April 30, 1968 D. I. REBIKOFF 3,380,256

UNDERWATER DRILLING INSTALLATION AND METHOD OF CONSTRUCTION

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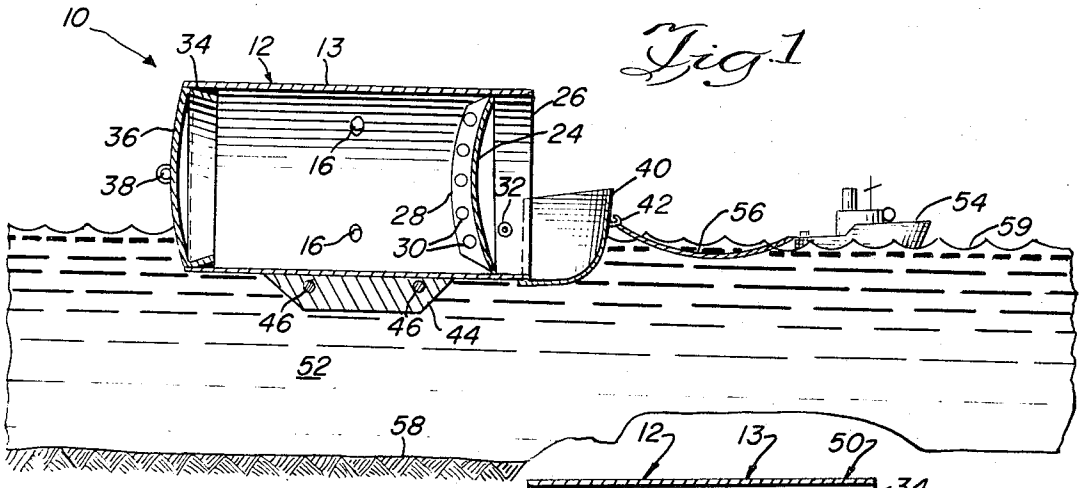


Fig. 1

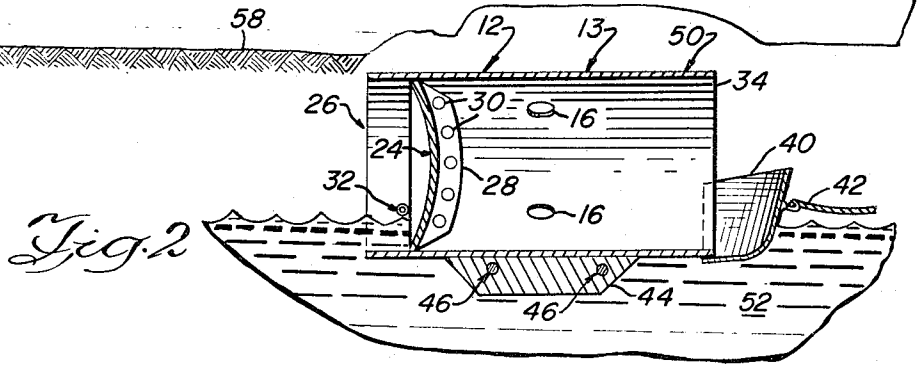


Fig. 2

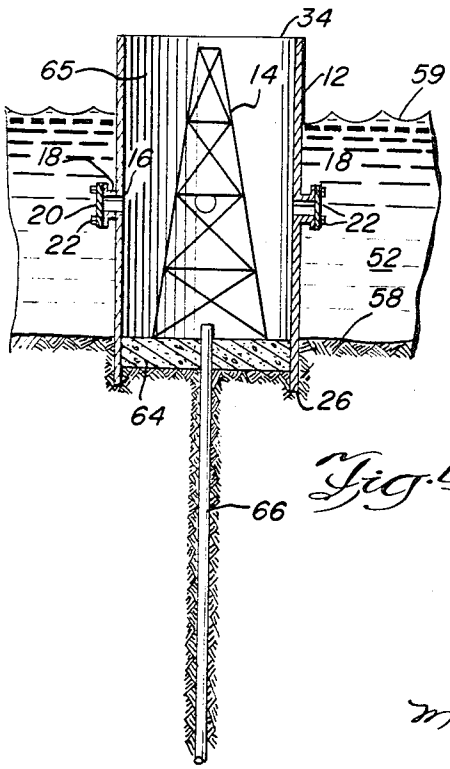


Fig. 4

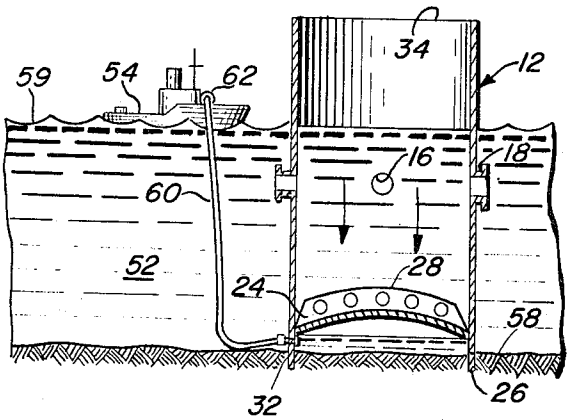


Fig. 3

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Fig. 5

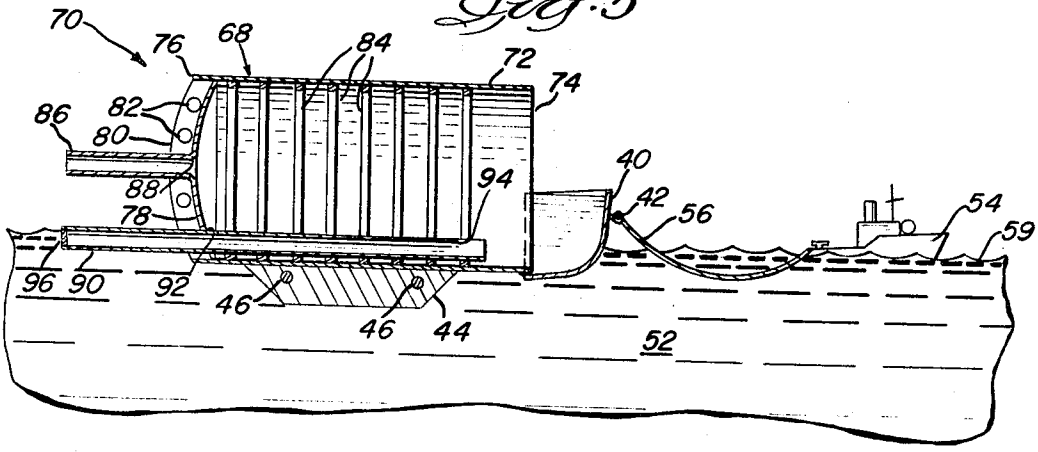


Fig. 6

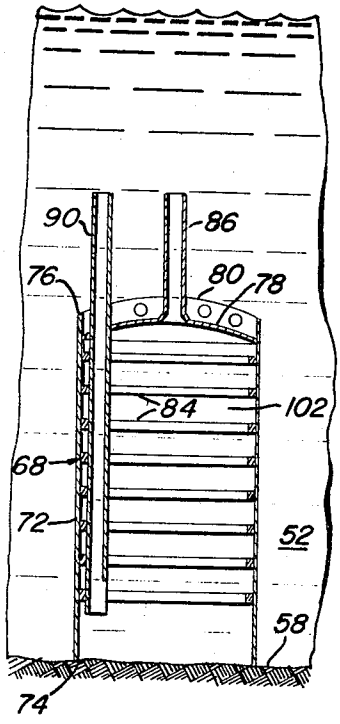


Fig. 7

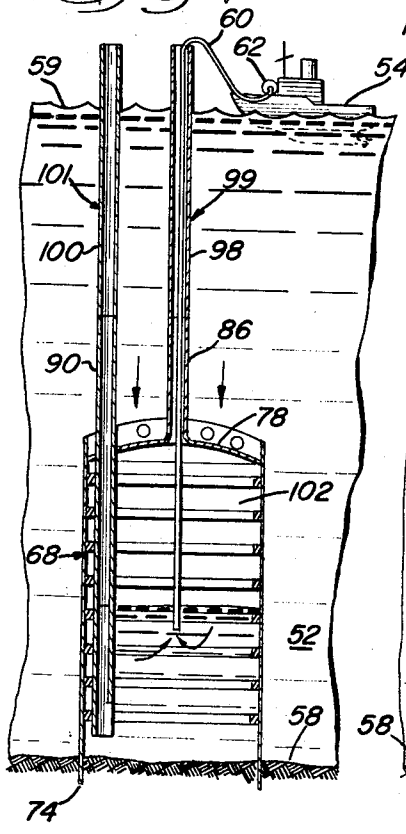
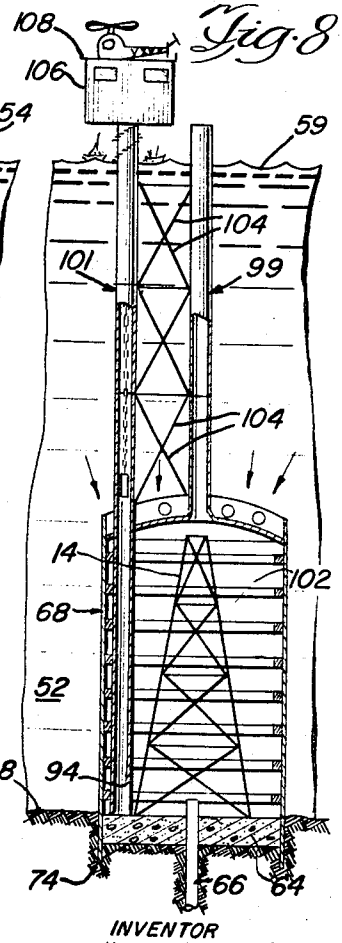


Fig. 8



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UNDERWATER DRILLING INSTALLATION AND METHOD OF CONSTRUCTION

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2 Claims. (Cl. 61—46.5)

This invention relates to underwater drilling installations and to their construction. More particularly, the invention relates to an installation including a casisson driven into the bottom of a body of water and a drilling rig therein, and to a new and improved method of constructing the installation including, especially, a method of installing a caisson for use in the installation or for other uses.

Various apparatus and methods have been provided in the past for conducting offshore underwater drilling operations in ocean and inland waters. Drilling has been conducted from surface vessels and from sub-surface vessels. Drilling rigs have been mounted above the water level, partly above and partly below the water level, and on the bottom of the water body. The prior apparatus has been very expensive to construct, operate and maintain. Operations frequently have been difficult or involved, especially when personnel work under water. Severe weather conditions have endangered personnel, installations and equipment, and have hampered operations.

The present invention provides an underwater drilling installation and a method of constructing the installation that have a number of advantages over the prior installations and construction methods and overcome various disadvantages thereof. In particular, the invention provides a strong, rigid and safe installation that is very functional while being simple and inexpensive. Drilling operations take place directly on the bottom of the water body, and personnel may work on the bottom with little difficulty at atmospheric pressure. Production efficiency is comparable to the efficiency of onshore production, and supplies, equipment, and personnel are readily transported to and from the installation. The installation is employed to great advantage in drilling for oil, and it may be employed similarly for other drilling or mining purposes, such as drilling for water or other natural resources.

The new method of constructing an underwater drilling installation is exceptionally simple, efficient, and economical. Installation is rapid and hazards are minimized. Quite especially the new installation is perfectly safe from storms and hurricanes through its inherent stability and reduced windage.

Construction of the underwater drilling installation according to the invention embodies a novel method of installing a caisson on the bottom of a body of water. The drilling installation is completed by mounting a drilling rig in the bottom of the caisson. Alternatively, the caisson may be employed for other purposes where there is need for a caisson mounted on the bottom of a body of water, for example, in mining operations.

These and other features, objects, and functions of the invention will be apparent on reference to the specification and to the attached drawings illustrating preferred embodiments of the invention, wherein like parts are identified by like reference symbols in each of the views, and wherein:

FIGURE 1 illustrates a caisson being transported on a body of water to an installation site, the caisson being assembled with temporary accessory members for floating it on the water body and the assembly being shown in vertical longitudinal cross section;

FIGURE 2 is an alternate floating assembly of the caisson and accessory members;

FIGURE 3 illustrates the caisson being installed on the bottom of thew ater body, the caisson being shown in vertical longitudinal cross section;

FIGURE 4 illustrates the caisson as finally installed and a drilling rig therein providing an underwater drilling installation, the caisson being shown in vertical longitudinal cross section;

FIGURE 5 illustrates another embodiment of a caisson being transported on a body of water to an installation site, the caisson being assembled with accessory members for floating the caisson and the assembly being shown in vertical longitudinal cross section;

FIGURE 6 illustrates the caisson of FIGURE 5 seated on the bottom of the water body ready for installation, the caisson being shown in vertical longitudinal cross section;

FIGURE 7 illustrates the caisson assembled with shafts extending above the water level and being installed on the bottom of the water body, the assembly being shown in vertical longitudinal cross section; and

FIGURE 8 illustrates the caisson as completely installed and having a drilling rig mounted therein and a structure mounted on one of the shafts to provide a drilling installation, the caisson and portions of the shafts being shown in vertical longitudinal cross section.

The invention provides an underwater drilling installation which includes a caisson with a tubular portion having one end driven into the bottom of a water body, and a drilling rig mounted in the bottom of the caisson. The opposite end of the caisson may be open or closed and project above the upper surface of the water body, or may be closed and submerged in the water body. In the former case, the caisson forms a working chamber extending above the water level. In the latter case, the caisson forms a submerged working chamber, and a shaft may extend from the chamber to the upper surface of the water body for establishing communication therebetween. Also, while the lower portion of the caisson driven into the sea bottom is generally tubular, the upper portion can be cylindrical, ellipsoidal, spherical or any other suitable shape.

In constructing the underwater drilling installation, a tubular caisson having one end open for being driven into the bottom of the water body and having a bulkhead extending thereacross in spaced relation to the one end, is immersed in the water body with the one end seated on the bottom of the water body and the bulkhead submerged in the water body, and the pressure in the caisson at the one end is reduced to cause the water pressure above the bulkhead to drive the caisson into the bottom of the water body. A drilling rig subsequently is mounted in the bottom of the caisson.

The construction of an underwater drilling installation initially involves the transportation of a caisson to the installation site. Referring to the drawings, particularly FIGURE 1, a floating assembly **10** of an open cylindrical tubular caisson **12** and accessory members is provided. The caisson includes a circular tubular wall **13** having a large diameter suitable for mounting a drilling rig including a derrick **14** (FIGURE 4) and other conventional drilling equipment therein. The caisson is especially adapted for drilling at relatively shallow depths, e.g., on the order of 100 feet or less. The caisson wall is constructed to withstand the pressures at such depths, and its longitudinal dimension is such that its height when installed is greater than the depth of the water body.

The caisson wall **13** is provided with a number of portholes or openings **16** therethrough, for purposes described hereinafter. As seen in FIGURE 4, ports **18** in the form

of flanged pipe fittings or the like are mounted on the outer surface of the wall in register with the portholes. Cover plates **20** are secured to the ports by bolts **22**, for closing the portholes.

An inwardly concavo-convex bulkhead or wall **24** extends across the caisson in adjacent spaced relation to one open end **26** thereof. The wall **13** at this end is adapted for being driven into the bottom of a body of water, and the edge thereof may be ground for this purpose. The bulkhead is secured to the caisson wall to provide a watertight barrier therein, such as by welding. The convex side of the bulkhead is reinforced by a plurality of arcuate trusses **28** secured thereto as by welding and having a plurality of weight-reducing holes or perforations **30** therein. The bulkhead performs a function subsequently described, and it may serve to keep water out of the caisson when it is being transported, especially when transported in the manner illustrated in FIGURE 2. A hose fitting **32** is mounted in the wall of the caisson outwardly of the bulkhead and adjacent thereto.

The opposite end **34** of the caisson **12** is temporarily closed by an outwardly concavo-convex cap **36** inserted therein and secured thereto by suitable means, such as welding. The cap may be provided with one or more lifting rings **38**. The cap prevents water from entering the caisson, resists wave action, and reinforces the caisson.

The components of the assembly so far described are sufficient for floating the caisson **12**. However, additional accessory members preferably are provided for improving control and maneuverability of the assembly in the water. A prow **40** is secured to the open end **26** of the caisson, such as by welding. A towing hook **42** is mounted on the prow. A keel **44** is removably secured to the caisson by cables **46** or other suitable means. The prow and the keel assist in controlling the movement of the caisson, and the keel also serves as ballast.

FIGURE 2 illustrates another floating assembly **50** which may be employed for transporting the caisson **12** on a body of water. The assembly is like the assembly **10** of FIGURE 1 in a number of respects, and the same reference numerals designate like parts. In the assembly **50** of FIGURE 2, the prow **40** is mounted on the caisson end **34** remote from the bulkhead **24**, and the remote end remains open. This embodiment is lacking in the reinforcement provided by the cap **36** of the first assembly embodiment **10**, and the stern end **26** is open to the water up to the bulkhead. On the other hand, the assembly **50** is constructed for installing the caisson **12** more readily.

Either of the floating assemblies **10** and **50** is assembled on land or in a dry dock and then towed on a body of water **52** to the installation site by a tug **54** having a towline **56** attached to the towing hook **42**. Accessory members are removed from the caisson **12** at the site, after which the caisson is immersed or sunk in the water body and the end **26** settles on the bottom or bed **58** of the water body with the bulkhead **24** submerged below the upper surface or water level **59**.

In one manner of operation, pontoons or the like, not shown, may be attached to the assembly **10** at the installation site, preparatory to removing the unwanted accessory members. The prow **40** is removed by a cutting torch or in another appropriate manner. The closure plates **20** are removed from the ports **18**, to enable water to enter the caisson through the portholes **16**. The cap **36** is removed with a cutting torch or in another suitable manner, while supporting the cap by its lifting ring **38** and additional attachment means if needed. The keel **44** is released, such as by disconnecting or cutting the cables **46**. Upon removing the pontoons, the caisson fills with water and settles on the bottom **58**.

Referring to FIGURES 3 and 4, the end **26** at which the bulkhead **24** is mounted being the heaviest, tends to settle first, and this manner of settling is insured and the caisson is righted by suitable guide lines attached to the caisson during descent. The caisson end **26** is seated on

the bottom **58** and may become partly imbedded therein owing to its weight. In this connection, the invention is employed where the bottom is relatively penetrable or soft, with hard earth strata covered by a layer of mud or other penetrable substance. The caisson becomes flooded up to the upper surface **59** of the water body, and the caisson projects upwardly above the surface. The bulkhead **24** is submerged in the water body under the pressure of the column of water in the caisson up to the surface.

A hose **60** is connected to a pump **62** on the tug **54** and to the hose fitting **32** below the bulkhead **24** in the caisson. Water is pumped from beneath the bulkhead to reduce the pressure in the caisson at the lower end **26**. As the lower end of the caisson is evacuated in this manner, the pressure of the water and the atmosphere above the bulkhead drives the lower end of the caisson into the bottom **58** of the water body, as illustrated in FIGURE 3. Water enters the open ports **18** as the caisson is driven into the bed, to keep the bulkhead under the pressure of a column of water up to the surface. The caisson is driven into the bottom and may be so driven up to the bulkhead. The caisson extends sufficiently far into the bottom **58** for preventing substantial flow of water into the caisson beneath the lower end **26**, i.e., for preventing all but seepage flow into the caisson. The caisson also is imbedded a sufficient distance to support it rigidly on the bottom.

The ports **18** then are closed by the cover plates **20**, and water is removed from the caisson above the bulkhead **24** by pumping. At this time, the interior of the caisson above the bulkhead is at the pressure of the atmosphere, exerted through the open upper end **34** of the caisson.

An opening is provided through the bulkhead **24** to furnish access to the bottom **58** of the water body from above the bulkhead, for conducting drilling operations. In a preferred method, the entire bulkhead is removed, together with the trusses **28**, by a cutting torch. Alternatively, it may be sufficient to provide only a smaller opening through the bulkhead, as in the center thereof.

In order to prevent water seepage and also to provide a more rigid support for equipment, a layer of concrete **64** (FIGURE 4) may be poured on the bottom in the caisson, or the bottom ground enclosed by the caisson may be frozen. If it be desired to retain the bulkhead **24** with an opening therethrough for drilling, concrete may be poured beneath the bulkhead. In this manner, a working chamber **65** is provided, which is open from the bottom **58** of the water body to the atmosphere above the surface **59**.

The installation is completed by mounting the derrick **14** and other components of a drilling rig on the floor provided by the concrete layer **64**. A well casing **66** is inserted into the bottom through the concrete layer, and drilling operations are conducted in the same manner as dry land operations are conducted. Equipment and supplies are lowered from the upper end **34** of the caisson. All operations are conducted at the pressure of the atmosphere.

In an alternative method of installation, the cap **36** in the assembly **10** may remain on the caisson **12** until the caisson is seated on the bottom of the water body. A greater number of portholes **16** in the wall of the caisson and ports **18** therearound may be provided for increasing the rate of filling with water in sinking the caisson. The cap or parts thereof may be removed when the caisson is imbedded in the bottom. In a further alternative, the cap or similar structure, or a portion thereof, may remain on the upper end **34** of the caisson for use as a service platform or as a heliport.

The assembly of FIGURE 1 also may be employed for installing a closed caisson beneath the upper surface **59** of the water body **52**. In this embodiment, the caisson **12** of suitable length and weight and the cap **36** or other suitable end closure remaining on the caisson are completely submerged in the water body. After setting the

lower end 26 of the caisson in the bottom 58, the ports 18 are closed, and the water is removed from above the bulkhead 24. The resulting closed chamber above the bulkhead is maintained at a suitable internal pressure. The caisson is heavy enough to offset buoyancy by use of thick steel plate, concrete lining or other materials.

When the floating assembly 50 of FIGURE 2 is employed for installing the caisson 12, the assembly may be supported on pontoons until it is prepared for sinking the caisson. The portholes 16 are opened by removing the covers 20 from ports 18 secured therearound as illustrated in FIGURE 4. The prow 40 is removed from the end 34 of the caisson, and the keel 44 is removed from the caisson. The pontoons supporting the caisson are removed, and the caisson is sunk and the installation is completed as described above with reference to FIGURES 1, 3 and 4.

Alternatively, the prow 40 in the assembly 50 of FIGURE 2 may remain on the caisson when the caisson is sunk, providing additional portholes 16 to increase the rate at which the caisson is filled with water. The prow may be removed when the caisson is imbedded in the bottom 58, or the prow may be allowed to remain on the caisson.

FIGURES 1–4 illustrate structures and methods for installing directly a caisson 12 which extends from the bottom 58 of the water body to above the upper surface of the water body. Instead of employing a single caisson section having the desired height, a plurality of sections may be employed and joined together to provide a caisson having the desired height. Thus, a bottom section may be constructed and installed on the bottom 58 of the water body as described for the caisson 12. After the bottom section is imbedded in the bottom, one or more additional sections may be mounted on top of the bottom section. The illustrative structures and methods have the advantage of requiring a minimum of installation operations which must be conducted under water.

FIGURES 5–8 illustrate an underwater drilling installation and a method of constructing the installation which are preferred for operating at greater depths, for example, at depths on the order of from 100 to 300 feet. In this embodiment, a closed end or bell type caisson is employed, forming a submerged chamber, and communication between the chamber and the atmosphere above the water body is established by one or more shafts.

Initially, accessory members are assembled with a tubular caisson 68 to provide a floating assembly 70. The caisson includes a circular tubular wall 72 having one end 74 open and the opposite end 76 closed by an outwardly concavo-convex bulkhead 78. The bulkhead is reinforced by trusses 80 thereon having weight-reducing openings 82 therein. The parts are secured together by welding or other suitable means, to provide a watertight end closure. A number of reinforcing rings 84 are secured around the inner periphery of the wall 72 in spaced apart relation therealong.

A tubular shaft section 86 is secured to the bulkhead 78 on the exterior of the caisson. The shaft section is joined to the bulkhead in a watertight manner around a corresponding opening 88 in the bulkhead, and the section extends from the bulkhead in the axial direction of the caisson. The structure provides a shaft connection to the bulkhead for access to the interior of the caisson. A second shaft section 90 extends through a corresponding opening 92 in the bulkhead from the exterior to the interior of the caisson, along the wall 72. A watertight joint is formed between the section and the bulkhead where they join. The second shaft section extends to a location adjacent to and spaced from the open end 74 of the caisson, where a doorway 94 is provided in the section. The outer end of the second section is temporarily closed by a cover 96 preventing water from entering the caisson while it is being transported on the water body.

A prow 40 having a towing hook 42 is secured to the open end 74 of the caisson, and a keel 44 is secured to the caisson wall 72 by cables 46, similar to the structures of FIGURES 1 and 2. The resulting assembly 70 floats on the surface 59 of the water body 52, and it may be towed to an installation site by the tug 54 and the towline 56 therefrom connected to the towing hook 42.

On reaching the installation site, the assembly 70 may be supported by pontoons while it is readied for sinking the caisson 68. The cover 96 is removed from the shaft section 90, and the prow 40 and the keel 44 are separated from the caisson. When the pontoons are removed, the caisson sinks, and it may be guided in its descent to the desired upright position by cables attached to the caisson. The caisson is sunk with its open end 74 seated on the bottom 58 of the water body as illustrated in FIGURE 6, or penetrating the bottom somewhat owing to its weight. By making the diameter of the lower portion of the caisson smaller than the maximum upper diameter of the caisson the cutting edge 74 on the smaller portion will produce better penetration into a hard sea bottom.

As illustrated in FIG. 7, additional shaft sections 98 and 100 are attached to the respective shaft sections 86 and 90 for extending the resulting shafts 99 and 101 upwardly above the surface 59 of the water body. The shaft sections may be welded together where they abut, or they may be secured by other suitable means such as flange joints. Alternatively, it may be desirable to pre-assemble the shafts completely for transportation to the installation site.

A chamber 102 ultimately constituting a working chamber is formed between the end 74 of the caisson seated on the bottom and the bulkhead 78. The chamber and the shafts 99 and 101 fill with water up to the upper surface 59 of the water body, and the bulkhead 78 is submerged and subjected to the pressure of a column of water thereabove up to the surface. As illustrated in FIGURE 7, the hose 60 connected to the pump 62 on the tug 54 is inserted through the central shaft 99 into the chamber 102, and water is pumped from the chamber. When the water level is lowered beneath the bulkhead 78, the underside of the bulkhead is subjected to the water vapor pressure at that temperature, while the upper side of the bulkhead is subjected to the much greater pressure of the water column thereabove. The pressure differential thus created drives the lower end 74 of the caisson into the bottom 58. The caisson becomes rigidly embedded in the bottom, and substantial flow of water into the caisson from beneath is prevented, as in the preceding installations.

The shafts 99 and 101 are interconnected by trusses 104 to secure them against the natural forces of wind, waves and gravity. If desired, a third shaft or column may be incorporated in the structure and interconnected with the shafts 99 and 101 to provide a triangular superstructure of greater rigidity and resistance to natural forces.

In the illustrative installation, the central shaft 99 serves as a blowout stack and as an access shaft for supplying drill pipe to the chamber 102. The remaining shaft 101 serves as an elevator and ventilation shaft, and a housing 106 having a heliport 108 thereon may be mounted on the shaft.

Equipment and supplies are lowered through the elevator shaft and/or through the central shaft. Seepage into the chamber may be prevented by pouring a layer of concrete 64 or freezing the bottom ground, as in the preceding installations. The derrick 14 and other components of the drilling rig are erected within the caisson, and the well casing 66 is set in the bottom. Drilling operations then may be conducted under atmospheric pressure at that length in the manner in which they are conducted on dry land.

The invention thus provides an installation for conducting drilling or other operations at the bottom of a water body under atmospheric conditions. Structures and machinery are firmly supported on the bottom of the water body, and personnel and equipment are protected by a

caisson rigidly imbedded in the bottom. The caisson is installed and a drilling rig is mounted in the caisson readily and economically.

While certain preferred embodiments of the invention have been illustrated and described, it will be apparent that various changes and modifications may be made therein within the spirit and scope of the invention. It is intended that such changes and modifications be included within the scope of the appended claims.

What is claimed is:

1. A method of installing a caisson on the bottom of a body of water which comprises providing a tubular caisson having one end open for being driven into the bottom of a water body and having a bulkhead extending thereacross in spaced relation to said one end for forming a working chamber therebetween and a shaft connection to said bulkhead for establishing communication between said chamber and the upper surface of the water body, immersing said caisson in the water body with said one end seated on the bottom of the water body and said bulkhead submerged in the water body, establishing communication between said chamber and the upper surface of the water body by a shaft extending from said shaft connection, and removing water from said chamber to cause the water pressure above said bulkhead to drive the caisson into the bottom of the water body.

2. A method of constructing an underwater drilling installation which comprises installing a caisson according to the method of claim 1, and mounting a drilling rig in the bottom of said caisson.

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