United States Patent

[11] 3,603,408

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[45] Patented **Sept. 7, 1971**
[32] Priority **Oct. 17, 1968**
[33] **Netherlands**
[31] **6814 339**

[54] **SUBMARINE DRILLING APPARATUS**
11 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **175/6,** 175/171
[51] **Int. Cl.** **E21b 7/12,** E21c 19/00
[50] **Field of Search** 175/56, 26, 171, 257, 258

[56] **References Cited**
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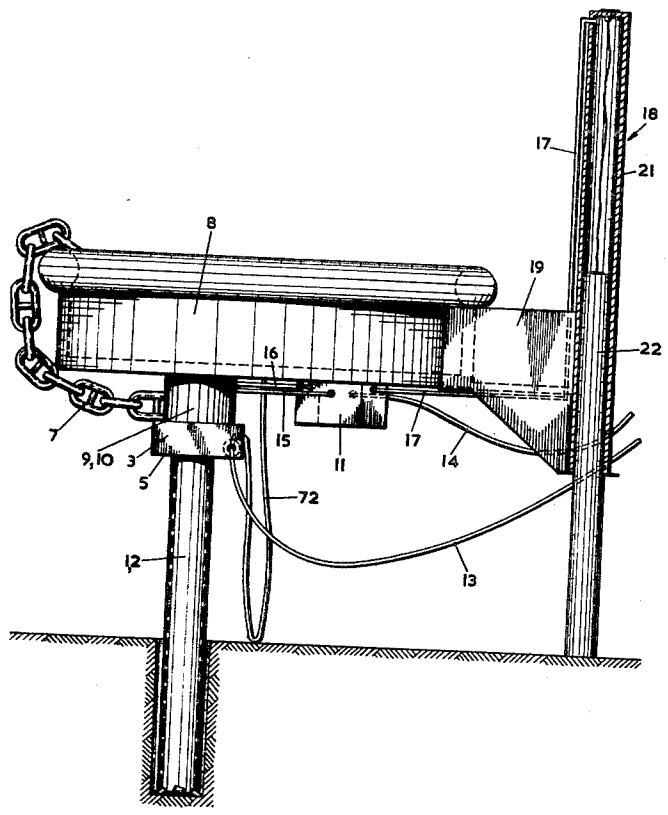
Primary Examiner—Stephen J. Novosad
Assistant Examiner—Richard E. Favreau
Attorney—Young and Thompson

ABSTRACT: Submarine drilling apparatus comprises a rotor and a stator with a drill casing detachably connected to the stator and a drill which is in the casing and suspended from the rotor. The apparatus is lowered from a vessel to the bottom, where it rests on at least three supports, at least one of which is the drill. The drill is hydraulically,operated from a source on the vessel, and the remaining supports are also hydraulically operated, with a distributor valve that is automatically operated by a universally suspended pendulum so as to regulate the hydraulic system to maintain the drill upright. After drilling, the casing is cemented, for example by filling it with cement to provide submarine securement for an anchor chain. The onset of cementing automatically disengages the stator from the casing so that the apparatus can be raised leaving the casing in place. Continued raising of the apparatus disconnects and raises the cementing conduit.



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SHEET 1 OF 8

Fig. 1

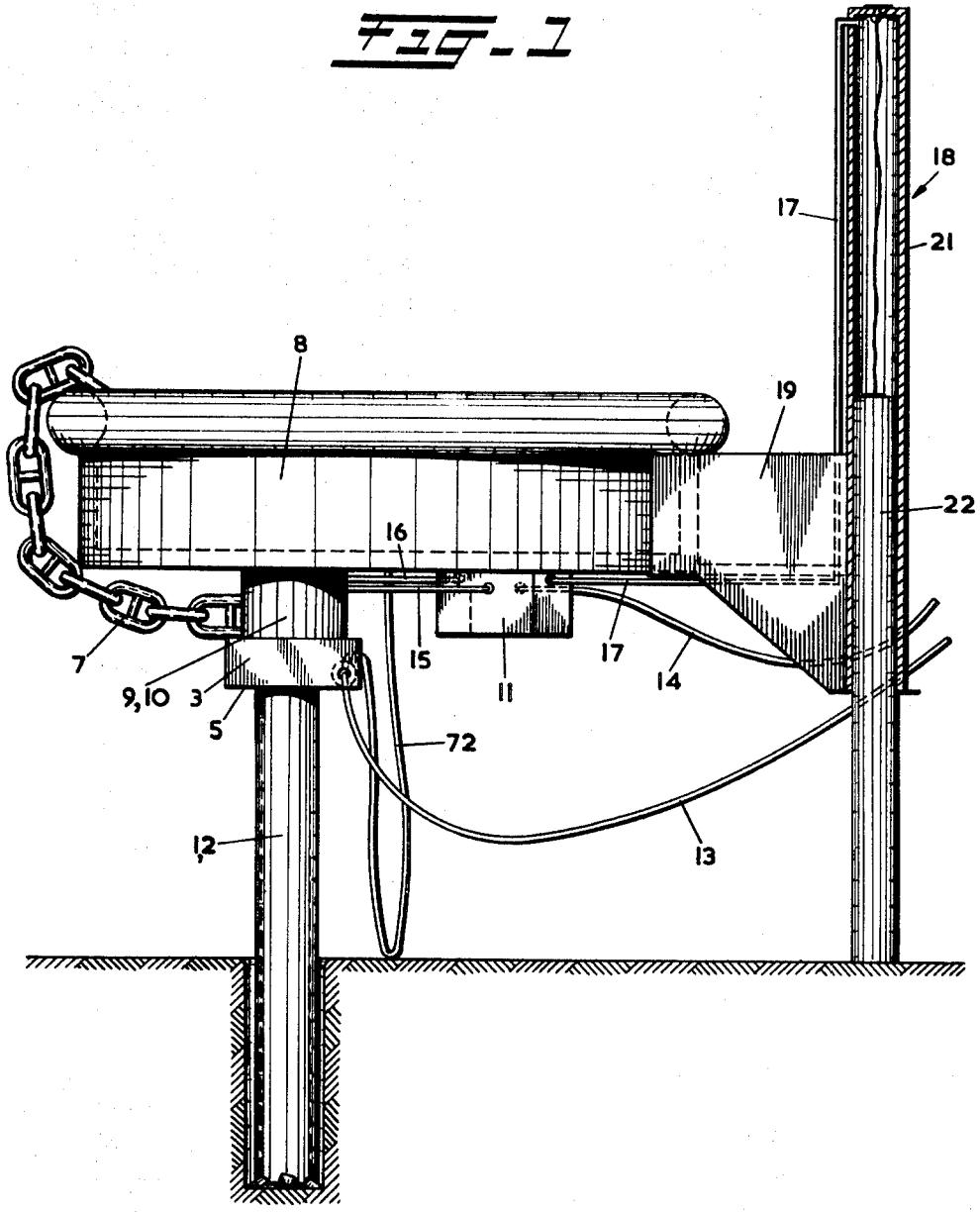

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Fig. 2

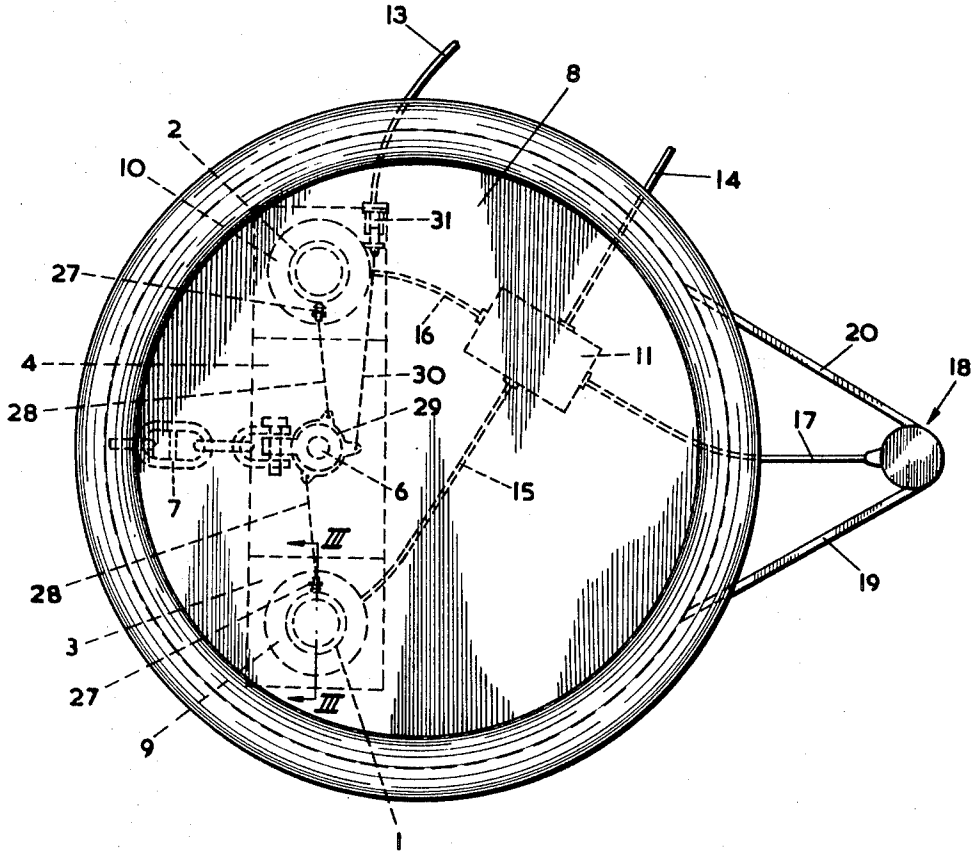

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Fig. 3

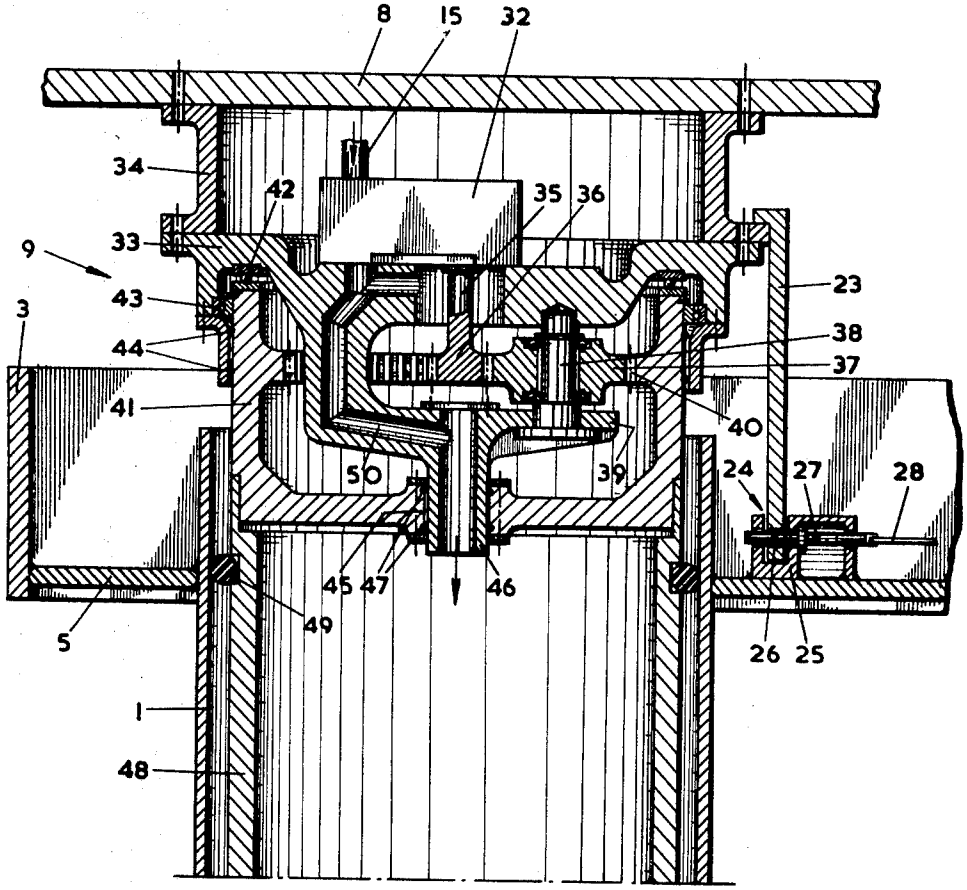

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Fig. 5

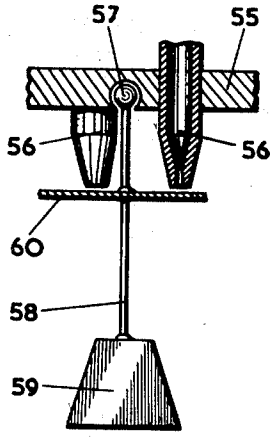

Fig. 6a

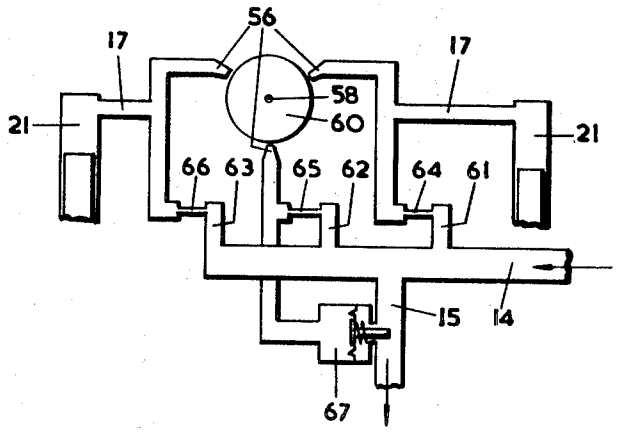

Fig. 6b

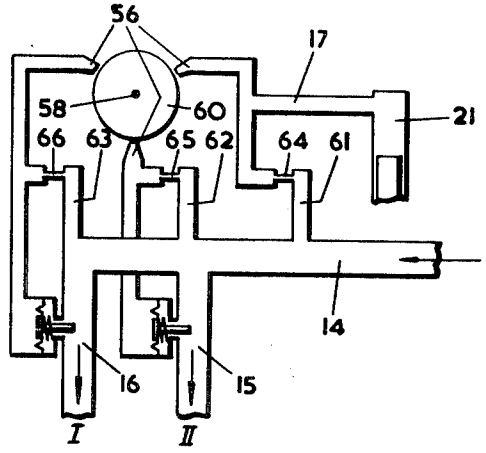

Fig. 6c

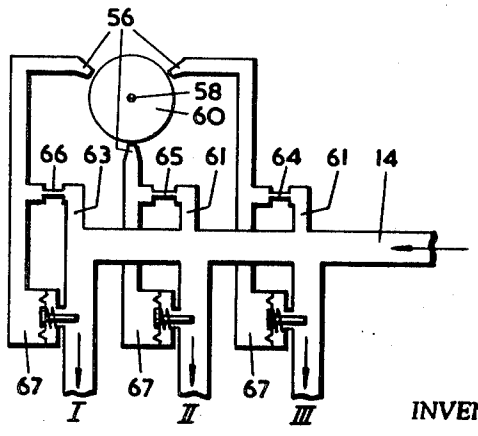

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Fig. 7

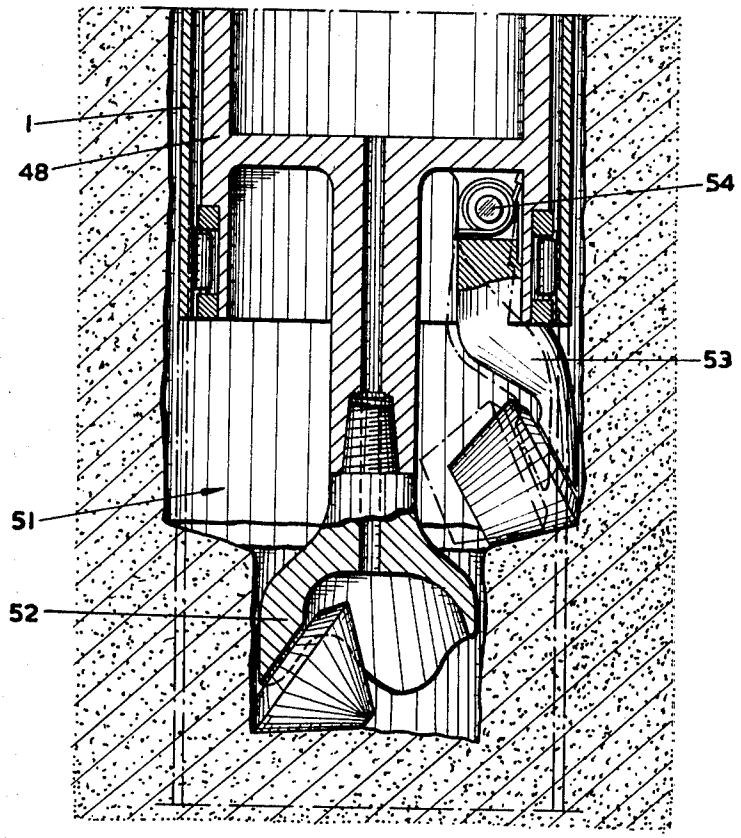

Fig. 8

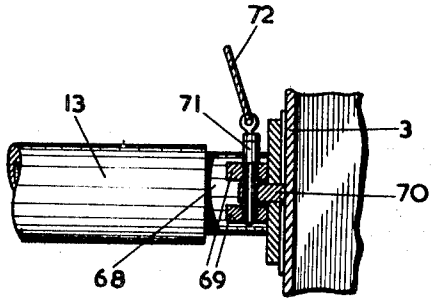

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Fig. 9

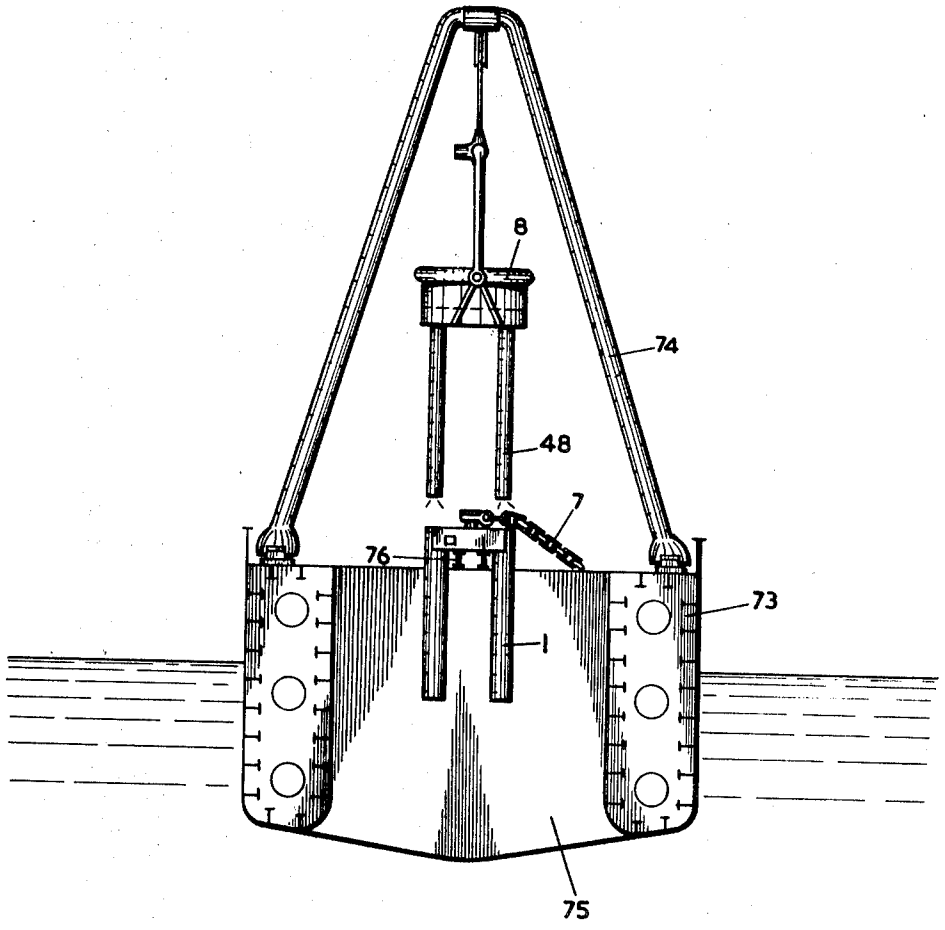

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Fig-10

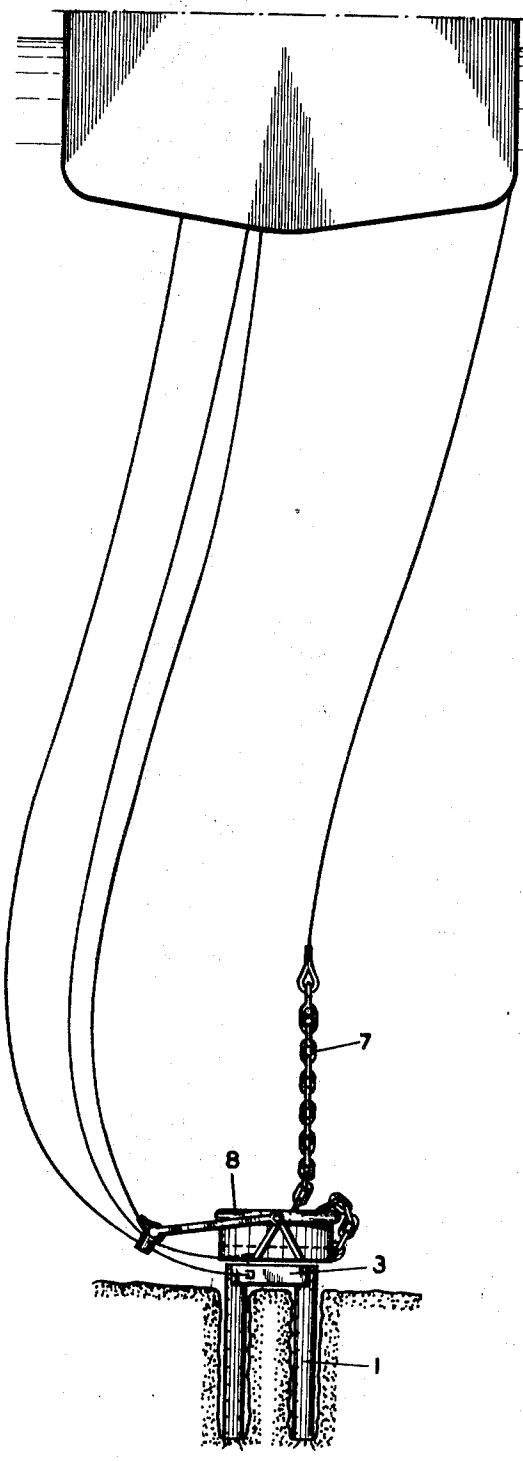
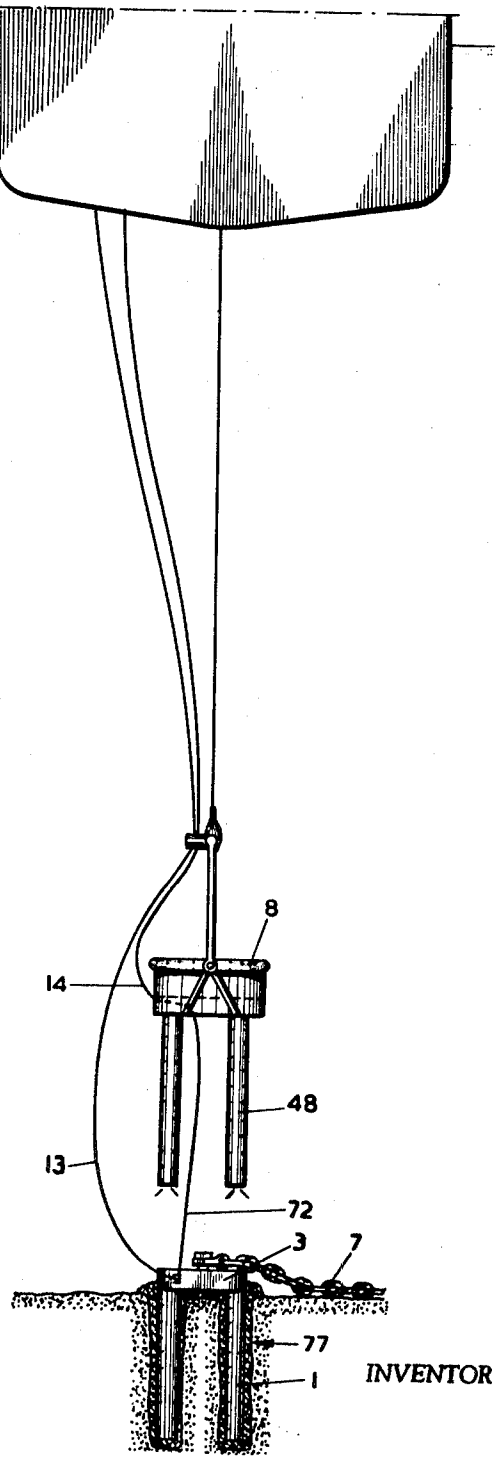


Fig-11



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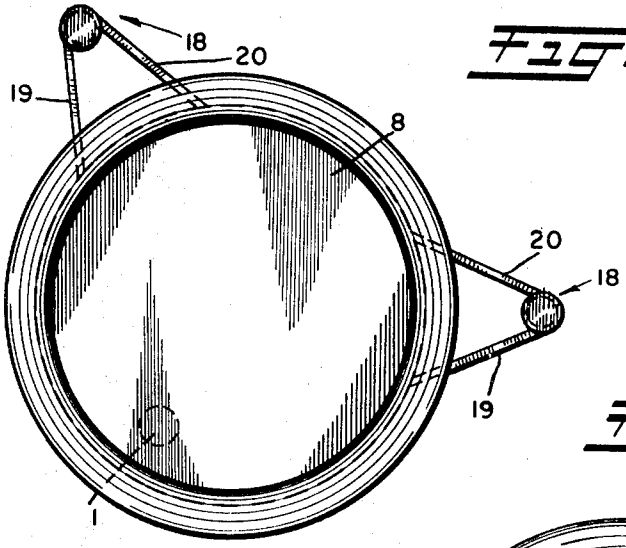
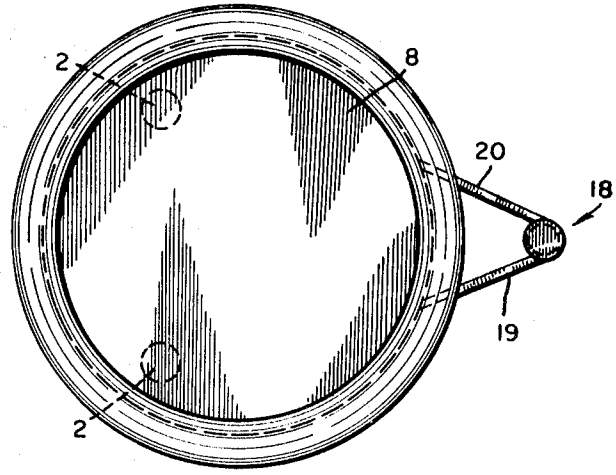


Fig- 4a

Fig- 4b



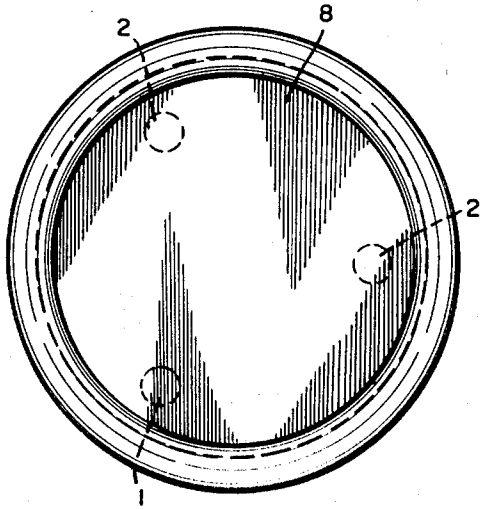


Fig- 4c

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SUBMARINE DRILLING APPARATUS

The present invention relates to apparatus for drilling holes and emplacing lengths of upright casing in marine soil at the bottom of a body of water, more particularly of the type in which drilling apparatus is lowered to and operates on the bottom.

It is already known to provide apparatus of this general type, as for example in U. S. Pat. No. 3,354,659, Nov. 28, 1967. It is also known to provide vessels that float on the surface of the water and that are adapted to drill holes in the bottom of the body of water, and also to provide such vessels that are semipermanently emplaced for this purpose.

However, all such apparatus as known heretofore suffers from the great disadvantage that it is extremely expensive to construct and/or operate.

Accordingly, it is an object of the present invention to provide submarine drilling apparatus, which will be useful at great depths.

It is also an object of the present invention to provide such apparatus in which the various operations of lowering the apparatus, drilling, cementing the casing, and raising the apparatus may be remotely controlled from a floating vessel.

Finally, it is an object of the present invention to provide such apparatus which will be relatively simple and inexpensive to manufacture, easy to assemble, emplace, operate, maintain and repair, and rugged and durable in use.

Briefly, the objects of the invention are achieved by providing submarine drilling apparatus which comprises a rotor and a stator with a drill casing detachably connected to the stator and a drill which is in the casing and suspended from the rotor. The apparatus is lowered from a vessel to the bottom, where it rests on at least three supports, at least one of which is the drill. The drill is hydraulically operated from a source on the vessel, and the remaining supports are also hydraulically operated, with a distributor valve that is automatically operated by a universally suspended pendulum so as to regulate the hydraulic system to maintain the drill upright. After drilling, the casing is cemented, for example by filling it with cement to provide submarine securement for an anchor chain. The onset of cementing automatically disengages the stator from the casing so that the apparatus can be raised leaving the casing in place. Continued raising of the apparatus disconnects and raises the cementing conduit.

Other features and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a somewhat schematic side elevational view of one embodiment of apparatus according to the present invention, characterized by two drills, shown in place on the sea bottom with a hole partly drilled;

FIG. 2 is a top plan view of the apparatus of FIG. 1;

FIG. 3 is an enlarged cross-sectional view taken on the line III—III of FIG. 2;

FIGS. 4*a*, 4*b* and 4*c* are schematic top plan views of three different embodiments of the invention, showing how the invention is adaptable for the use of one, two or three drills, respectively;

FIG. 5 is a fragmentary side cross-sectional view showing a portion of the distributor valve mechanism of the present invention;

FIGS. 6*a*, 6*b* and 6*c* are diagrams of the hydraulic circuitry for the arrangements of FIGS. 4*a*, 4*b* and 4*c*, respectively;

FIG. 7 is a view similar to FIG. 3 but showing the lower end of the drill and casing;

FIG. 8 shows the structure for disconnecting the cementing conduit prior to raising the same;

FIG. 9 shows in schematic side cross section the vessel with the apparatus of the present invention being assembled thereon prior to emplacement; and

FIGS. 10 and 11 show respectively the drilling operation and the removal of the apparatus following the drilling operation.

Referring now to the drawings in greater detail, and first to FIGS. 1 and 2, there is shown drilling apparatus according to the present invention, in use in the environment of emplacing upright casings in submarine soil and filling them with concrete, so as to provide an underwater securement for an anchor chain. The apparatus comprises a pair of casings 1 and 2 interconnected by means of a crosshead 3. Crosshead 3 is box-shaped and comprises a cover plate 4, a bottom plate 5, and a pin 6 extending upward from cover plate 4. An anchor chain 7 is secured to pin 6 at one end and carried for most of its length in an upwardly open container 8 secured to crosshead 3. Two drilling machines 9 and 10, each characterized by a stator and a rotor to be described in greater detail hereinafter, are releasably secured to crosshead 3 and extend between crosshead 3 and container 8. A distributor valve 11, also to be described hereinafter in greater detail, is secured to the underside of container 8. Also secured to crosshead 3 is a feed conduit 13 for cement mortar for filling the emplaced casings; while to the distributor valve 11 is secured a feed conduit 14 for hydraulic actuating medium such as water under pressure. Distributor valve 11 communicates with the drilling machines 9 and 10 through conduits 15 and 16, respectively, while a conduit 17 extends from distributor valve 11 to a hydraulic cylinder and piston assembly 18 which is rigidly secured to container 8 by means of connections 19 and 20 and which comprises in turn a vertical cylinder 21 closed at its top and containing a vertical piston 22 slidable therein and which constitutes one of the supports of the apparatus. In the embodiment illustrated in FIGS. 1 and 2, as indicated above, there are two drills and one cylinder and piston support; although as indicated in FIGS. 4*a*, 4*b* and 4*c*, and also FIGS. 6*a*, 6*b* and 6*c*, there could be one, two or three drills, respectively, and correspondingly two, one or no cylinder and piston supports, respectively.

The means for releasably connecting the casings 1 and 2 and the crosshead 3 to the stator are shown at the right of FIG. 3. A member 23 has a lower end disposed in a slot 24 in a block 25 that is welded to the upper side of the plate 5 of crosshead 3. Member 23 and block 25 have aligned openings 26 therethrough, in which is disposed a pin 27 having limited axial movement in block 25. A pull rod 28 interconnects pin 27 with a disc 29 that is mounted for rotation on pin 6. A push rod 30 is also connected to disc 29 at one end and at its other end to a plunger 31 shown in FIG. 2 at the outlet of the feed conduit 13 for cement mortar. When the cement is forced down conduit 13 from the ship, for the purpose of cementing the emplaced casing, the pressure of the cement first pushes the plunger 31 and rod 30 in a direction to rotate disc 29 so as to exert a pull on rods 28, which in turn retract the pins 27 to the right as seen in FIG. 3, thereby releasing the member 23 so that the assembly of the container 8 and drilling machines 9, 10 can be raised at the onset of the cementing operation.

Each drilling machine 9 or 10 comprises a rotary hydraulic motor 32 mounted on a stator 33 which is secured by a connecting ring 34 to the underside of container 8. A driven shaft 35 is rotated by motor 32 and carries a pinion 36 thereon which engages a gear 37 on shaft 38 which is mounted for rotation in stator 33 at its upper end and in an arm 39 integral with stator 33 at the lower end of shaft 38. Gear 37 in turn engages a ring gear 40 integral with the inner surface of a rotor 41. Bearings 42 and 43 disposed between stator 33 and rotor 41 absorb both axial and lateral thrust. Rotary seals 44 also seal between the rotor and the stator.

Rotor 41 has a central bore 45 therethrough which receives a connector end 46 of arm 39 of stator 33 with seals 47 thereabout.

A drill rod 48 in the form of a hollow cylindrical shaft is secured to the lower outer portions of rotor 41 and is rotatable with the rotor 41, by means of screw threading or other rigid connections. At its upper end, rotatable drill rod 48 seals against stationary casing 1 by means of packing 49.

Motor 32 may be of conventional construction, including an inlet for actuating hydraulic fluid such as water under pressure, from conduit 15, and an outlet 50 which extends through arm 39 and thence through connector end 46. The expended hydraulic medium from the motor 32 flows downwardly through the drill rod 48 and serves to flush the lower end of the drill.

The lower end of the drill is shown in FIG. 7, and comprises a drill assembly 51 having a bit of the expansible type. Thus, in addition to a fixed ring bit 52, the cutting end of the drill comprises bits mounted on arms 53 which are pivotally mounted for vertical swinging movement and inwardly and outwardly about horizontal axes on shafts 54, so that in its outer position, the bit extends out beyond casing 1 and drills a hole whose diameter is somewhat greater than the outer diameter of casing 1. Torsion springs surrounding shaft 54 continuously urge arms 53 outwardly; while upon upward retraction of the drill, the lower end of the casing cams the arms 53 radially inwardly, as can be seen from FIG. 7. In its retracted position, shown in broken lines in FIG. 7, the drill rods and bits may be hoisted from within casings 1 and 2 without interference with the casing.

The details of the construction of the distributor valve 11 are shown in FIG. 5 and also in FIGS. 6*a*, 6*b* and 6*c*. The distributor valve is encased in a box shown in FIG. 1 to be secured to the underside of container 8. This box is subdivided into two sections by a horizontal dividing plate 55. Spray nozzles 56 extend through plate 55 and are equal in number to the number of supports by which the apparatus rests on the bottom of the sea. A ball joint 57 supports a vertical rod 58 for universal lateral swinging movement. Rod 58 carries a weight 59 at its lower end, so that rod 58 tends always to be vertical, regardless of the inclination of plate 55. Rod 58 carries a horizontal plate 60 thereon which is perpendicular to the rod 58 and is disposed immediately below the nozzle 56. It will be understood that as plate 55 and nozzles 56 swing away from the position corresponding to the upright position of the apparatus, that is, as the drill tends to incline away from the vertical, then one of the nozzles 56 will approach more closely the plate 60, so that pressure in the fluid supplied to that nozzle 56 will increase. The effects of this are shown in FIGS. 6*a*, 6*b* and 6*c*.

In FIG. 6*a*, the situation is shown in which the apparatus is supported by one drill and by two hydraulic cylinders, for a total of three supports. Thus, the supply conduit 14, in FIG. 6*a*, feeds three branch conduits 61, 62 and 63, which in turn lead to the respective nozzles 56 via constrictions 64, 65 and 66 respectively. The conduit 15 also branches off conduit 14 to the fluid motor 32. Between the restrictions 64 and 66 and their corresponding nozzles 56, the conduits 61 and 63 respectively communicate with hydraulic cylinders 21 through conduits 17. However, the conduit 62 is connected to a diaphragm valve 67 which moves a gate in conduit 15.

Thus, as the drill bites into the submarine soil, the support provided by that drill will tend to sink and the apparatus will tend to heel over toward the drill, so that the drill will no longer be vertical. However, weight 59 will ensure that rod 58 remains substantially vertical, so that the nozzle 56 associated with the drill will approach plate 60. The escape of fluid from that nozzle 56 will thus be impeded and the pressure in valve 67 will accordingly rise and the fluid flowing in conduit 15 will be correspondingly reduced. The action of the drill will thus be somewhat slowed. At the same time, however, the nozzles 56 associated with the hydraulic cylinders 21 will be somewhat opened, so that the flow of fluid through those latter two nozzles 56 will be less impeded and the pressure in cylinders 21 will accordingly fall. As the pressure in cylinders 21 falls, as seen in FIG. 6*a*, the cylinders will tend to settle lower over their piston rods. The supports provided by the cylinder and piston assemblies will thus in effect be shortened, and the apparatus will thus right itself, until plate 60 resumes its FIG. 5 position relative to all the nozzles 56.

It will thus be seen that opposite sides of plate 60 move oppositely with respect to the nozzles 56, thereby to increase the pressure upstream of at least one nozzle 56 at the same time that the pressure upstream of at least one other nozzle 56 is decreased. It will also be seen that an increase in the pressure of the cylinder and piston circuits acts oppositely to an increase in the pressure in the drill hydraulic circuit: the former increase tends to raise the apparatus while the latter increase tends to lower the apparatus.

FIGS. 6*b* and 6*c* operate in the same manner, except that the number of drills and cylinder and piston assemblies is different in each case. The explanation given above in connection with FIG. 6*a* also explains the operation of FIGS. 6*b* and 6*c*.

FIG. 8 shows the detachable connection between the cement mortar conduit 13 and the crosshead 3 which remains with the casings 1 and 2 when drilling is completed. Thus, once the apparatus is emplaced, crosshead 3 is not raised again, so that the cement mortar conduit must be detachably connected to crosshead 3 and must be removable therefrom upon the completion of the cementing operation.

Thus the detachable connection shown in FIG. 8 comprises a connecting piece 68 on the conduit 13 having two ears 69 on each side thereof, each vertically superposed pair of ears 69 extending above and below an ear 70 on crosshead 3. A pin 71 extends through holes through each stack of ears 69 and 70, and a flexible cable 72 connects pin 71 to container 8 with ample slack (see FIG. 1). When cementing is completed and the apparatus is raised again from the FIG. 11 position, cable 72 will pull the pins 71 to release conduit 13 so that conduit 13 can be hauled aboard the vessel.

It will be understood that the particular cementing operation shown in the illustrated embodiment by way of example consists in filling crosshead 3 with cement mortar, which also flows down into and fills casings 1 and 2 so as to provide an anchored lower end for anchor chain 7. The location of the free end of chain 7 can for example be indicated by a buoy (not shown).

The sequence of operations is shown in FIGS. 9, 10 and 11. In FIG. 9, the vessel 73 is shown with a derrick 74 on its deck and a central hold 75 open at top and bottom with I-beams 76 adjacent the top thereof for supporting the casings and crosshead while derrick 74 lowers the drills and container 8 thereinto. With the drills fully seated in the casings, disc 29 is rotated to insert pins 27 in holes 26 and to advance plunger 31 toward the top of FIG. 2. The assembly can then be lowered through the hold of the ship, to the drilling position.

The position after drilling is shown in FIG. 10. Then, the anchor chain 7 is removed from the box and the cement conduit 13 is pressurized so that the vertically removable parts are separated from the emplaced casing. The FIG. 11 position is then reached; and upon completion of cementing the casing, the cement conduit 13 is detached by tension in cable 72 upon continued rising of the retrieved assembly.

In view of the foregoing disclosure, therefore, it will be evident that all of the initially recited objects of the present invention have been achieved. Although the present invention has been described and illustrated in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand.

What is claimed is:

1. Drilling apparatus for drilling a hole and emplacing a casing in the bottom of a body of water, comprising a stator, a rotor, a casing releasably secured to the rotor, a drill secured to the rotor and rotatable within the casing, and means operable from a vessel on the surface of the body of water to detach the casing from the stator and to lift the stator and rotor and drill toward the surface while leaving the casing in the drilled hole.

2. Apparatus as claimed in claim 1, and means for maintaining the casing and drill in a substantially vertical position during drilling.

3. Apparatus as claimed in claim 1, and a container on the stator, and an anchor chain in the container.

4. Apparatus as claimed in claim 1, and means for supplying cement to the casing after the drilling operation is completed, and means responsive to the supplying of cement to detach the stator from the casing.

5. Apparatus as claimed in claim 1, and conduit means extending between the vessel and the apparatus and for applying cement to the casing after drilling is completed, and means remotely controlled from the vessel to detach the conduit means from the apparatus.

6. Apparatus as claimed in claim 1, and means for conveying fluid under pressure from the vessel to the apparatus to rotate the rotor.

7. Apparatus as claimed in claim 1, the assembly of the stator and rotor resting on at least three spaced supports at least one of which is said drill.

8. Apparatus as claimed in claim 7, and means for maintaining said drill and casing substantially vertical during the drilling operation.

9. Apparatus as claimed in claim 8, said vertical maintaining

means comprising hydraulic means including distributor valve means, and means responsive to deviation of said drill from a vertical position to position said valve means to actuate said hydraulic means to correct said deviation.

10. Apparatus as claimed in claim 9, said hydraulic means acting on each of said supports to control the vertical inclination of the apparatus, said distributor valve means comprising a member suspended for swinging in all lateral directions, each of said supports having a spray nozzle for fluid from said hydraulic means, said spray nozzles being directed toward said member so that upon deviation of the drill from a vertical position, the nozzles are positioned different distances from said member to alter the pressures in the hydraulic fluid upstream of the nozzles so as to correct the position of the apparatus.

11. Apparatus as claimed in claim 10, in which at least one of said supports comprises a cylinder and piston, the cylinder being in fluid communication with a said nozzle.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,603,408 Dated September 7, 1971

Inventor(s) August Hendrik Maria Smulders

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet insert -- [73] Assignee N. V. Industrieele Handelscombinatie Holland --.

Signed and sealed this 31st day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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