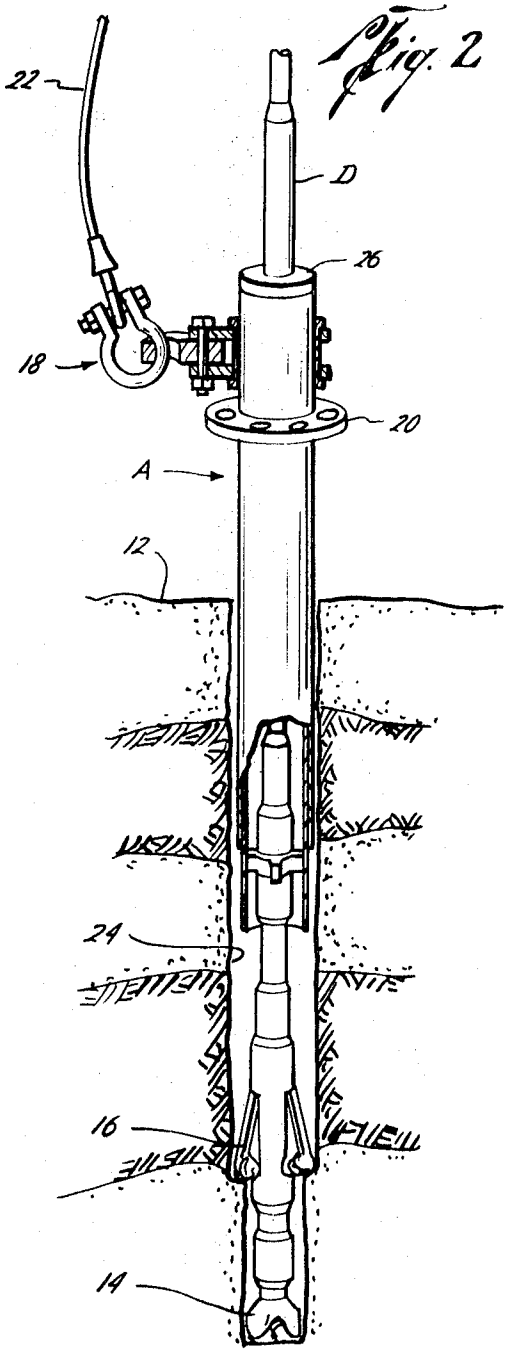

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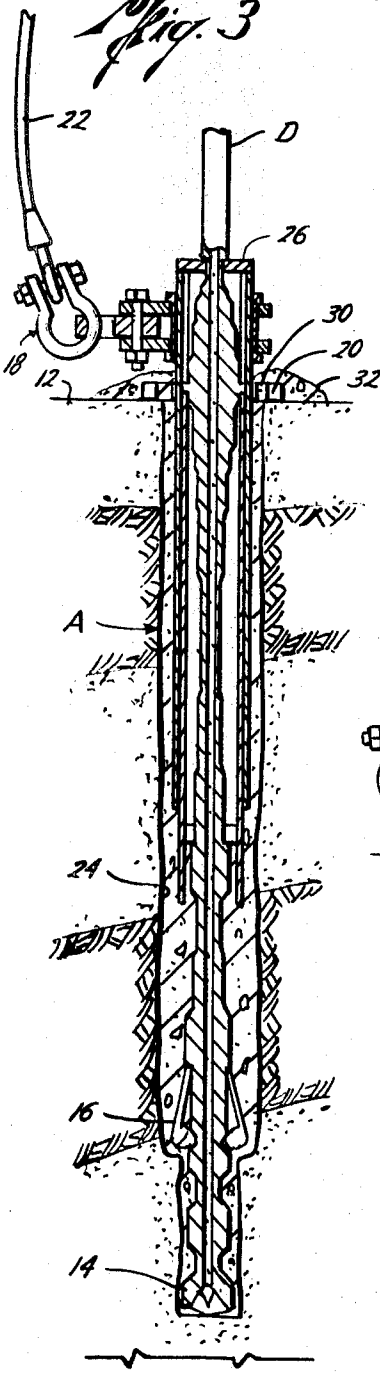
Fig. 3



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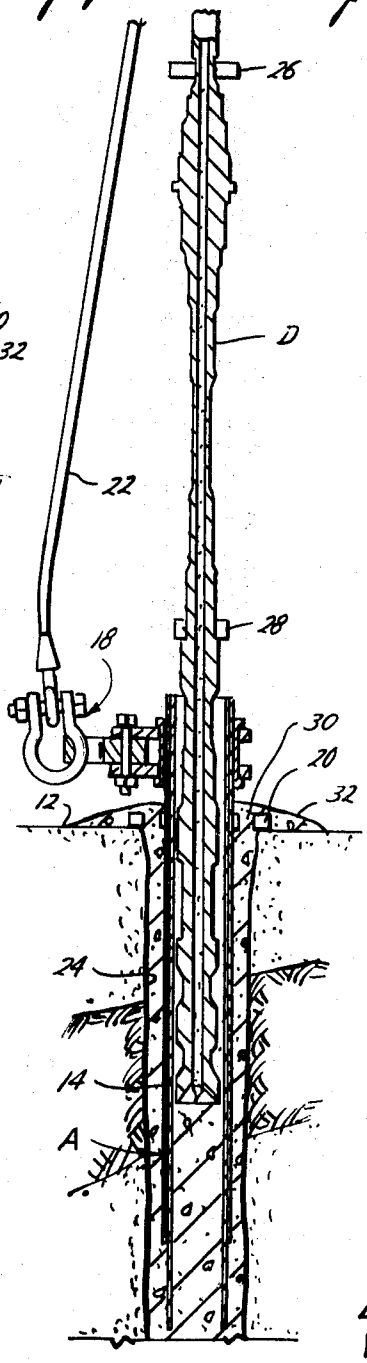

Fig. 5

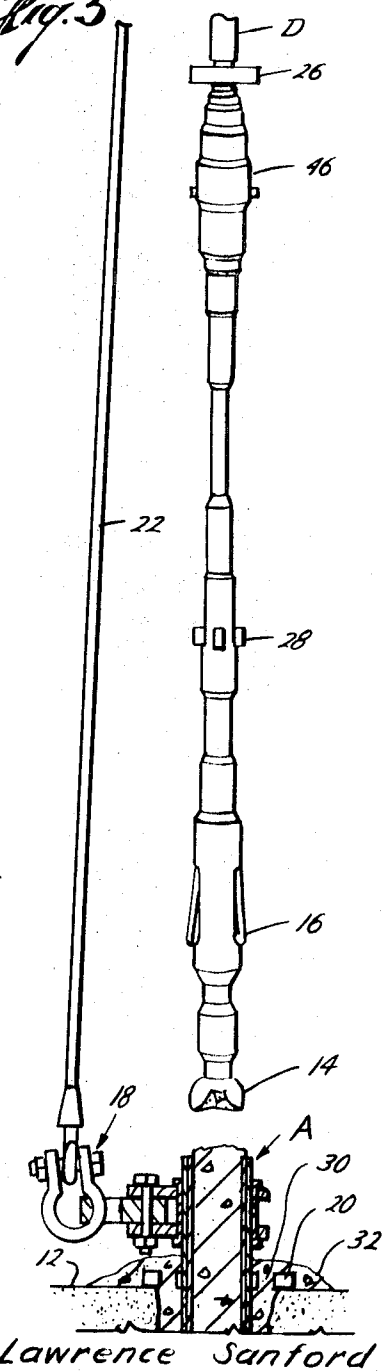

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Fig. 6

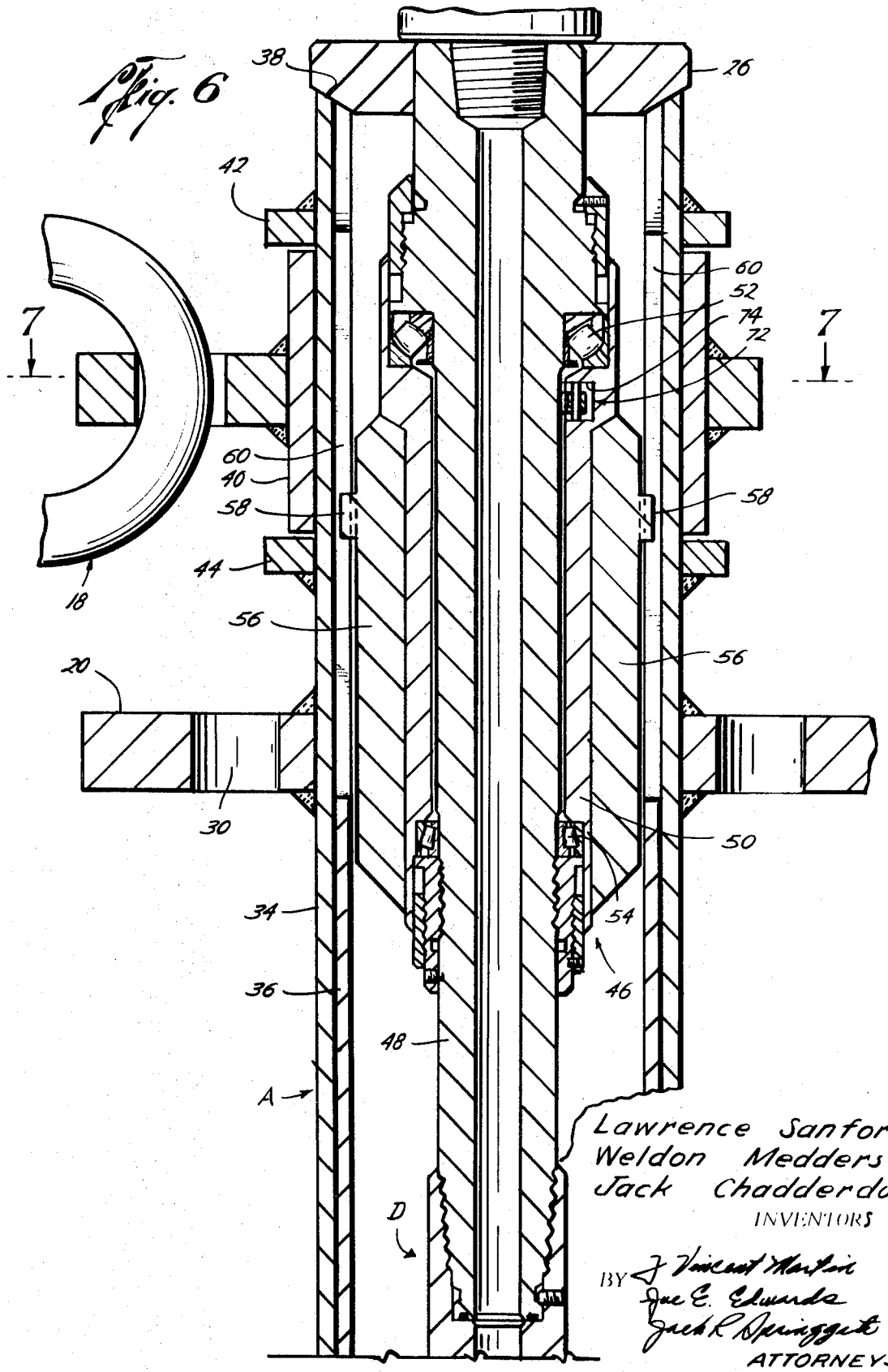

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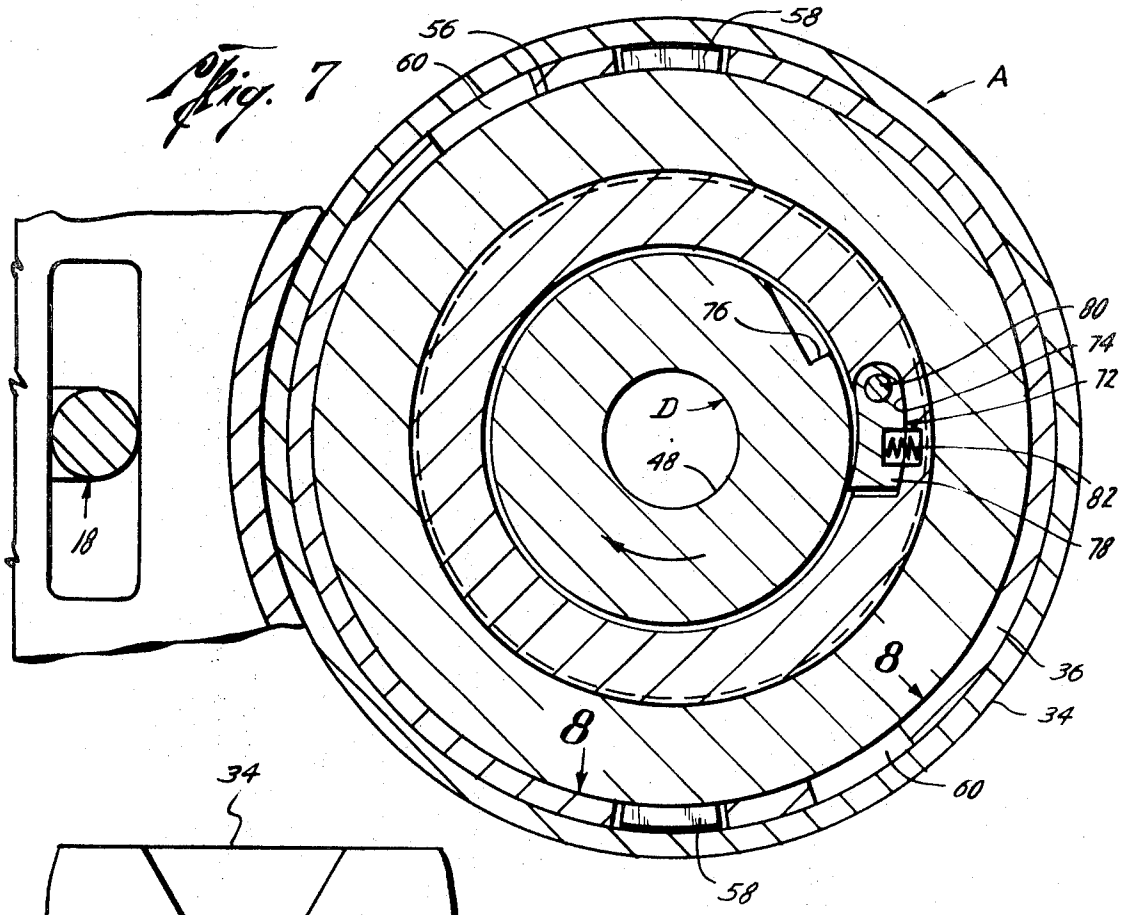
Fig. 7



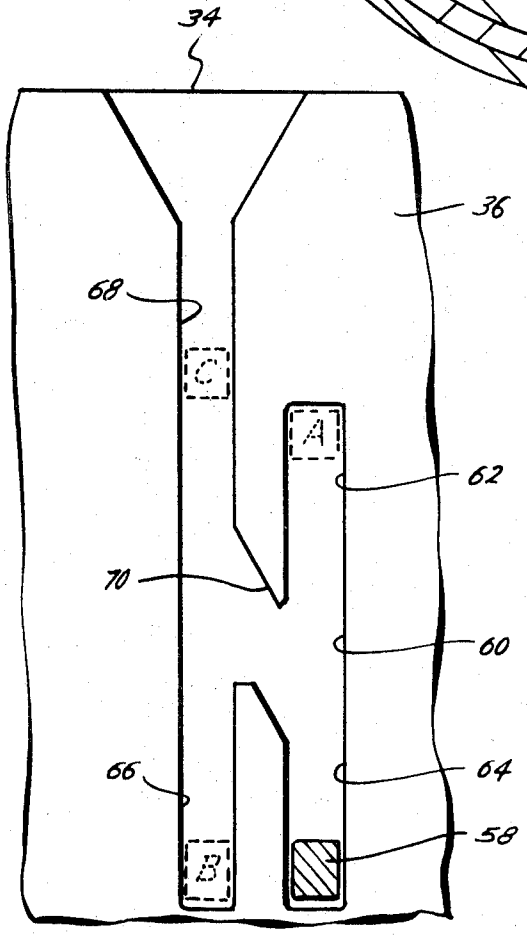


Fig. 8

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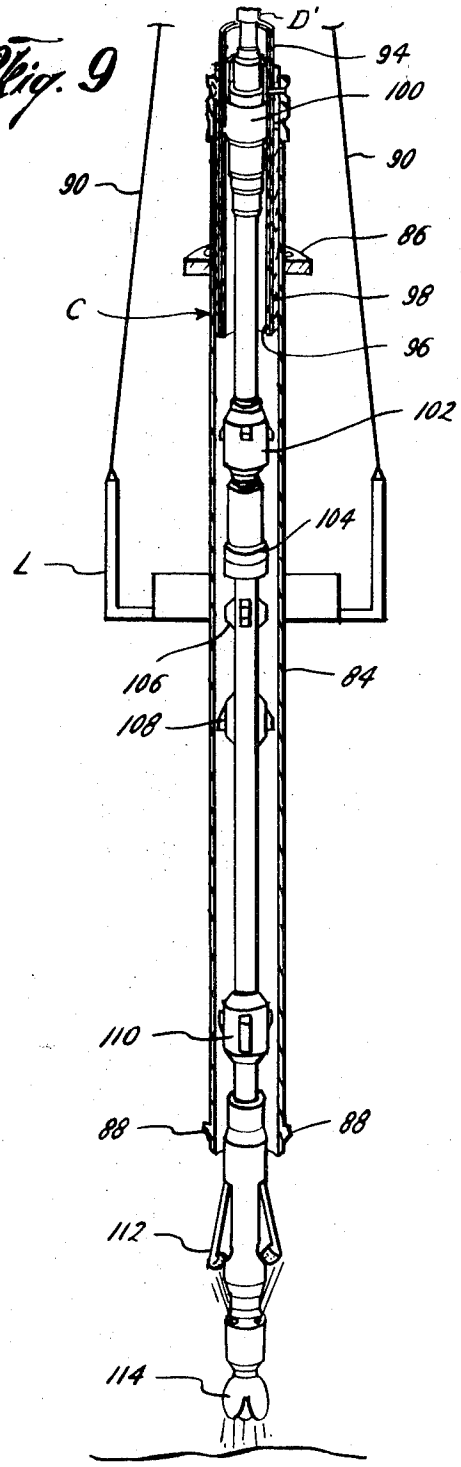
Fig. 9



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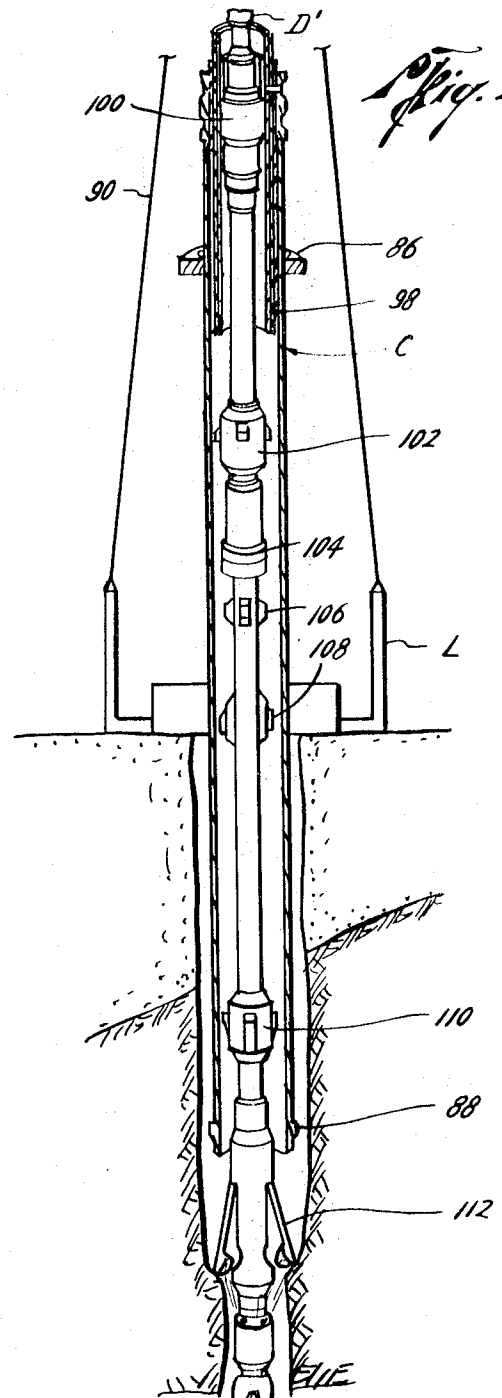

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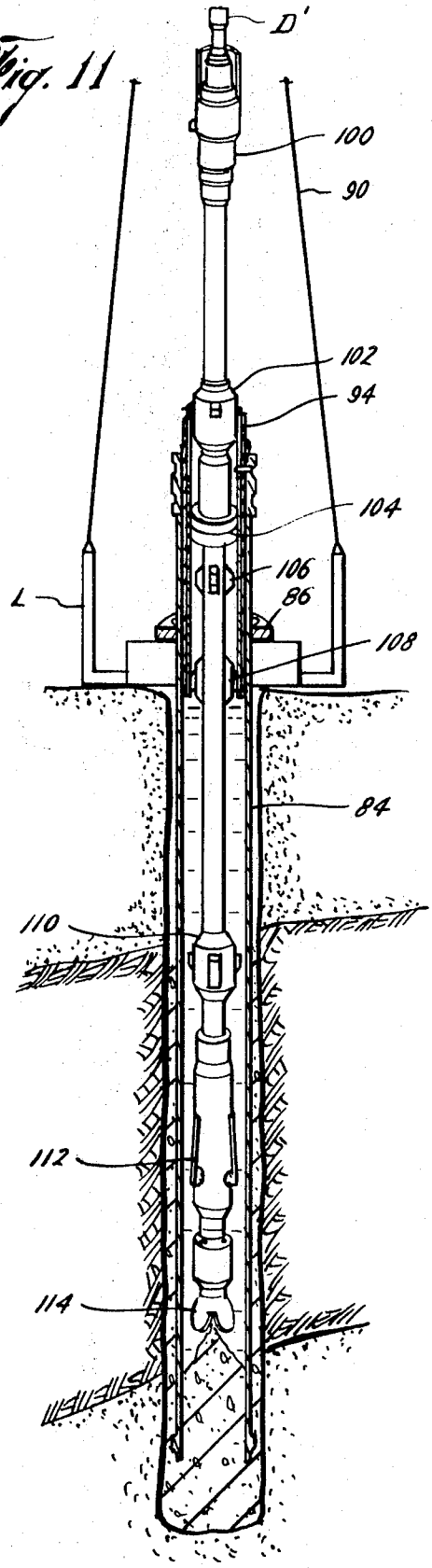
Fig. 11



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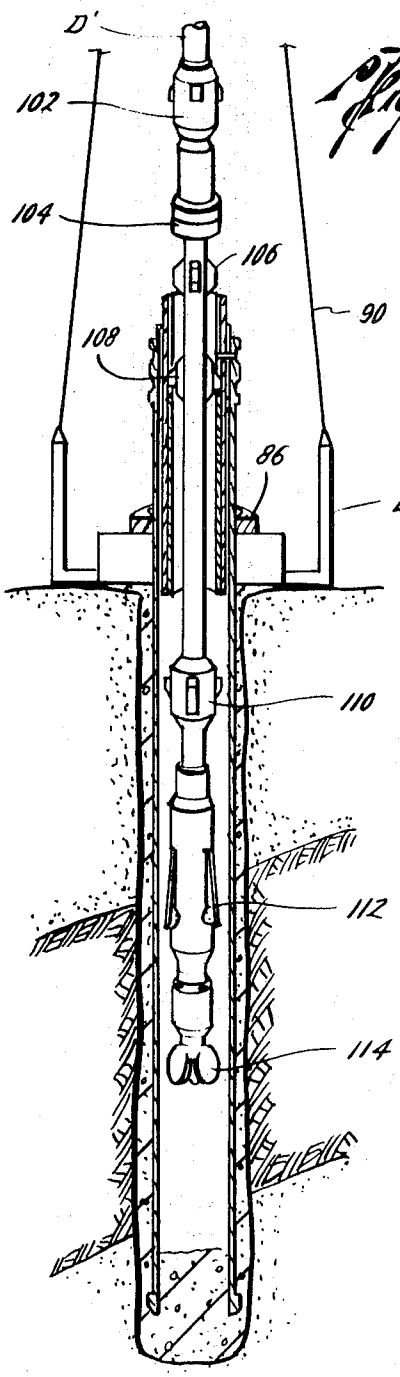

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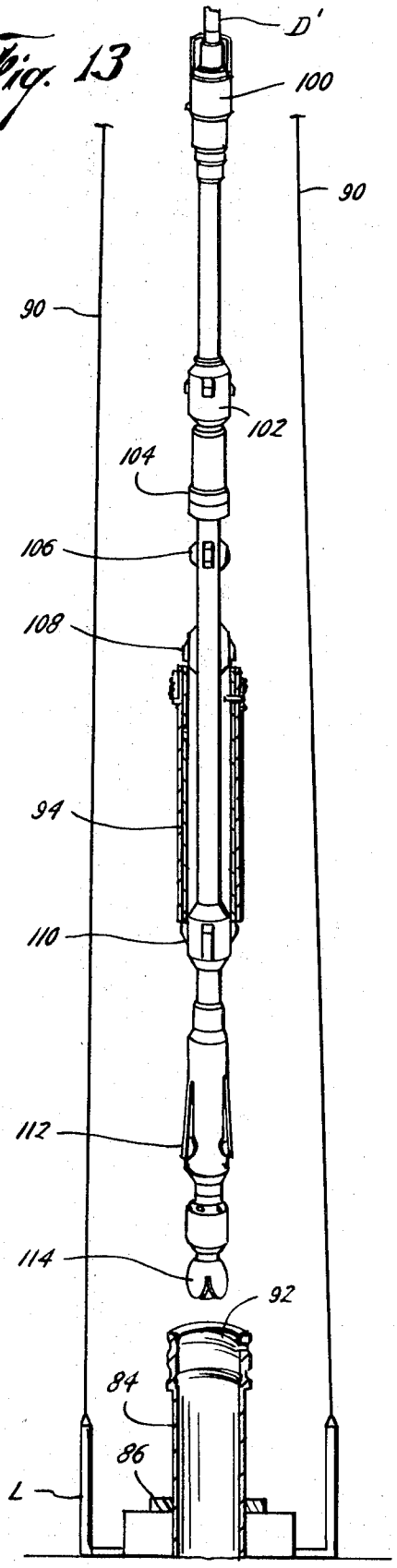
Fig. 13



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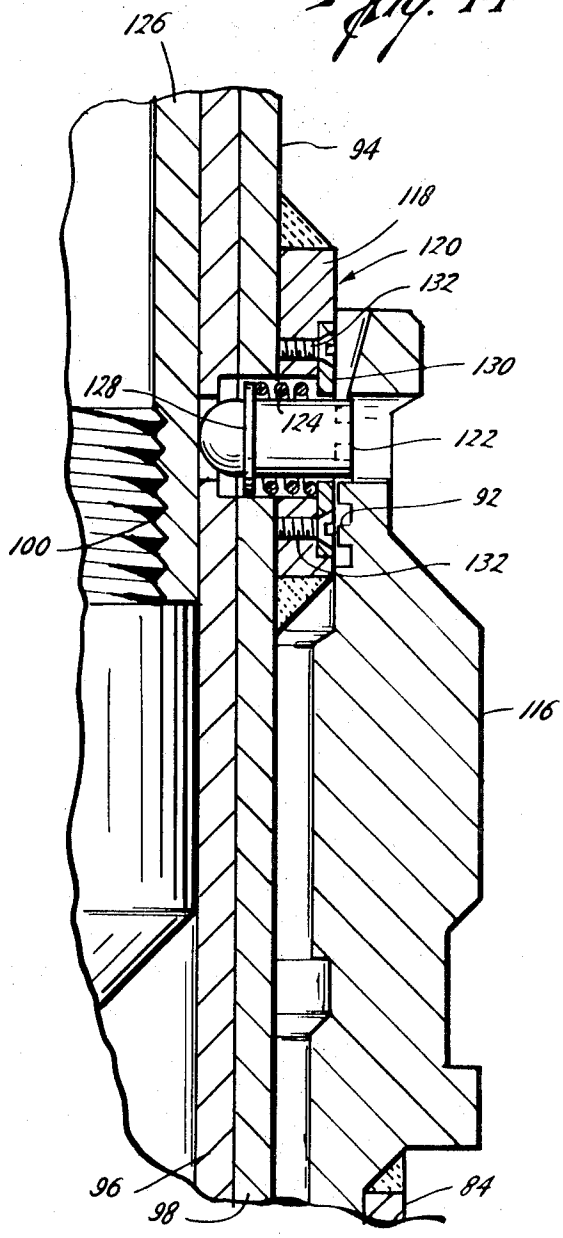

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METHOD OF AND APPARATUS FOR SETTING AN UNDERWATER STRUCTURE

BACKGROUND OF THE INVENTION

Floating structures have been anchored in the past in a manner similar to that used for anchoring boats, i.e., a hook-type anchor is lowered in the water at a preselected position and when it engages the bottom, it is tied by a cable or other suitable means to the floating structure. Difficulty has been encountered with such anchors dragging so that the floating structure is not held in a relatively fixed position with respect to an underwater position such as an underwater wellhead or drilling site. Also, in drilling a well from a floating drilling vessel, it has been common practice to drill a hole in the earth and to provide a conductor pipe assembly in this hole with suitable guiding means extending upwardly to the surface of the water to assist in subsequent operations. In such systems, drivers have been employed and the setting of the conductor pipe assembly has required several round trips of a drill string.

SUMMARY

The present invention relates to an improved method of and apparatus for setting an underwater structure.

It is an object of the present invention to provide an improved method of and apparatus for permanently setting an underwater structure in a hole in the earth from a floating vessel which requires only a single round trip of the drill string to complete the hole, position the structure in the hole and to cement the structure in the hole.

Another object of the present invention is to provide an improved method of and apparatus for setting an underwater anchor from the water surface so that the anchor remains in its set position regardless of the condition of the bottom.

Another object is to provide an improved method of and apparatus for setting an underwater structure in a drilled hole which is simply and positively accomplished from the water surface.

A further object is to provide an improved method of and apparatus for setting a permanent underwater structure in a minimum amount of time.

Still another object is to provide an improved method of and apparatus for setting an underwater structure such as an anchor or a conductor pipe assembly in a hole drilled in the bottom which requires only one round trip of the drill string.

A still further object is to provide an improved anchor structure adapted to be supported on a drill string and moved into the hole drilled by the drill string as it is being drilled.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention are hereinafter set forth and described with reference to the drawings wherein:

FIG. 1 is an elevation view partly in section of the improved anchor structure and drill string being lowered in the water and ready to drill.

FIG. 2 is a similar view illustrating the drilling of the hole with the anchor structure moving into the drilled hole while drilling is progressing.

FIG. 3 is a sectional view illustrating the cementing around the exterior of the anchor structure.

FIG. 4 is a sectional view illustrating the cementing of the interior of the anchor structure during removal of the drill string.

FIG. 5 is a view similar to FIG. 1 illustrating the position of the drill string when it is free of the anchor structure and the position of the cement in and around the upper portion of the anchor structure.

FIG. 6 is a longitudinal sectional view illustrating the releasable support of the anchor structure by the drill string.

FIG. 7 is a sectional view taken along line 7—7 in FIG. 6 and illustrating the ratchet connection between the drill string and the anchor structure.

FIG. 8 is a sectional view taken along line 8—8 in FIG. 7 and illustrating the pin and slot connection between the drill string and the anchor structure.

FIG. 9 is an elevation view of a conductor pipe structure and landing base being lowered in the water.

FIG. 10 is a similar view illustrating the drilling of the hole with the conductor pipe assembly moving into the hole and the landing base positioned on the bottom.

FIG. 11 is another similar view illustrating the cementing position of the drill string with respect to the landing base.

FIG. 12 is another similar view illustrating the disconnection of the tubular adapter from the conductor pipe assembly.

FIG. 13 is another similar view illustrating the recovery of the drill string.

FIG. 14 is a partial sectional view illustrating the pawl assembly which locks the tubular adapter within the conductor pipe assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the preferred method of the present invention, it is desired to set an underwater structure from a floating barge or vessel by lowering the structure on a drill string, moving the structure into the hole as it is drilled by the drill string, cementing the structure in the hole by conducting cement through the drill string and recovering the drill string.

SETTING AN UNDERWATER ANCHOR STRUCTURE

In FIG. 1, the floating vessel V at the surface 10 of the body of water is positioned over a preselected anchoring point on the floor or bottom 12 of the body of water. The vessel V is the type of vessel normally equipped to perform drilling and therefore includes means for handling drill string sections, the usual rotary table, and means for pumping drilling fluid and cement. The setting of the anchor structure A begins by releasably connecting the anchor structure A to the drill string D at a position above the drill bit 14 and the expansible underreamer 16 as hereinafter explained. The anchor structure A is provided with a clevis and shackle assembly 18 connected to its upper end above the stop plate 20. The clevis and shackle assembly 18 provides the means for connecting the anchor chain or cable 22 from the anchor structure A to the vessel V. Thus, as the drill string D with the anchor structure A supported thereon is lowered in the water, the chain 22 is paid out with sufficient slack so that it does not interfere with the lowering and drilling. As shown in FIG. 1, the circulation of drilling fluid through drill string D is commenced as the drill bit 14 nears the floor 12.

The connection between anchoring assembly A and drill string D allows drill string D to be rotated in the usual manner for drilling within the anchor structure A. The drilling progresses in the usual manner with the drill bit 14 and underreamer 16 drilling the hole 24. The drill string D includes the collar 26 which engages the upper end of anchor structure A during drilling to force anchor structure A downwardly in the hole 24 as it is being drilled. The drill string D also includes the stabilizer 28 which functions to hold the lower end of anchor structure A concentric about the drill string D so that it readily enters the hole 24. Because the underreamer drills the hole 24 to a diameter larger than the diameter of anchor structure A below stop plate 20, and because anchor structure A is held concentric with the drill string D, the anchor structure A is readily moved into the hole 24 as the drilling progresses. Any force required to move anchor structure A into the hole 24 is applied by the collar 26.

The drilling is completed when the stop plate 20 rests on the bottom 12 as shown in FIG 3. Circulation of drilling fluid is continued to clean the cuttings from the hole 24. With collar 26 in engagement with the upper end of anchor structure A, cement is pumped through the drill string D and is discharged into the lower portion of hole 24. Since communication upwardly through anchor structure A is closed by collar 26, the cement is forced upwardly around the exterior of anchor

structure A. Stop plate 20 defines a plurality of perforations 30 so that it does not block the flow of cement upwardly around anchor structure A. The amount of cement pumped is preselected to be sufficient to fill the hole below and around the anchor structure A. An excess amount is preferably supplied and this cement accumulates over and around stop plate 20 as indicated at 32.

When this predetermined amount of cement has been pumped through drill string D, the connection between drill string D and anchor structure A is released. If preferred, this connection may be released before the cementing is commenced since the structure of such connection, as hereinafter explained, allows collar 26 to close the upper end of the anchor structure A in either position. Cementing is continued with cement being pumped through the drill string D while it is lifted out of anchor structure A. This cement is positioned in the bore of anchor structure A as shown in FIG. 4.

When the drill bit 14 clears the upper end of anchor structure A, as shown in FIG. 5, the interior of anchor structure A is completely filled with cement. In this position the drill string D can be recovered by lifting onto the vessel V in the usual manner. The chain 22 extends from the secured anchor structure A to vessel V and may be used to anchor the vessel V or some other floating structure. Usually to anchor a floating drilling platform or barge, a plurality of anchor structures are set at positions spaced around the desired drilling position and the anchor chains from each of the anchor structures are secured to the floating barge with the desired amount of tension in the chains.

The anchoring of the present invention is effective under varied conditions encountered at the floor of the body of water and therefore provides an improved anchoring of floating structures. This anchoring is accomplished quickly and simply from a floating drilling vessel and requires only a single trip of the drill string to completely set the anchor structure.

As has been explained, a means of releasably connecting the anchor structure to the drill string is provided and such means allows the drill string to perform its usual drilling function without releasing such connecting means. The details of the preferred structure for such connecting means is illustrated in FIGS. 6, 7 and 8. The anchor structure A includes the outer sleeve 34 and the inner sleeve 36 secured within outer sleeve 34. Inner sleeve 36 extends through outer sleeve 34 and projects below the lower end of outer sleeve 34 as best seen in FIGS. 1 through 4. The upper ends of sleeves 34 and 36 define the seat 38 which is suitable for engagement by collar 26. Seat 38 is tapered downwardly and inwardly to assure tight closure by collar 26 during the initial cementing steps as hereinbefore explained. The drill string D is provided with a downwardly facing shoulder 37 against which collar 26 abuts so tat the weight of the drill string D may be transmitted by the collar 26 to the anchor structure A. The clevis and shackle assembly 18 is secured to the ring 40 surrounding outer sleeve 34 between the flanges 42 and 44 which are suitably secured as by welding to outer sleeve 34. The ring 40 provides a swivel connection of the clevis and shackle assembly 18 to the anchor structure A. The stop plate 20 is secured, as by welding, around the outer sleeve 34 at a position below the flange 44.

The drill string D is provided with the swivel 46 which includes the mandrel 48 having a central bore therethrough, mandrel 48 being connected in the drill string D and the sleeve 50 which surrounds mandrel 48 and is rotatably supported thereon by the b earing 52 and 54. Suitable packing is provided to seal the bearings. Adapter sleeve 56 is secured to the exterior of the sleeve 50. The adapter sleeve 56 defines at least two outwardly projecting pins 58, each of which is adapted to engage within one of the slots 60 defined in the upper end of inner sleeve 36.

As best seen in FIG. 8, the slot 60 includes the sections, 62, 64, 66, 68 and crossover section 70. Sections 62 and 64 are vertically aligned with each other and form one vertical leg. Section 62 is closed at its upper end and section 64 is closed at its lower end. Sections 66 and 68 are vertically aligned with each other and form the second vertical leg. Section 66 is closed at its lower end and section 68 is open at its upper end. Crossover section 70 extends between the two vertical legs as shown. The positioning of the pins 58 in the sections 62 and 64 of slots 60 provides the means connecting drill string D to the anchor structure A.

Since the mandrel 48 is free to rotate within the sleeve 50, a means is provided for moving the pins 58 from sections 62 and 64 through crossover section 70 into sections 66 and 68 to allow release of the connection between the drill string D and the anchor structure A. This release means is provided by the ratchet assembly 72 contained within the recess 74 defined in sleeve 50 and the notch 76 defined in the exterior of mandrel 48. The ratchet assembly 72 includes the arm 78 which is pivotally mounted in recess 74 by pin 80 and is urged inwardly toward engagement in notch 76 by spring 82. The ratchet assembly 72 is arranged to allow normal drilling operations to proceed without imparting a rotation to sleeve 50, that is, a right-hand or clockwise rotation of drill string D rotates mandrel 48 freely within sleeve 50. When it is desired to disconnect the drill string D from anchor structure A, the drill string D is lifted slightly and rotated to the left. This action causes pins 58 to be lifted slightly and rotated to the left. This action causes pins 58 to be lifted to a position opposite the crossover section 70 in slots 60 and the engagement of arm 78 in notch 76 positively rotates sleeve 50 and pins 58 to position pins 58 in sections 66 and 68 of slots 60. The force necessary to so move the pins 58 is not sufficient to cause unthreading of any of the sections of the drill string D. With the pins 58 in this position, the drill string D can be lowered, positioning pins 58 in the lower end of sections 66, and allowing collar 26 to engage seat 38 so that the initial cementing is around anchor structure A. Also, with the connecting means in this position, the drill string D may be lifted and removed from within anchor structure A with the pins 58 passing out through the open upper end of section 68 of slot 60.

In FIG. 8, the various positions of the pin 58 in the slot 60 are shown. The position of pin 58 shown in section is the position of pin 58 during drilling. The dashed positions shown are labeled A, B, and C with position A being the position of pin 58 during the lowering of the drill string D and anchor structure A position B being the position of pin 58 after the connection has been released and during initial cementing and position C being the position of pin 58 as the drill string D is being lifted out of anchor structure A during final cementing of the interior of anchor structure A.

SETTING AN UNDERWATER CONDUCTOR PIPE ASSEMBLY

FIGS. 9 through 13 illustrate the method of the present invention used to set an underwater conductor pipe assembly C and landing base L. As shown in FIG. 9, the conductor pipe assembly C is supported on the drill st ring D' and is lowered into the water from a vessel (not shown). The landing base L is positioned around the conductor pipe 84 of the assembly C at a position between the stop plate 86 which is secured to the conductor pipe 84 near its upper end and the lugs 88 which are secured to the lower exterior of the conductor pipe 84. The landing base L is slidable on the conductor pipe 84 and is independently supported by the guidelines 90. The lugs 88 and the stop plate 86 prevent the landing base from being disengaged from the conductor pipe 84. The upper end of the conductor pipe 84 is provided with the internal left-hand threads 92 into which the J-slot housing 94 is threaded as hereinafter described. The J-slot housing 94 includes an inner sleeve 96 having a slot configuration as shown in FIG. 8 and the outer sleeve 98. A releasable means is provided to retain the threaded connection between conductor pipe 84 and housing 94.

The drill string D' includes the swivel 100 which has projections for engaging in the slot defined by the inner sleeve 96. The initial engagement of the swivel projections is in the

closed portion of the slot so that a positive connection is provided between the drill string D' and the conductor pipe assembly C. The spacer latch **102** is connected to the drill string below the swivel **100** and is associated with the packer **104**. The stabilizer **106**, the releasing dogs **108**, the retrieving latch **110**, the underreamer **112** and the drill bit **114** are connected to the drill string D' below the packer **104** as shown in the drawings.

As previously described, the swivel **100** is designed to allow a free rotation of the drill string D' within the J-slot housing in one direction but to provide a connection when the drill string D' is rotated in the opposite direction so that drilling may progress without disengaging the connection between the drill string D' and the conductor pipe assembly and to provide means for disengaging the swivel **100** from the J-slot housing **94**.

As the drill bit **114** approaches the bottom, circulation of drilling fluid is commenced and the drill string D' is rotated so that drilling commences when the drill bit engages the bottom. As shown in FIG. **10**, as the drilling progresses, the conductor pipe **84** which is supported on the drill string D' is lowered into the bore hole that is drilled as the drill string moves downward. It is preferred that the landing base L be lowered onto the bottom as soon as a sufficient amount of borehole has been drilled to allow the lower end of the conductor pipe **84** to enter the borehole. In this way, the landing base is positioned in its final position as soon as possible to assure that the weight of the drill string is not carried by the guidelines **90**.

The drilling is continued until the stop plate **86** rests on the landing base L. The projections on swivel **100** are moved into the open end of the seat in inner sleeve **96** by reverse rotation of drill string D' to allow the lifting of drill string D'. With circulation continuing, the drill string D' is raised so that the spacer latch **102** is above the upper end of housing **94**. The continued circulation clears the borehole of cuttings. The drill string D' is then lowered so that the spacer latch **102** rests on the upper end of housing **94**. Spacer latch **102** coats with packer **104** to position packer **104** within the housing **94** and to set the packer **104** when the weight of the drill string is exerted on spacer latch **102**.

With the packer **104** set within housing **94**, cement is circulated downwardly through the drill string D'. Since flow upwardly through conductor pipe **84** is blocked by packer **104**, the cement flows upwardly around the exterior of conductor pipe **84** as shown in FIG. **11**. A sufficient quantity of cement is delivered through drill string D' followed by a quantity of heavy weight mud to assure that the space between the exterior of conductor pipe **84** and the borehole is completely filled with cement up to landing base L. Since in setting of a conductor pipe assembly, it is not desired to fill the conductor pipe with cement, the mud which is pumped down the drill string following the cement assures that only the lower portion of the conductor pipe **84** is filled with cement. It is generally preferred when cementing is completed that the level of the cement in the conductor pipe **84** be ten to fifteen feet below the lower end of the drill bit **114**. The cement is allowed to set with the drill string being intermittently rotated to insure that all elements thereof are free of the cement.

Before the cement has completely set, the drill string D' is again elevated to position the releasing dogs in the slot defined by the inner sleeve **96** of the J-slot housing **94**. The lifting of the drill string D' releases the packer **104** so that the string is easily raised. With the releasing dogs **108** in engagement in the slot of housing **94**, the drill string D' is rotated to the right to unthread the housing **94** from the threaded engagement with the threads **92** on the conductor pipe **84**. The retaining means, hereinafter described, has been released by the initial lifting of the drill string D' at the completion of the drilling step. This unthreading step is illustrated in FIG. **12**.

When the J-slot housing **94** is free of its threaded connection to the conductor pipe **84**, the drill string D' is again lifted. The retrieving latch **110** engages the lower end of the J-slot housing **94** and as the drill string D' is lifted to the surface vessel, the housing **94** is supported on the retrieving latch **110** and lifted to the vessel with the drill string D'. This retrieval step is shown in FIG. **13**.

With the retrieval of the drill string D' and the J-slot housing **94**, the setting of the conductor pipe assembly C is completed and drilling operations may be commenced through the conductor pipe assembly C in the usual manner. It should be noted that the landing base L remains connected to the vessel by the guide lines **90** so that a drill string for subsequent drilling may be guided into the conductor pipe **84**.

The preferred form of structure for the means retaining the threaded engagement of the J-slot housing **94** to the conductor pipe **84** is illustrated in FIG. **14**. As shown, the threads **92** are defined in the interior of landing head **116** which is connected to the upper end of conductor pipe **84**. The collar **118** is welded or otherwise suitably secured around the exterior of outer sleeve **98** and is threaded (not shown) for engagement with the threads **92**. The retaining means includes the pawl assembly **120** having the pawl **122** which is adapted to the positioned in holes defined in sleeves **96** and **98** and to engage in the hole defined in landing head **116** when the threaded connection is completely made up. The pawl **122** is biased inwardly by the spring **124** but is held in its outer engaging position by the sleeve **126** secured to the swivel **100**.

The pawl assembly **120** includes the pawl **122** which has a collar **128** and the spring **124** which engages the collar **128** and the cover **130** to urge the pawl **122** inwardly. The cover **130** is secured to the collar **118** by suitably means such as screws **132**.

The threaded connection between housing **94** and the landing head **116** is made up so that the holes in the housing **94** are in alignment with the hole in the landing head **116**. Since the pawl **122** is biased inwardly by the spring **124**, it does not engage the landing head **116** until the swivel **100** is positioned within the housing **94**. The exterior of the collar **126** on swivel **100** engages the inner end of the pawl **122** and forces it outwardly into engagement with the landing head **116** to assure that rotation of the drill st ring D' does not disengage the threaded connection until the swivel **100** has been removed from within housing **94**. Thereafter, since the support holding the pawl **122** in engagement with landing head **116** has been removed, the spring **124** moves the pawl **122** out of engagement with the landing head **116** and the threaded connection may thereafter be unthreaded.

While only one of such pawl assemblies has been illustrated, it is contemplated that such retaining means may include more than one of such assemblies, for example, three of such pawl assemblies in the housing **94** which coact with three holes defined in the landing head **116**.

From the foregoing, it may be seen that the present invention provides an improved method of and apparatus for permanently setting an underwater structure, such as an anchor or a conductor pipe assembly, from a floating structure with a single trip of a drill string. The present invention is applicable to setting such structures in deep water, under varied types of floor or bottom conditions and does not require divers or additional equipment to maintain contact with the drilled hole. The present invention also provides an improved anchor structure, an improved combination tubular structure and drill string allowing the structure to be moved into the hole as the hole is drilled and an improved drill string swivel having a means for rotating the swivel sleeve in one direction with rotation of the of the drill string and allowing free rotation of the drill string in the opposite direction. Also provided is an improved means for retaining a threaded connection during drilling which means is released by lifting the drill string so that the connection may be unthreaded when drilling and cementing operations are completed.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

We claim:

1. A drill string adapted for setting an underwater structure, comprising

a plurality of tubular drills sections, a drill bit secured to the lower end of said sections,

an expansible underreamer secured to said sections above said drill bit,

a swivel connected to said drill sections,

said swivel having a central mandrel, a sleeve rotatably mounted on said mandrel and defining outwardly projecting pins and means preventing rotation of said mandrel in one direction in relation to said sleeve whereby said mandrel is free to rotate in one direction within said sleeve and is prevented from rotating in the opposite direction within said sleeve.

2. A drill string according to claim 1, including

a housing having an inner sleeve and an outer sleeve secured around said inner sleeve,

said inner sleeve defining slots adapted to receive said projecting pins,

each of said slots having two vertical legs and a crossover section connecting between said vertical legs,

one of said vertical legs of each slot being closed at both ends and the other vertical leg being open at its upper end whereby said pins may be disengaged from said slots.

3. A drill string according to claim 2, wherein

said housing defines exterior threads and including

means mounted in said housing for releasably retaining said threads in engagement with mating threads.

4. A drill string according to claim 3, wherein said retaining means includes

a pawl positioned within a radial hole defined by said housing,

a spring urging said pawl inwardly out of retaining position, and

means on said swivel engaging said pawl when said swivel is connected to said housing whereby said pawl is held in its retaining position by said means and is moved inwardly by said spring when said swivel is disconnected from said housing.

5. An underwater conductor pipe assembly, comprising

a conductor pipe,

a landing head secured to the upper end of said conductor pipe,

said landing head defining internal threads and at least one hole adapted to receive a retaining pawl whereby a structure engaging in said threads may be retained in threaded engagement,

a stop plate secured around the exterior and near the upper end of said conductor pipe, and

lugs secured to the lower exterior of said conductor pipe.

6. The method of setting an underwater structure, including the steps of

positioning a tubular structure in surrounding relation to a portion of a drill string with a drill bit on the lower end of said drill string located below said tubular structure and supporting said tubular structure from said drill string,

lowering said drill string with said tubular structure thereon in a body of water,

rotating said drill string within said tubular structure to drill a hole in the earth at the bottom of the body of water with said drill bit so that as the hole is drilled and said drill string is lowered, said tubular structure is lowered into the hole,

sealing between the drill string and the tubular structure,

pumping cement through said drill string and into the annulus between said tubular structure and the walls of the drilled hole while sealing between the drill string and the tubular structure to assure placement of cement in said annulus,

releasing the seal between the drill string and the tubular structure after the annulus cementing is completed and thereafter continuing the pumping of cement while raising the drill string to fill the interior of the tubular structure with cement, and

recovering said drill string with said drill bit thereon.

7. The method of setting an underwater structure, including the steps of

positioning a tubular structure in surrounding relation to a portion of a drill string located below said tubular structure and supporting said tubular structure from said drill string,

lowering said drill string with said tubular structure thereon in a body of water,

rotating said drill string within said tubular structure to drill a hole in the earth at the bottom of the body of water with said drill bit so that as the hole is drilled and said drill string lowered, said tubular structure is lowered into the hole,

cementing around the exterior of said tubular structure in the drilled hole,

cementing the interior of said tubular structure,

releasing the connection providing support of the structure on the drill string prior to said interior cementing step,

lifting the drill string during said interior cementing step so that the cement completely fills the interior of said tubular structure, and

recovering said drill string with said drill bit thereon.

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