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Madary et al.

[11] **3,738,113**

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[54] **OFFSHORE OIL STORAGE STRUCTURE WITH SUBMERGENCE SHELL**

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[73] Assignee: **Chicago Bridge & Iron Company,** Oak Brook, Ill.

[22] Filed: **Oct. 14, 1971**

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[52] **U.S. Cl.** .... **61/46.5,** 61/34, 114/.5 T

[51] **Int. Cl.** **E02b 17/00,** B65d 89/10

[58] **Field of Search** .... 61/46.5, 46, .5, 61/34; 114/.5 T

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Attorney—Charles J. Merriam, William A. Marshall, Jerome B. Klose et al.

[57] **ABSTRACT**

An offshore structure floatable to a site for positioning on the floor of a body of water having a roof shell enclosing a volume therebelow, said roof shell having a peripheral ballasting ring, a conduit to remove air from beneath the roof shell and supply the same with liquid in submerging the structure, a submergence shell joined at its bottom to the roof shell and extending upwardly spaced away from the roof shell thereby defining a material well between the submergence shell and the roof shell, a plurality of partitions dividing the material well into compartments, means to supply ballasting material to, and remove it from, the material well, at least one hollow vessel joined to the roof shell, said hollow vessel being of such size that the buoyancy of the vessel will statically float the roof shell above the floor of a body of water partly or fully submerged at least with all air removed from beneath the roof shell and with the material well full of ballasting material and means to supply ballasting material to, and remove it from, the hollow vessel.

14 Claims, 14 Drawing Figures

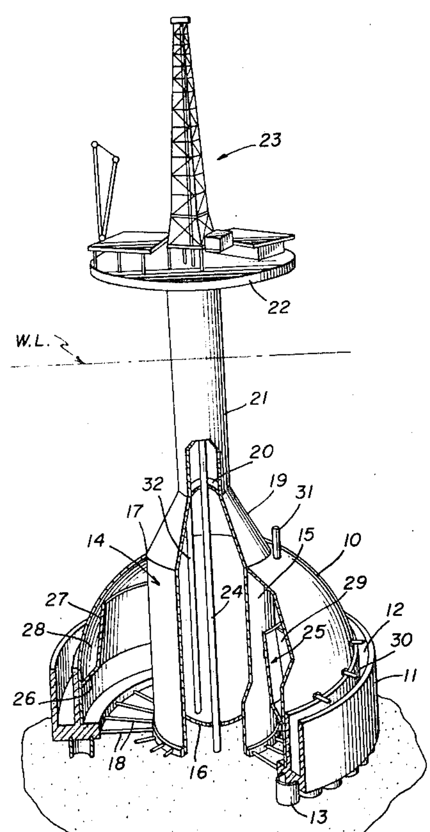


FIG. 1

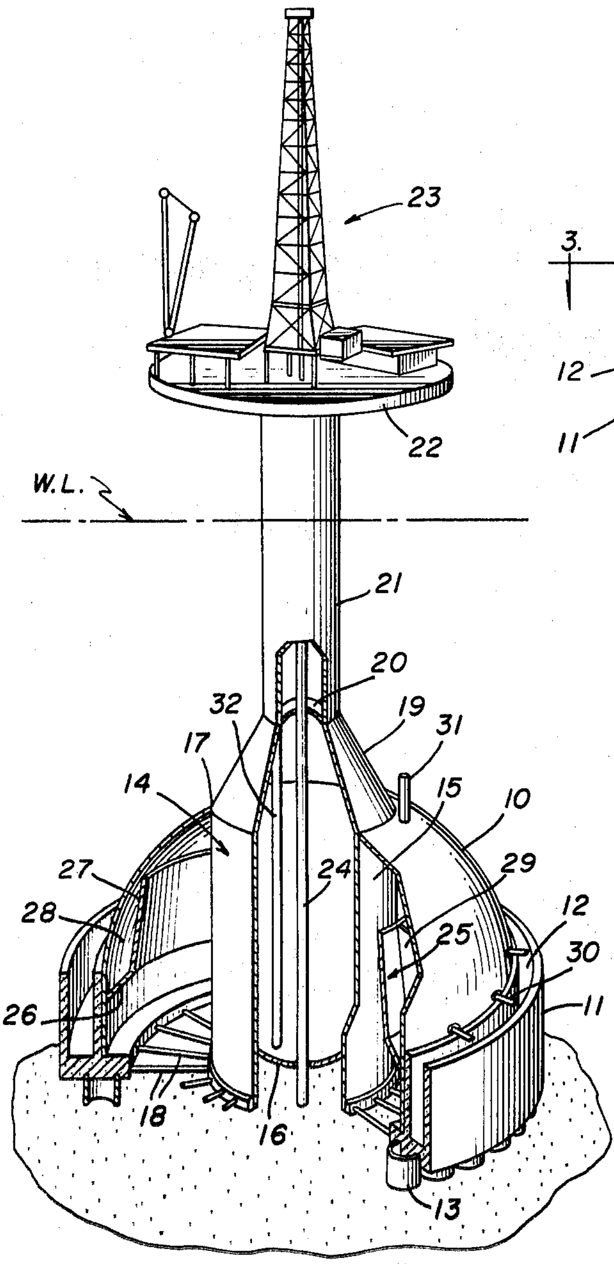


FIG. 2

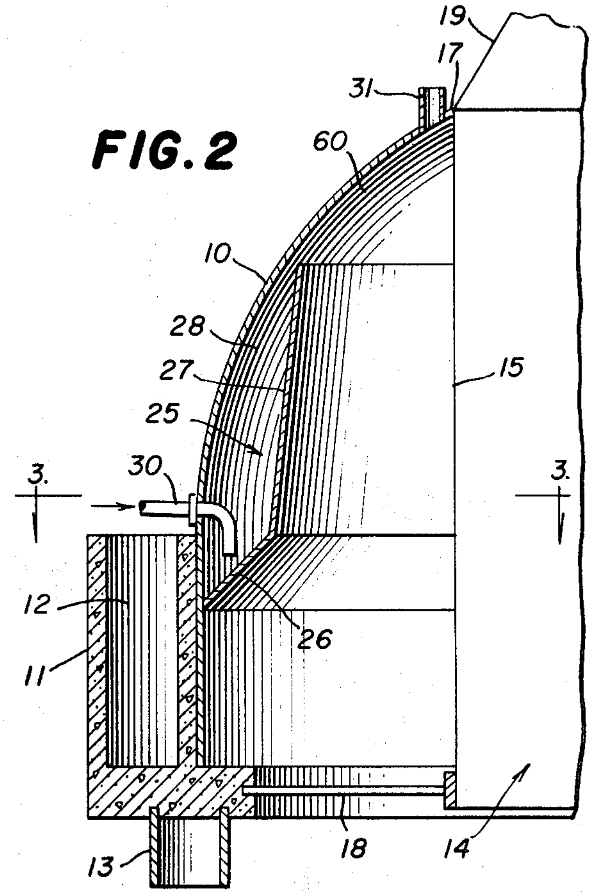


FIG. 4

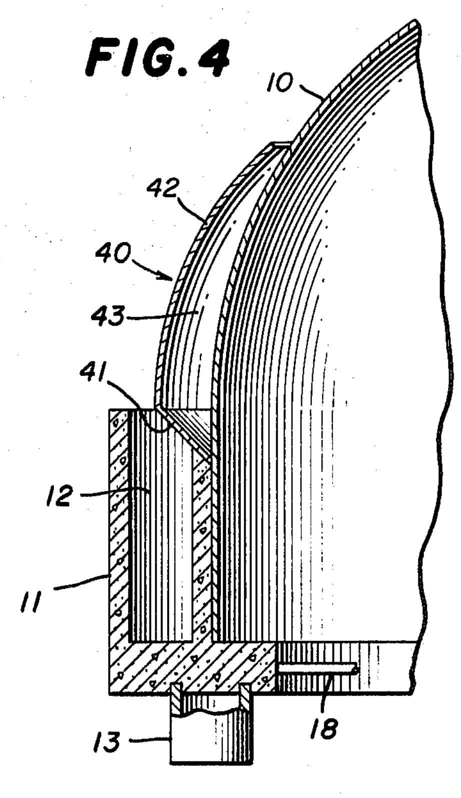


FIG.3

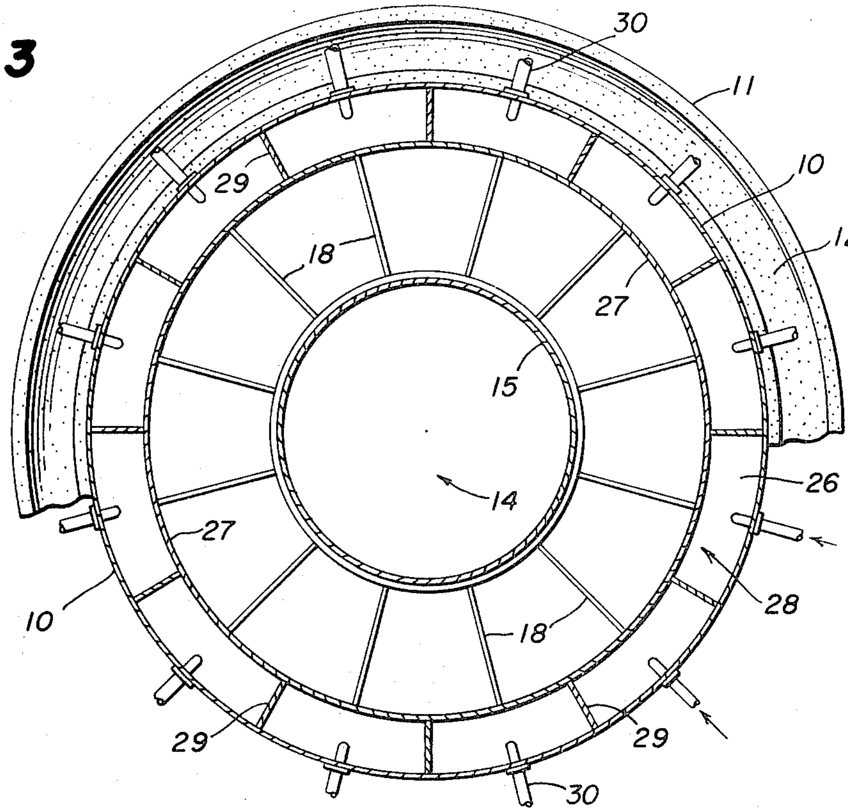


FIG.6

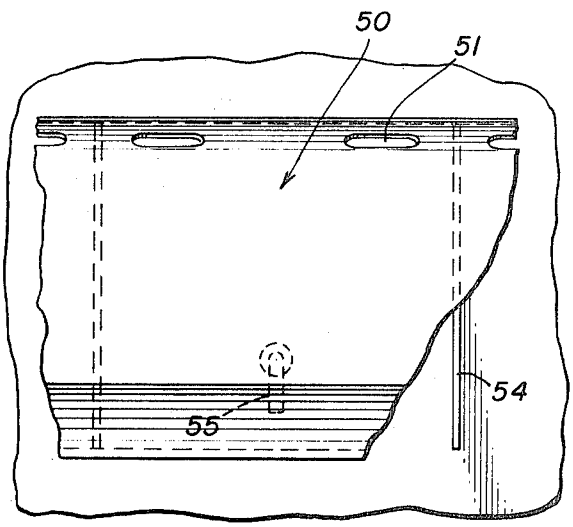


FIG.5

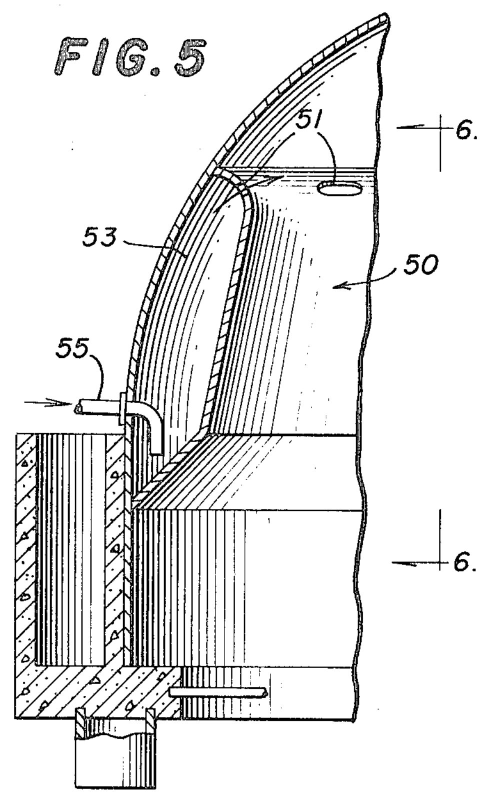


FIG. 10

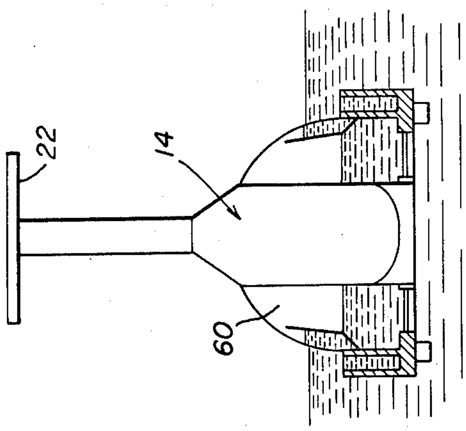


FIG. 9

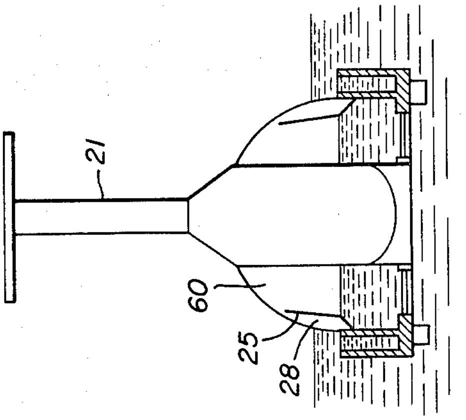


FIG. 8

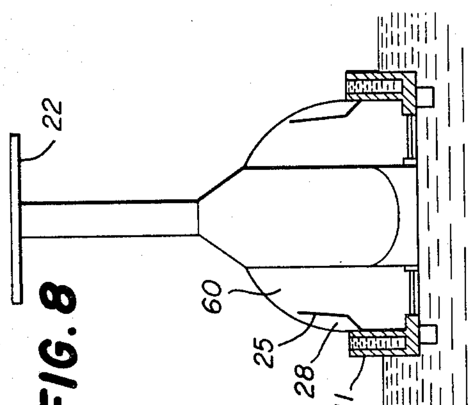


FIG. 7

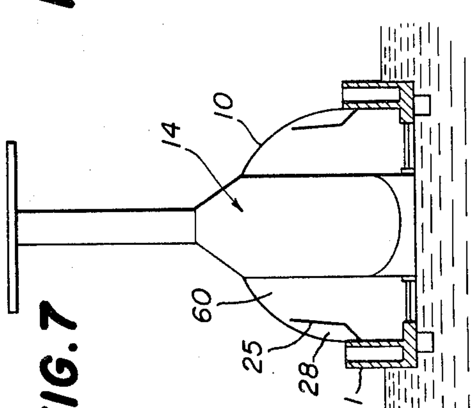


FIG. 14

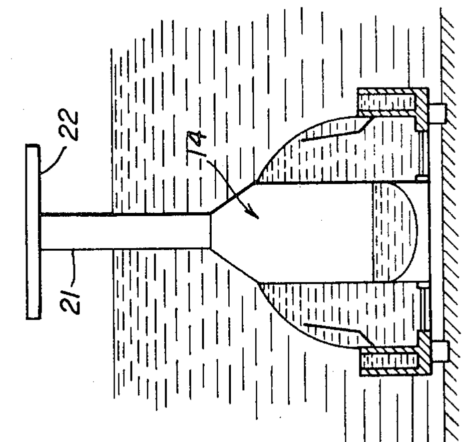


FIG. 13

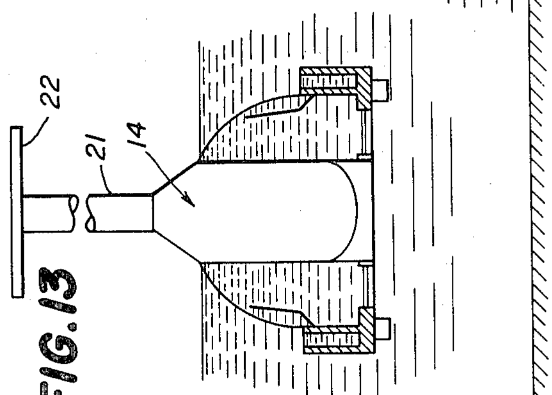


FIG. 12

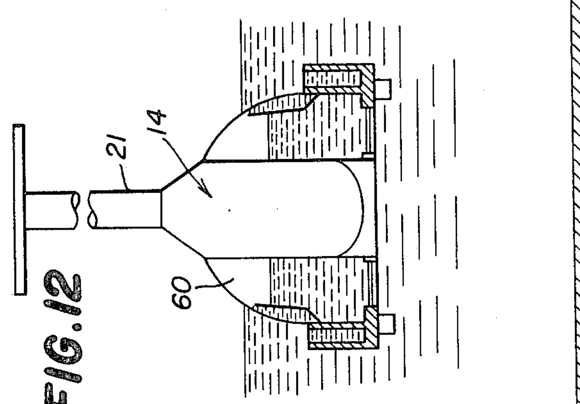
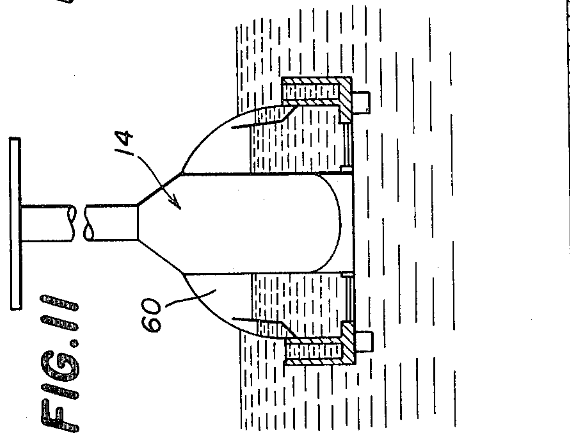


FIG. 11



OFFSHORE OIL STORAGE STRUCTURE WITH SUBMERGENCE SHELL

This invention relates to offshore structures. More particularly, this invention relates to offshore structures used for drilling for oil, the storage of oil and the mooring of vessels.

Many areas offshore around the world are being explored for mineral deposits, and particularly for oil. With particular reference to oil exploration, after an offshore area has been investigated and studies indicate that there exists a possibility that it contains oil deposits, it becomes necessary to actually drill wells to verify that oil exists.

To drill wells offshore requires a barge which floats on the water and supports the drilling apparatus, or a structure which can be supported on the floor of the body of water and which extends from the floor to a suitable height to support the necessary drilling equipment above the water surface. Although various structures of the described types have been developed for drilling oil wells offshore, there is a need for an offshore structure which can be readily submerged without loss of stability. Furthermore, there is a need for such an offshore structure which can be moved from one location to another by floatation on the body of water, submerged and subsequently raised when desired. Such a structure can be used in oil exploration since it can be floated to an area which is believed to have potential oil deposits, submerged to the floor of the body of water at such area and drilling commenced to establish or not the presence of oil. If the drilling proves fruitless, the structure can be refloated and then moved to another area for further exploratory oil well drilling. In addition to having such capabilities, the structure should also advisably be able to store a substantial quantity of oil produced from one or more offshore oil wells so that the same structure can be employed both for oil exploration and oil production to thereby eliminate the need for separate structures for each of these objects.

There is provided according to the subject invention, a novel offshore structure which can be floated to a suitable area offshore and submerged to the floor of the body of water. Furthermore, in its most useful form it can be refloated or raised at any suitable time and moved thereafter to another locality. In addition, the novel offshore structure possesses the capacity to store a substantial quantity of oil while it rests on the floor of a body of water. Thus, oil produced from offshore wells can be conveyed to the structure and held in storage there until loaded onto a ship for transportation. The offshore structure provided herewith also possesses total stability when submerged to the floor of a body of water. Its most suitable form also has total stability when it is raised or refloated from the floor of a body of water. Such offshore structure can be raised and lowered in a vertical line with only minimal tilt due to wind and wave action.

The offshore structure provided by this invention can be further characterized as having a roof shell which encloses a volume therebelow. The roof shell has a peripheral ballasting ring which provides a substantial righting moment against significant tilting of the structure while the ballasting ring is at least partly above water level. The structure also has a submergence shell, joined at its bottom to the roof shell, extending upwardly spaced away from the roof shell, which defines a material well between the submergence shell and the roof shell. A plurality of spaced apart partitions, advisably extending from the submergence shell to the roof shell, divide the material well into compartments. In addition, the offshore structure has at least one hollow vessel joined to the roof shell. The hollow vessel is of such size that the buoyancy of the hollow vessel will statically float the roof shell above the floor of a body of water partly or fully submerged at least with all air removed from beneath the roof shell and with the material well full, i.e., not contributing buoyancy.

The offshore structure also has suitable means to remove air from the space beneath the roof shell and to supply the space with a suitable liquid, advisably water, during submergence of the offshore structure. Means are also provided in the offshore structure to supply a material such as a liquid, and advisably water, to the material well. Means are also advisably provided to remove the material from the material well such as when raising the structure. Suitable means in addition can supply a material, such as water, to the hollow vessel and remove it therefrom when desired.

The hollow vessel advisably is vertically positioned in axial central relationship in the offshore structure. It advisably is provided with a vertical cylindrical wall from at least near the bottom to an intersection of the roof shell with the cylindrical wall. A vertical tube or column is furthermore advisably positioned to communicate with the top interior of the hollow vessel and to extend upwardly therefrom to above the water surface when the offshore structure rests on the floor of a body of water. The roof shell is desirably concentrically joined to an upper walled part of the hollow vessel and extends therefrom radially outwardly and downwardly.

The submergence shell can be positioned either inside of the roof shell or on the outside of the roof shell. The submergence shell can generally comprise a metal plate, ring-like element, joined at its lower edge to the roof shell and extending laterally outwardly and upwardly from such location to wall-in a substantial volume comprising the material well. The upper edge of the submergence shell can be joined to the roof shell or it can be fixed in position spaced away therefrom so as to leave the upper area of the material well open. In an alternative embodiment, the upper part of the submergence shell can also be joined to the roof shell and suitable openings or ports provided at strategic locations in and around the submergence shell to permit communication between the interior space comprising the material well and the space outside of the material well.

The submergence shell projects upwardly for a substantial distance and thereby provides a rather high material well space which serves to supply a very substantial righting moment to the offshore structure during floatation of the offshore structure when at least part of the material well space is in submerged position but during which at least some of the material well is above the surface of the water. The substantial righting force results because of the comparatively wide cutwater plane which exists when the water level intersects the material well space.

The invention will now be described further in conjunction with the attached drawings, in which:

FIG. 1 is an isometric view, partially cut away, of one embodiment of an offshore structure provided by the invention having a submergence shell under the roof shell and shown resting on the floor of a body of water;

FIG. 2 is a partial vertical sectional view of the offshore structure of FIG. 1;

FIG. 3 is a partial horizontal sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a partial vertical sectional view of another embodiment of the invention and has the submergence shell outside of the roof shell;

FIG. 5 is a partial vertical sectional view of a third embodiment of the invention and shows a submergence shell below the roof shell with an opening in the upper portion of the submergence shell;

FIG. 6 is a partial elevational view taken along the line 6—6 of FIG. 5; and

FIGS. 7 to 14 illustrate a submergence sequence for placing the offshore structure of FIGS. 1 to 3 on the floor of a body of water.

So far as is practical the same elements or parts which appear in the various figures of the drawings will be designated by the same number.

With reference to FIGS. 1 to 3, the offshore structure has a roof shell 10, shaped substantially like a segment of a spherical surface, which envelopes a volume or space 60 beneath it. The roof shell is however open at the bottom although it can have closed bottom. The roof shell 10 has a peripheral ballasting ring 11, such as of concrete, at its bottom edge portion. It provides a substantial righting moment against significant tilting of the offshore structure while the ballasting ring is at least partly above water level. While the ballasting ring can be completely solid, it advisably has a deep channel 12, open at the top, extending circularly in the ring. The presence of such a channel however is not necessary even though it provides a better structure. A plurality of shear cans 13 are placed on the bottom of the ballasting ring. When the offshore structure rests on the bottom or floor of a body of water, the shear cans 13 penetrate into the sea bed and anchor the structure against lateral movement by sea currents and waves.

The hollow vessel 14 has a vertical cylindrical portion 15, circular in horizontal cross-section, which extends from the bottom plane of the ballasting ring 11 to the intersection 17 with roof shell 10. A dished bottom 16 (FIG. 1) closes the lower end of the circular cylindrical portion 15. A plurality of tubular spokes 18 extend radially and horizontally from the bottom edge of cylindrical portion 15 to ballasting ring 11 and serve to maintain the hollow vessel 14 in fixed position relative to the roof shell 10. The hollow vessel 14 has a conical top 19 (FIG. 1), which projects upwardly from cylindrical portion 15, and it is closed by plate 20 (FIG. 1).

Extending upwardly from conical top 19 of hollow vessel 14 is a hollow cylindrical tube or column 21 (FIG. 1) upon which platform 22 is supported above the sea level when the offshore structure rests on a sea floor. Apparatus 23 is mounted on the platform as desired for the needs of oil well drilling or oil production. The presence of such apparatus makes the structure top-heavy but nevertheless controlled submerging of the offshore structure is readily effected with complete stability. Pipe 24 comprises a well casing for drilling a well or for oil production.

Submergence shell 25 (FIGS. 1-3) has a lower conical ring portion 26 of metal plate, and an upper conical ring portion 27 of metal plate. The lower edge of conical portion 26 is joined to the inside surface of roof shell 10, advisably below the top of ballasting ring 11. The submergence shell 25 extends upwardly therefrom spaced away from the roof shell 10 and thus defines a material well space 28 between the submergence shell and the roof shell.

Partitions 29 are placed vertically, spaced apart from one another, as shown most clearly in FIG. 3, in the material well space 28 and extend from the submergence shell to the roof shell, thereby dividing the material well into compartments. Conduits 30 communicate with each compartment to supply a material, usually water, although it can be a solid particulate material such as gravel or sand, thereto during submergence of the structure and to remove it therefrom to raise the structure.

Conduit 31 removes air from beneath roof shell 10 during submergence and supplies air during raising of the offshore structure. Conduit 32 is used to supply a material such as water or other ballast to hollow vessel 14 to submerge the structure and is used to remove the ballast, particularly water, from hollow vessel 14, while air is supplied by another conduit not shown, to raise the offshore structure.

FIG. 4 shows another embodiment of the invention with the submergence shell 40 on the outside of the roof shell 10. The submergence shell 40 has a lower conical ring portion 41 of metal plate, joined at its lower edge to roof shell 10, and an upper curved ring portion 42 of metal plate which extends upwardly from ring 41 and terminates spaced away from the roof shell. The space between submergence shell 40 and roof shell 10 defines a material well space 43 similar to well space 28 in the embodiment of FIGS. 1 to 3. The material well space 43 is partitioned into compartments by vertical spaced apart partitions or bulkheads in the same way as shown in the embodiment of FIGS. 1 to 3. Each compartment is in communication with a conduit to supply a ballasting material, such as water, to, or remove it from, the compartment.

FIGS. 5 and 6 illustrate another embodiment of the invention. In this embodiment, the submergence shell 50 is joined at its upper and lower edges to roof shell 10. Openings 51 at the top portion of the submergence shell provide a means for air to leave the material well 53 space and flow to the space beneath the roof shell 10 when the material well 53 is supplied with water or other ballasting liquid or solid material. The material well 53 if partitioned into compartments by spaced apart, radially positioned vertical bulkheads 54 and a conduit 55 provides a means to supply a material such as water to each compartment separately.

FIGS. 7 to 14 show schematically the submergence steps for placing the offshore structure of FIGS. 1 to 3 on the floor of a body of water. The procedure however is also broadly applicable to the second embodiment shown in FIG. 4 and the third embodiment of FIGS. 5 and 6.

FIG. 7 represents the maximum floating position of the offshore structure after its construction on shore in a graving dock followed by floatation towing to the location where it is to be submerged. The offshore structure floats on the air bubble trapped in the space 60 below the roof shell 10. Stability of the structure is inherent because of the large cut-water plane of the ballasting ring 11 on the water surface.

In the first step of submerging the offshore structure, water or some other liquid or solid ballasting material is placed in the channel **12** in ballasting ring **11.** This lowers the structure to the position shown in FIG. **8.** If a liquid such as water is placed in channel **12,** it is necessary to partition the channel into compartments to keep the liquid from flowing to one side since that will cause a tilting moment which leads to instability of the structure.

After the ballasting ring **11** has been filled with ballast, some air is removed from beneath the roof shell by conduit **31** to lower the offshore structure to the position shown in FIG. **9.** In this position, the submergence shell **25** lower edge is below the surface of the sea and as a result a substantial cut-water plane is created which stabilizes the structure against tilting even though the entire ballasting ring **11** is beneath the sea. Ballasting material such as water is then supplied in equal amounts to each of the compartments in the material well **28** until the well is about one-half filled to lower the structure to the position shown in FIG. **10.**

Further air is then released from beneath the roof shell to lower the structure to the position shown in FIG. **11.** The material well is then completely filled to further lower the structure to the position shown in FIG. **12.** Then all air is removed from beneath the roof shell, thereby lowering the structure to the position shown in FIG. **13.** At this position, the entire structure is supported by hollow vessel **14.** Hollow vessel **14** can be constructed as a pressure vessel to withstand the pressure of the sea or it can be made of thin plate and pressurized internally to balance the sea pressure.

Submerging of the offshore structure from the position shown in FIG. **13** until it rests on the sea floor can be effected by adding a ballasting material such as water or sand to the hollow vessel **14.** As the ballast is so added, the structure descends with total control in an upright vertical position until it rests on the sea floor as shown in FIG. **14.**

After the offshore structure is positioned on the sea floor, it can be used to drill exploratory oil wells or oil production wells. It can also be used for oil storage. The entire space below the roof shell, in the hollow vessel and the material well, can be used for oil storage. These spaces can be placed in common communication by cutting holes or openings in the submergence shell and in cylindrical wall **15.** With the bottom of the offshore structure open to the sea, oil pumped into the space below the roof shell displaces water which flows out beneath the ballasting ring **11.**

The submergence shell system as described, as well as obvious variations thereof which will occur to those skilled in the art, provides a means by which the offshore structure can be submerged and raised with total stability in a vertical line, with minimal tilting. It permits controlled ballasting after the structure is floating and permits use of cheap ballast, i.e., sea water. By reducing the permanent ballast built into the structure during construction on land, capital investment is reduced. Also, the offshore structure floats higher initially and thus is easier to float, with lower cost, out of a graving dock on shore.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

What is claimed is:

1. An offshore structure floatable to a site for positioning on the floor of a body of water comprising:

a roof shell enclosing a volume therebelow, said roof shell having a peripheral ballasting ring which provides a substantial righting moment against significant tipping of the structure while the ballasting ring is at least partly above water level;

means to remove air from beneath the roof shell and means to supply the same with liquid in submerging the structure;

a submergence shell joined at its bottom to the roof shell and extending upwardly spaced away from the roof shell thereby defining a material well between the submergence shell and the roof shell;

the upper part of said material well being provided with at least one opening permitting direct communication between the interior space of the material well and the exterior thereof;

said material well being so positioned as to be completely submerged when said structure is positioned on the floor of said body of water;

a plurality of spaced apart upright partitions dividing the material well into compartments;

means to supply ballasting material to the material well;

at least one hollow vessel joined to the roof shell, said hollow vessel being of such size that the buoyancy of the vessel will statically float the roof shell above the floor of a body of water partly or fully submerged at least with all air removed from beneath the roof shell and with the material well full of material; and

means to supply material to the hollow vessel.

2. An offshore structure according to claim **1** in which the hollow vessel has a vertical tube communicating with the top interior of the vessel and extending upwardly therefrom to above the water surface when the tank is on the floor of a body of water.

3. An offshore structure according to claim **1** in which the roof shell is concentrically joined to an upper walled part of the hollow vessel and the roof shell projects therefrom radially outwardly and downwardly.

4. An offshore structure according to claim **1** in which the submergence shell is under the roof shell.

5. An offshore structure according to claim **1** in which the submergence shell extends upwardly above the ballasting ring.

6. An offshore structure according to claim **4** in which the submergence shell is joined to the roof lower than the top of the ballasting ring.

7. An offshore structure according to claim **6** in which the submergence shell extends upwardly to above half the height of the roof shell.

8. An offshore structure according to claim **1** in which the submergence shell is on the outside of the roof shell.

9. An offshore structure according to claim **8** in which the submergence shell extends upwardly above the ballasting ring.

10. An offshore structure according to claim **1** in which the submergence shell is open at the top.

11. An offshore structure according to claim **1** in which the roof shell is open at the bottom.

12. An offshore structure according to claim **1** including means to remove material from the hollow vessel.

13. An offshore structure according to claim **1** including means to remove material from the material well.

14. An offshore structure according to claim **1** in which the partitions extend from the submergence shell to the roof shell.

* * * * *