March 12, 1968 B. G. HOLMES 3,372,745

SUBMERSIBLE CAISSON FOR SUBSURFACE WELL COMPLETION

Filed April 28, 1966 2 Sheets-Sheet 1

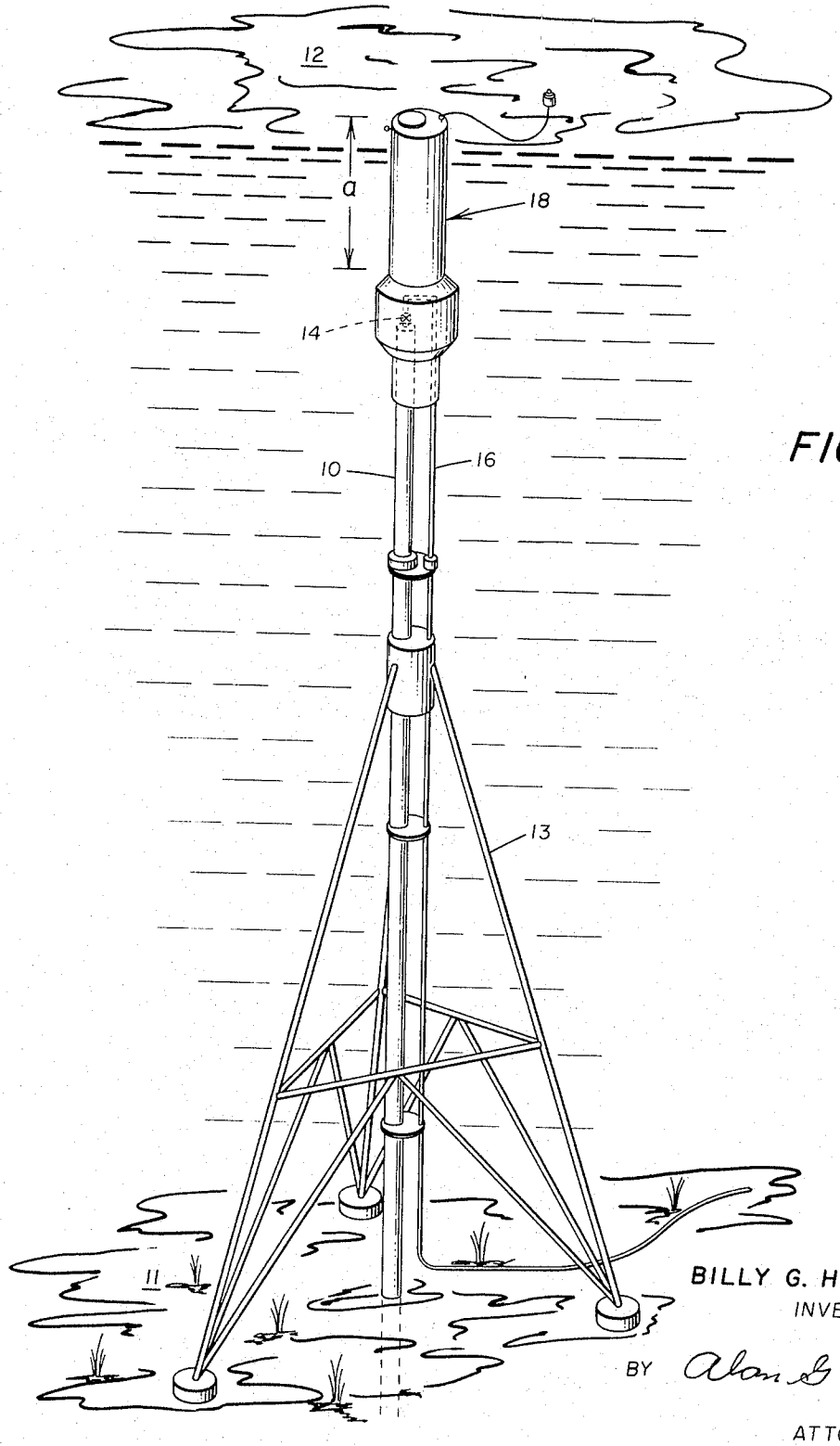


FIG. 1

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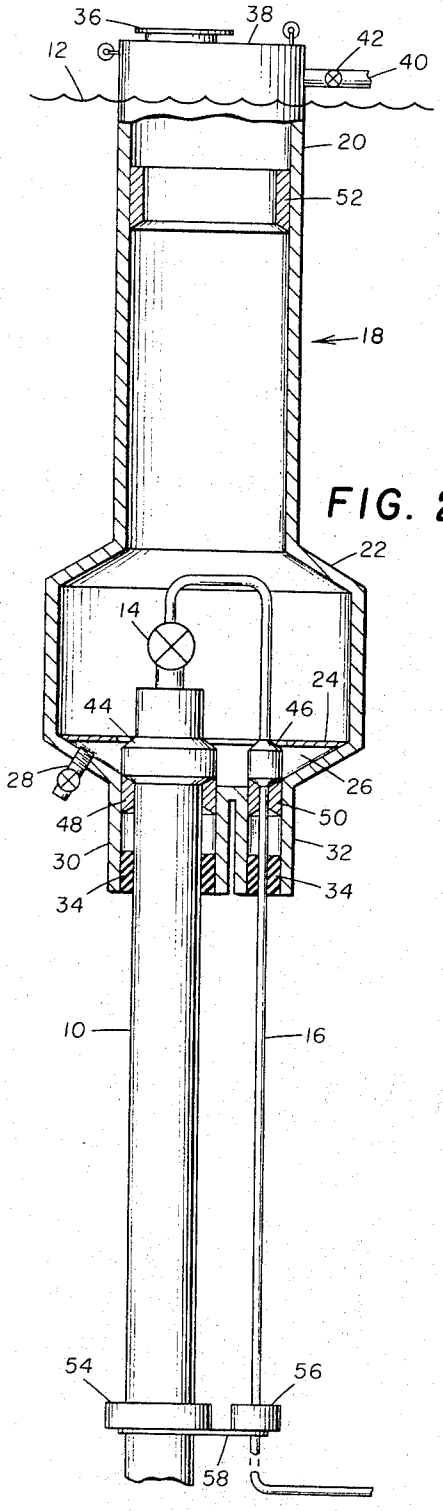


FIG. 2

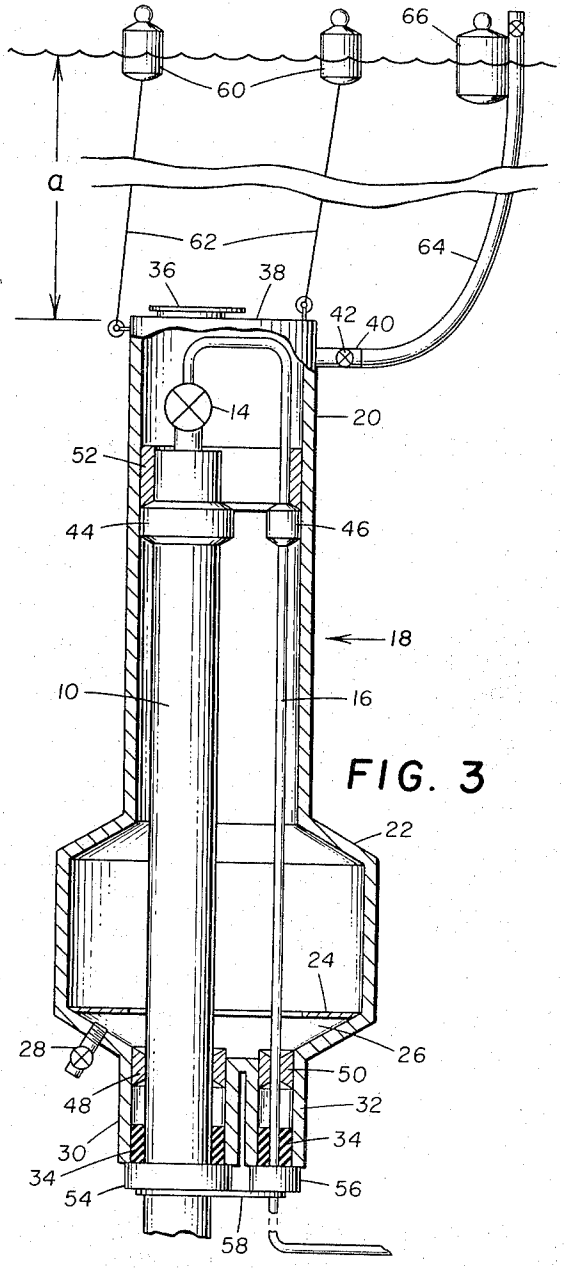


FIG. 3

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SUBMERSIBLE CAISSON FOR SUBSURFACE WELL COMPLETION

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8 Claims. (Cl. 166—.5)

The invention relates to a method and apparatus for completing a subaqueous well at a safe navigational depth beneath the surface of a body of water and more particularly to a means for manually maintaining a submerged wellhead without divers.

Present developments in the offshore oil and gas industry indicate that production efforts will soon be extended to underwater areas where bottom-supported surface structures are neither as economically nor technologically feasible as in the already developed leases in the Gulf of Mexico where such surface production platforms are rather commonplace. However, as the prolific producing areas such as the Gulf of Mexico become more and more developed and the number of production platforms increases, the problems of navigation, and the resultant danger to the surface structures from collisions with ships, become increasingly great. Large ships must thread their way between these structures, and utmost care must be used, particularly during foggy weather conditions. While the spacing of these platforms might not appear to present a navigational problem, at first glance, they do present one to a ship's captain who is usually confronted with navigating through large open areas with few obstacles. In the Gulf of Mexico where the density of offshore platforms is increasing at a rapid rate, several of these stationary surface structures have already been damaged in collisions.

Another problem that should be considered in conjunction with above-surface completions is that of the violent storms that ravage the Gulf Coast with almost yearly frequency. These storms take their toll of any equipment which breaks the surface of the water. A large production platform, if uprooted, is a tremendous economic loss to the owner, and depending upon the individual case, ten or more wells may have to be abandoned.

Therefore, it would be advantageous if the wells were completed below the surface of the body of water. Still in the experimental stage is the completion of wells at the mudline on the marine bottom. Such completions have their own problems, such as requiring divers for even the most simple repairs and maintenance situations. While robotic and TFL (through flowline) tools have been developed and are available for routine servicing or workover operations, these devices are complicated and expensive, and are, at this time, only used for a few limited tasks. At over two hundred feet a diver loses a considerable amount of his efficiency and is hampered still further by the shortened working time at such a depth.

To reduce the problems inherent with subsea completions it has been suggested that a submerged support structure be mounted over the well site, the structure extending from the marine bottom to a point beneath the surface which a diver can easily reach and which is not a navigational hazard. The well is extended from the subaqueous well bore to the upper end of the support structure by a riser pipe, on the upper end of which is fixed a production wellhead. While this suggestion would lessen the accompanying difficulties of subaqueous completions, there would still be some problems associated with utilizing the skills of a diver for working on the wellhead and the problems associated with the hostile environment

found beneath the sea which tends to corrode metal parts and freeze those parts designed to be moved.

Therefore, it is an object of the present invention to provide a means of access to a submerged wellhead surrounded by a breathable atmosphere.

It is a further object of the invention to provide a means for protecting a submerged wellhead from the hostile environment of the sea.

It is a still a further object of the invention to provide a surface access means, to a submerged wellhead, which may be retracted when not in use so as not to be a navigational hazard or be subject to surface wind and wave conditions.

Other objects and advantages of the invention will be readily apparent from the following description, or when taken in conjunction with the accompanying drawings that illustrate useful embodiments in accordance with this invention:

FIGURE 1 is a pictorial representation of an access caisson of the present invention when utilized with a subsurface well completion in deep water;

FIGURE 2 is an elevational view of a submerged wellhead, and the upper portion of a conductor pipe, of the present invention with the access caisson therefor extended to the surface; and

FIGURE 3 is an elevational view of the same subsea completion with the access caisson retracted to a safe navigational depth.

Referring now to the drawings, more in detail, by character reference, there is shown in FIGURES 1 and 2 a conductor or riser pipe **10** protruding from the subaqueous marine bottom **11** and terminating just below a designated distance *a* beneath the surface **12** of the body of water. The distance *a* indicates a sheltered depth at which apparatus will no longer be substantially subject to surface conditions. As to this sheltered depth at which the wave and tidal actions and surface storms would no longer be a substantial problem, this would vary with the total depth of the water. A figure used with present subsurface completions off California is one hundred feet. Of course, in the shallow waters of the Gulf Coast twenty-five to fifty feet might be more appropriate.

The conductor pipe **10** is capped by a production wellhead or christmas tree **14**, shown schematically, and is braced by a support structure **13** set on the marine bottom **11**. Above the support structure **13**, the conductor pipe **10** is self-supporting. A flowline **16**, for carrying the production products from a subaqueous well (not shown) through the well head **14** to separator or storage facilities (not shown) onshore, on the marine bottom, or on an above-surface platform, originates at the wellhead and parallels the conductor pipe down to the marine bottom **11**. The portion of the flowline **16** along the conductor pipe **10** would preferably be of a rigid material, such as steel pipe, and would be clamped to the conductor pipe **10** at intervals for support. The portion of the flowline laying along the marine bottom could be of more flexible material. An excess caisson **18** is slidably mounted on the upper end of the conductor pipe **10** and over the wellhead **14**.

Now turning more specifically, to FIGURES 2 and 3, the access caisson **18** has an upper narrow tubular section **20** which is large enough to surround the conductor pipe **10**, the well flowline **16**, and any protuberances on the wellhead **14**, as well as to permit a man to move therethrough. A lower working chamber section **22** of the access caisson **18** is enlarged to accommodate a man standing therein at any point around the wellhead **14** and flowline **16**. A horizontal floor **24** within the caisson **18** is provided to make it easy for a man to work within this structure. A sump section **26**, beneath the flooring **24**, is

designed to accommodate any residual water or that which may seep in and has a seacock or shut-off valve **28** connecting with the body of water outside the caisson **18**. Beneath the working chamber **22**, depend a pair of tubular extensions **30** and **32** surrounding the conductor pipe **10** and the well flowline **16**, respectively. Each of these tubular extensions has at least one circumferential seal or packing **34** for obtaining watertight sliding connections. At the upper end of the caisson **18** is a sealable hatch **36** built into the top **38** thereof. This hatch **36** may be opened to allow a man to enter the access caisson and when it is closed forms a watertight seal therewith. A port **40**, with a shut-off valve **42**, extends into the upper end of the access caisson **18** at a level designed to be above the surface **12** of the water, when the access caisson **18** is in the position shown in FIGURES 1 and 2.

To prevent the caisson **18** from rising up off the conductor pipe **10** when it is full of air, a pair of upper circumferential stops **44** and **46** are mounted on the conductor pipe **10** and the well flowline **16**, respectively. Cooperating stops **48** and **50** are built into the tubular extensions **30** and **32**, respectively. An upper circumferential stop **52**, in the upper section **20** of the caisson, cooperates with the stops **48** and **50** to prevent the upper end of the caisson **18** from hitting the wellhead **14** and the upper end of the flowline **16** when the access caisson **18** is in the position shown in FIGURE 3. Lower safety stops **54** and **56** encircling the conductor pipe **10** and the flowline **16**, just above a flowline support bracket **58**, would cooperate with the lower edges of the tubular extensions **30** and **32**, respectively, to prevent the flowline **16** from being torn out and the wellhead damaged if the upper stops, previously described, failed.

The seacock **28**, when opened, allows the caisson to flood in conjunction with the valve **42** being open, to attain the position shown in FIGURE 3. One or more buoys **60** are connected by flexible lines **62** to the top end of the caisson **18** to permit it to be located again when maintenance or repair operations are necessary. A flexible line **64**, connected to the outlet of the port **40**, also extends to the surface where the free end is held above the water surface **12** by a buoy **66**. The buoys **60** and **66** could also be remotely controlled, resting on the bottom or at least hanging down from the lines **62** and **64**, respectively, when they were not needed. A sonar signal actuated device on the buoys could then expel the water by pumps or by releasing a compressed gas into the interior thereof. Such a system would permit the buoys **60** and **66** to remain submerged when they are not needed for locating the caisson **18** to prevent any contact with surface ships. By pumping air into this line, water may be driven out through the seacock **28** to evacuate the caisson **18** and float it back to the surface when the well is to be worked on. Closing the seacock **28** then will permit the caisson **18** to remain floating after the hatch **36** is opened. After the repair or maintenance operations are over, the seacock **28** is reopened, air is allowed to escape through the port **40** and the line **64**, and the caisson refills with water slowly sinking down onto the stops **44** and **46**.

While it is expected that in the usual use the caisson will be flooded to lower it back over the conductor pipe and that air will be pumped in to raise it back to the surface, in some instances it may be desirable to protect the wellhead from the hostile environment in the water and, therefore, a heavy oil may be introduced into the caisson to protect the equipment while the caisson is submerged, and in such an instance a surface derrick may be necessary for raising the caisson back to the surface if it is not possible to dump the protective fluid into the water because of Coast Guard regulations.

It is seen that a workman can enter the caisson simply by expelling water therefrom to raise it to the surface and at that point closing the seacock. Raising the hatch he may then enter the caisson to work on the wellhead.

After he leaves the caisson, the hatch is relocked and the seacock and the valve **42** are opened, allowing the caisson to sink slowly back down onto its lower stops. In shallow water, say one hundred feet, a self-supporting conductor pipe **10** could be used. However, the depth of water at which this invention can be used would not be limited by the length of the unsupported conductor pipe since a subsurface platform could first be set over the well site to support the conductor pipe on its lower end as illustrated in FIGURE 1. For example, if the water were three hundred feet deep and it were desirable to have the wellhead fifty feet beneath the surface, the caisson would have to be approximately sixty feet long (fifty feet from the surface to the wellhead and about ten feet to allow for the tubular extensions **30** and **32**, and to permit the caisson **18** to extend far enough above the surface **12** so that waves would not wash over it). To leave room for the caisson to drop back over the conductor pipe **10** as shown in FIGURE 3, approximately fifty-five feet of free conductor pipe would be necessary between the upper end of the subsurface platform and the terminal end of the conductor pipe. This would leave a lower section of the conductor pipe of a hundred ninety-five feet, which could be completely supported by a subsurface support structure of this height, leaving only the upper fifty-five feet to be self-supporting. If the water depth were say six hundred feet and the depth *a* of the wellhead beneath the surface **12** were to be one hundred feet, a five hundred forty-five foot bottom-mounted subsurface platform would be fixed over the well site.

Although the present invention has been described in connection with details of a specific embodiment thereof, it is to be understood that such details are not intended to limit the scope of the invention. The terms and expressions employed are used in a descriptive and not a limiting sense and there is no intension of excluding such equivalents, in the invention described, as fall within the scope of the claims. Now having described the apparatus herein disclosed, reference should be had to the claims which follow.

What is claimed is:

1. A submersible access caisson for providing a breathable atmosphere surrounding a wellhead of a subaqueous well, said wellhead being located beneath the surface of a body of water, and fixed on a conductor pipe protruding a substantial distance above the marine bottom, said access caisson consisting of: an upper tubular section adapted to slide over said conductor pipe and said wellhead; a sealable hatch means in the upper end of said upper tubular section; an enlarged working chamber operatively connected at its upper end to the lower end of said upper tubular section, said enlarged working chamber being adapted to permit a workman to move around said wellhead when said enlarged working chamber surrounds said wellhead; and a sealing means operatively connected to the lower end of said enlarged working chamber, said sealing means being designed to permit sliding movement between said caisson and at least a conductor pipe while maintaining a substantially watertight seal therebetween.

2. An access caisson as recited in claim **1** wherein: port means are provided for filling said caisson with a breathable atmosphere or with water from a surrounding body of water.

3. An access caisson as recited in claim **2** wherein: said port means consists of a first port at the upper end of said caisson and a second port at the lower end of said caisson; a shut-off valve means associated with each of said ports; and an elongated flexible line connected to said first port and long enough for its free end to reach to the surface of a body of water in the lowest position of said caisson in said body of water whereby said caisson can be raised by filling said caisson with air through said flexible line.

4. An access caisson as recited in claim **2** in combina-

tion with: a subaqueous well having a conductor pipe thereof protruding from the marine bottom and terminating at a level, beneath the surface of the body of water, substantially unaffected by surface conditions; a submerged wellhead mounted on the upper end of said conductor pipe; said caisson being vertically slidably mounted over the upper end of said conductor pipe and said wellhead; and cooperating stop means fixed to said conductor pipe and said caisson to limit the vertical movement of said caisson on said conductor pipe between a position in which said hatch means is above the surface of said body of water and a position in which said hatch means is completely submerged and is not above said level substantially unaffected by said surface conditions.

5. The combination of an access caisson, and a submerged wellhead mounted on the upper end of said conductor pipe protruding from a marine bottom, as recited in claim **4**, wherein: a product flowline is connected to said wellhead, said flowline extending, in part, from said wellhead to the marine bottom; and means connected between said conductor pipe and said product flowline for supporting said flowline along its vertical length, said sealing means including a sealing portion on said caisson surrounding said flowline and permitting slidable movement therebetween while maintaining a watertight seal therewith.

6. The combination of an access caisson, and a submerged wellhead mounted on the upper end of said conductor pipe protruding from a marine bottom, as recited in claim **5**, wherein: said port means includes a first port at the upper end of said access caisson and a second port at the lower end of said access caisson; and a flexible line connected to said first port, the free end of said flexible line being attached to a buoy to float said free end of said flexible line above the surface of said body of water whereby said access caisson may be raised to its upper position by pumping air into said caisson through said line and said first port while expelling the water through said second port.

7. The combination of an access caisson and a submerged wellhead mounted on the upper end of said conductor pipe protruding from a marine bottom, as recited in claim **5**, wherein: buoy means are connected to said caisson to relocate said caisson after said caisson has been lowered into its completely submerged position.

8. The combination of an access caisson and a submerged wellhead mounted on the upper end of said conductor pipe protruding from a marine bottom, as recited in claim **5**, wherein: the body of water is too deep for said conductor pipe to be self-supporting for its entire length; a submerged support structure set on said marine bottom; and means rigidly connecting the upper end of said support structure to said conductor pipe, beneath where said access caisson reaches when in the said completely submerged position, and at least up to the point where said conductor pipe thereabove would be self-supporting.

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