United States Patent [19]

Arne et al.

[11] **3,719,048**

[45] **March 6, 1973**

[54] **OFFSHORE STRUCTURE WITH STATIC AND DYNAMIC STABILIZATION SHELL**

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[22] Filed: **Nov. 18, 1971**

[21] Appl. No.: **199,855**

[52] **U.S. Cl.** .....**61/46.5**, 61/69, 114/.5 T

[51] **Int. Cl.** **B65g 5/00**, E02b 17/00

[58] **Field of Search** .....61/46, 46.5, 69; 9/8 OP; 114/.5 D, .5 ST, 16 E

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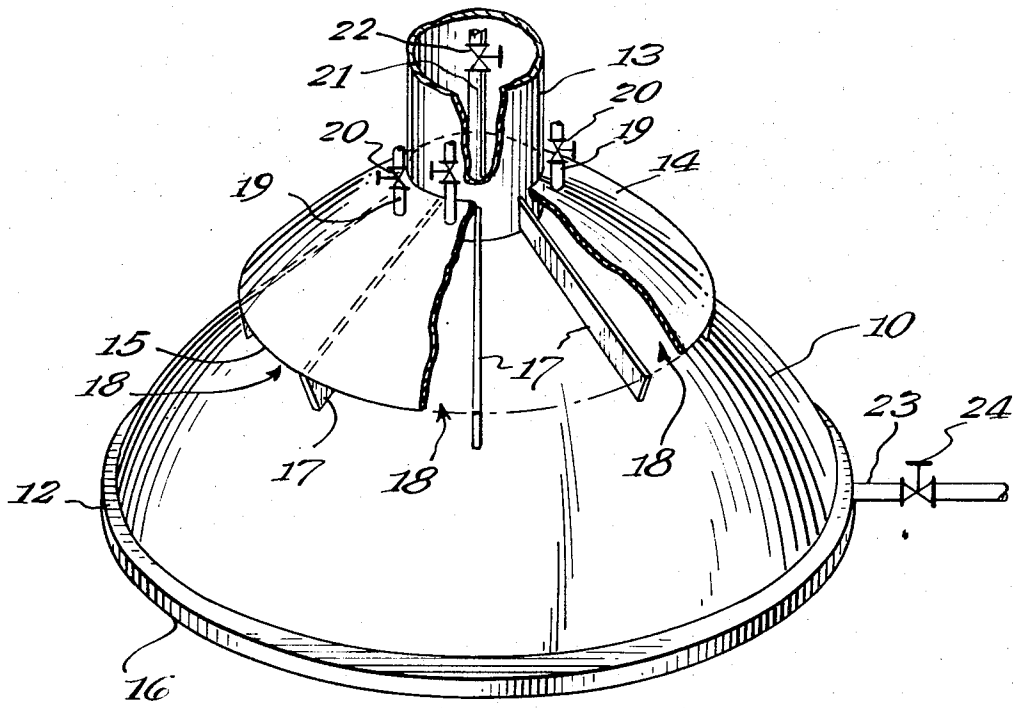
Primary Examiner—J. Karl Bell

Attorney—Charles J. Merriam et al.

[57] **ABSTRACT**

An offshore structure floatable to a site for positioning by submergence on the floor of a body of water and subsequently raising it having a domed roof shell enclosing a volume therebelow, said roof shell being open at the bottom and having 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, a stabilization shell mounted adjacent to the upper part of the roof shell in fixed position relative thereto by connecting means joined to the roof shell, said stabilization shell being open at the bottom and enclosing a volume between the shells, a plurality of spaced apart bulkheads extending vertically between the two shells thereby dividing the space between the shells into compartments, and means to remove air from beneath the roof shell and from said compartments in submerging the structure.

16 Claims, 8 Drawing Figures



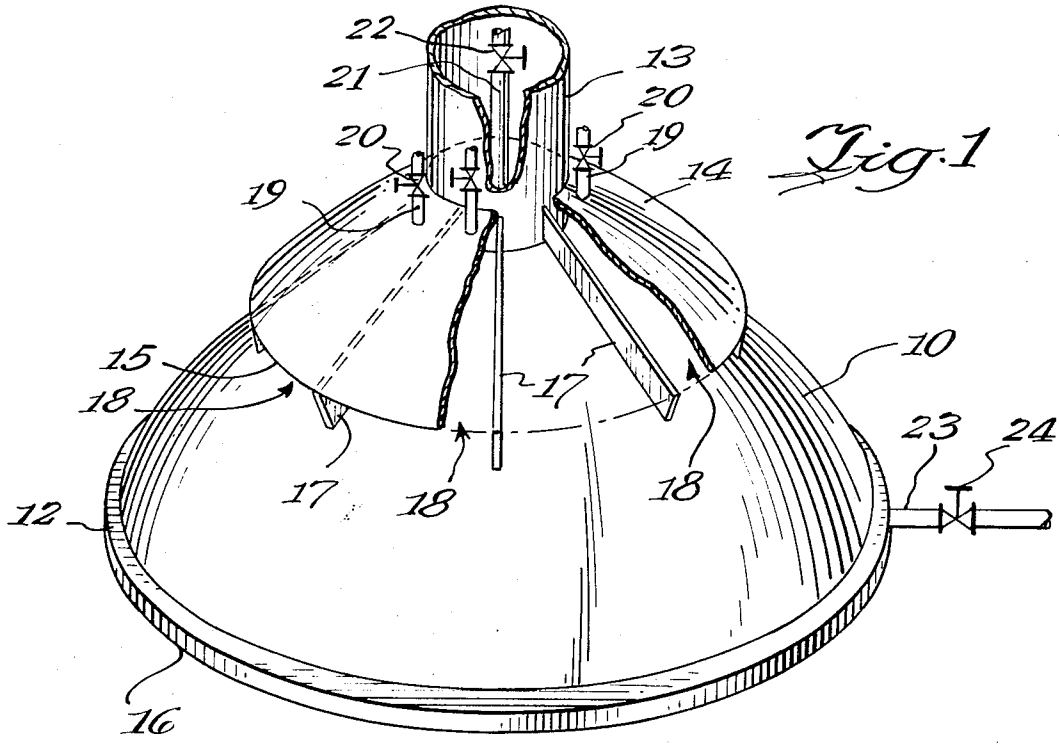

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Fig. 1

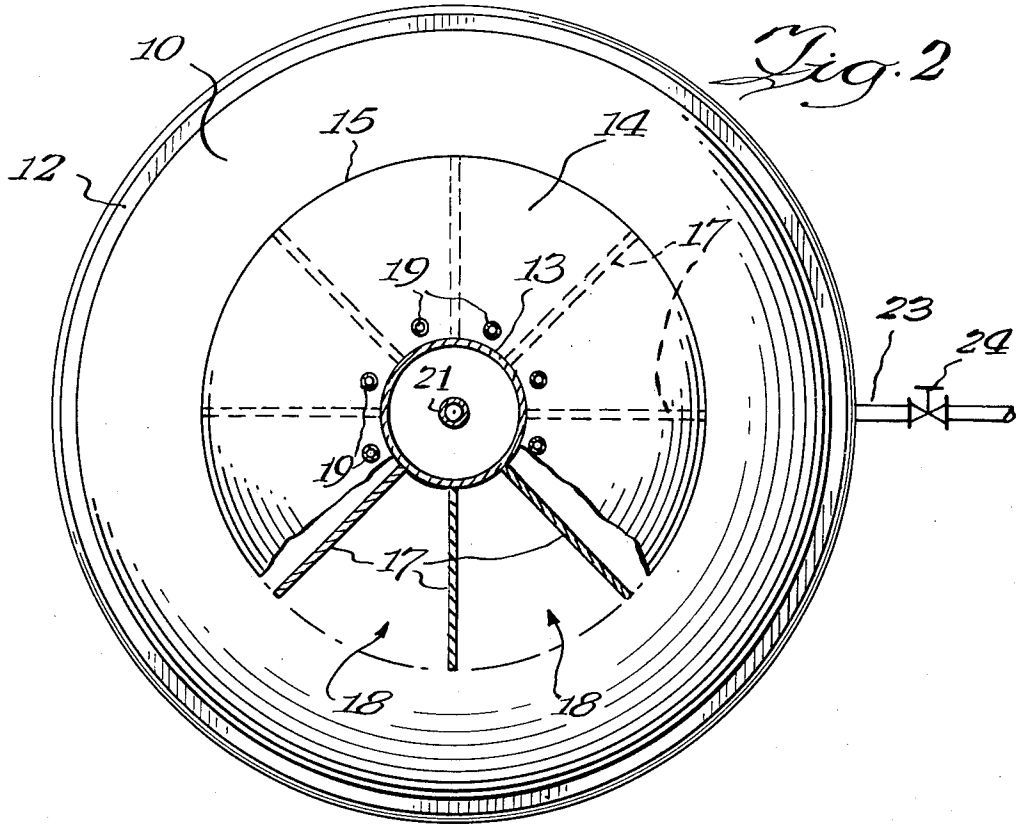

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Fig. 2

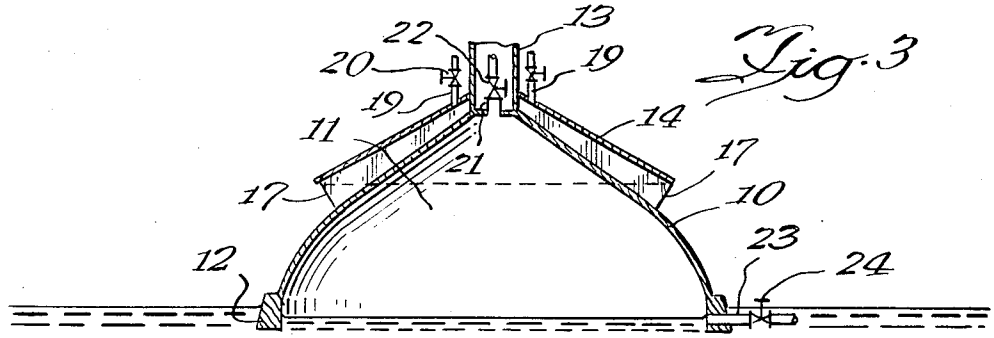


Fig. 3

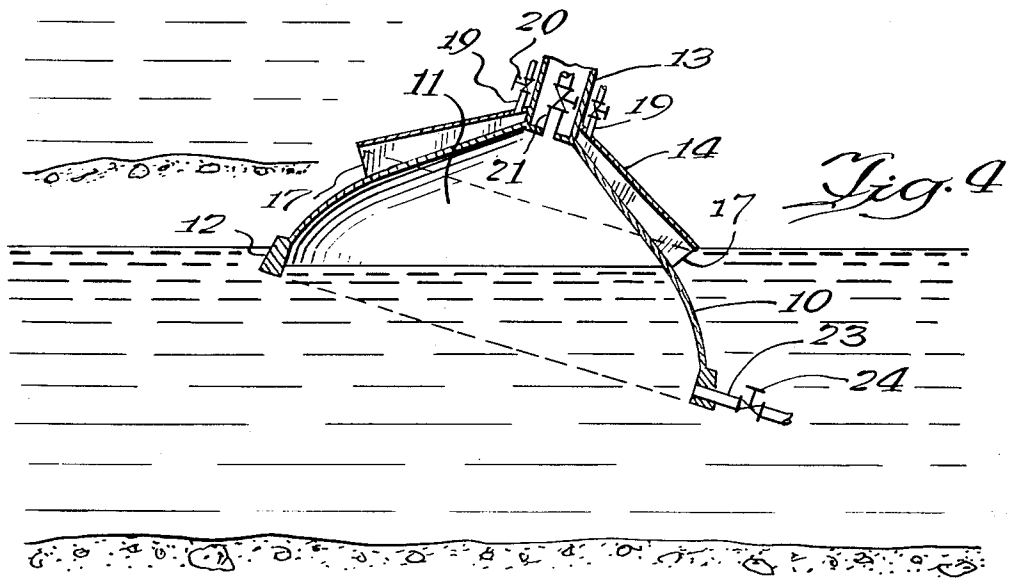


Fig. 4

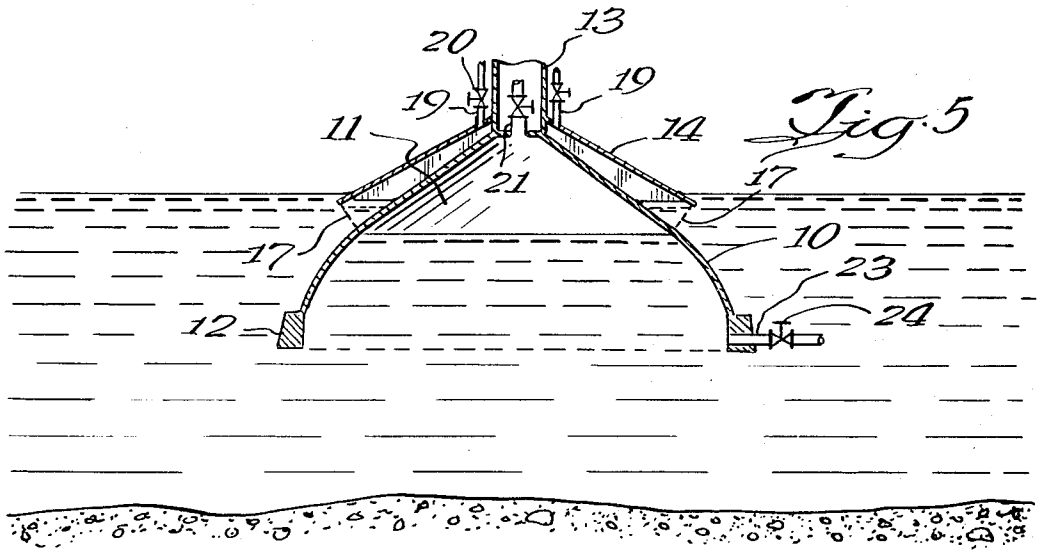


Fig. 5

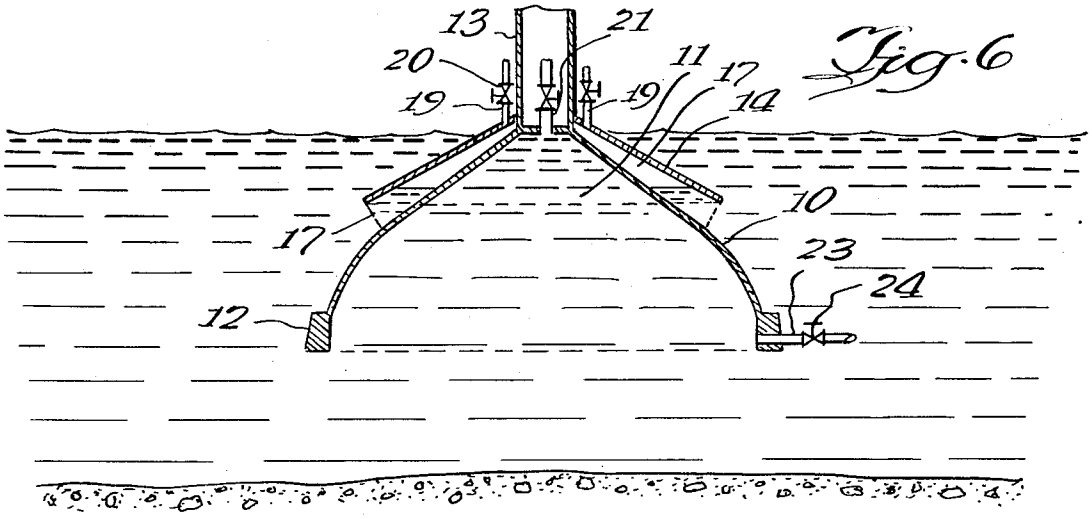


Fig. 6

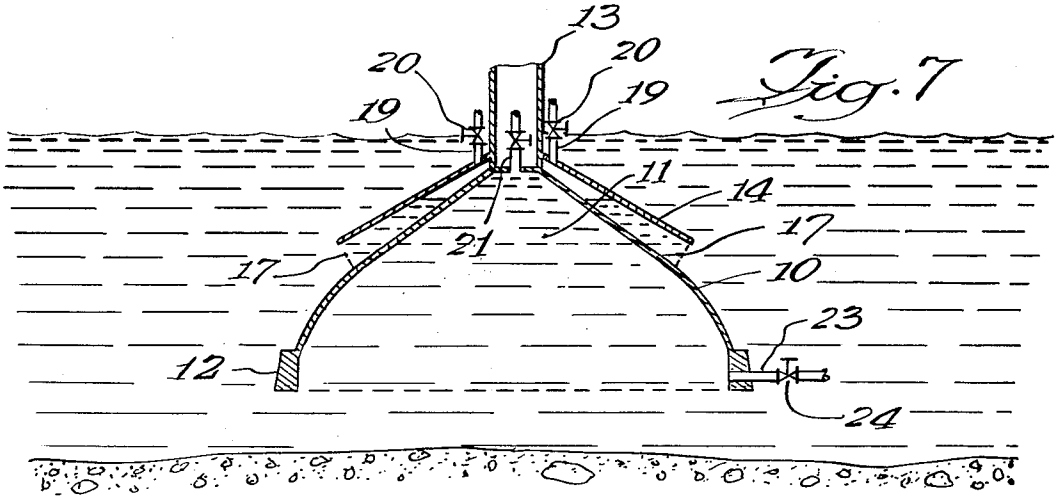


Fig. 7

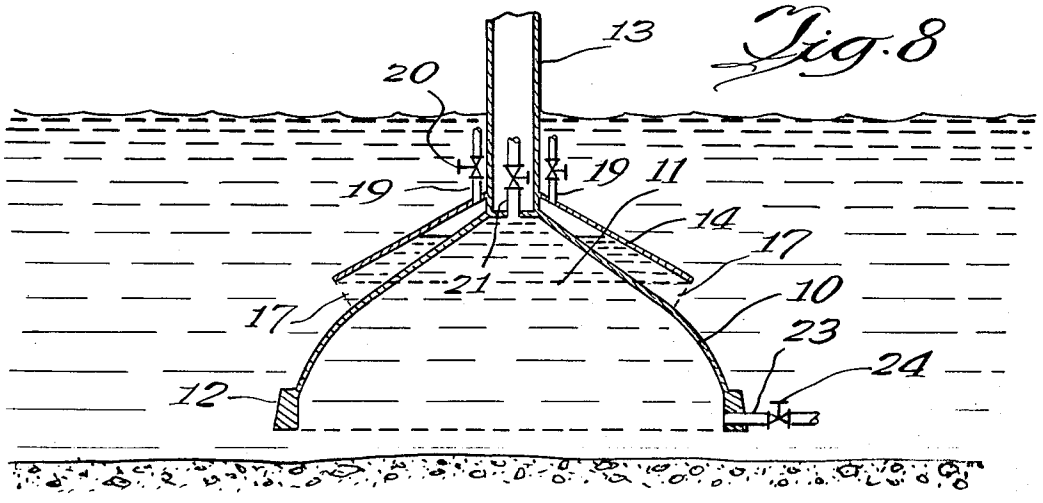


Fig. 8

OFFSHORE STRUCTURE WITH STATIC AND DYNAMIC STABILIZATION 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 particuarly 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 for 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 the presence or not 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.

The offshore structure provided by this invention can be further characterized as having a domed 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 stabilization shell enclosing a volume therebelow mounted above or adjacent to the upper part of the roof shell in fixed position relative thereto by connecting means joined to the roof shell. A volume is enclosed between the roof shell and the stabilization shell. Both the roof shell and stabilization shell are open at the bottom. A plurality of spaced apart bulkheads or partitions, advisably extending vertically from the stabilization shell to the roof shell, divide the space beneath the stabilization shell into compartments. Means are also provided to remove air from beneath the roof shell and the compartments in submerging the structure. The stabilization shell is of such size as to envelope a volume of air adequate to statically float the entire offshore structure above the floor of a body of water partly or fully submerged at least with all air removed from beneath the roof shell.

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

FIG. 1 is an isometric view of an offshore storage structure provided by this invention;

FIG. 2 is a plan view, partially broken away, of the offshore structure of FIG. 1;

FIG. 3 is a vertical sectional view of the offshore storage structure of FIGS. 1 and 2 shown floating with maximum buoyancy;

FIG. 4 is a vertical sectional view of the offshore structure of FIGS. 1 and 2 floating at maximum tilt when the confined air in the stabilization shell applies buoyancy to prevent further tilting;

FIG. 5 is a vertical sectional view of the offshore structure of FIGS. 1 and 2 floating with approximately one-half of the air removed from beneath the roof shell;

FIG. 6 is a vertical sectional view of the offshore structure of FIGS. 1 and 2 floating with all air removed from beneath the roof shell and with all the air still entrapped within the stabilization shell;

FIG. 7 is a vertical sectional view of the offshore structure of FIGS. 1 and 2 floating with part of the air removed from beneath the stabilization shell and no air beneath the roof shell; and

FIG. 8 is a vertical sectional view of the offshore structure of FIGS. 1 and 2 with more air removed from beneath the stabilization shell to submerge the offshore structure.

So far as is practical, the same parts or elements of the offshore structure which appear in the different view of the drawings will be identified by the same numbers.

With reference to FIGS. 1 and 2, the offshore structure structure has a roof shell **10**, generally dome-shaped, advisably made of metal plate with sufficient stiffening ribs as are required to maintain it rigid and sufficiently strong for the intended purpose. Roof shell **10** is open at the bottom. Roof shell **10** envelopes or encompasses a substantial volume or space **11** (FIG. 3) beneath it. A peripheral ballasting ring **12**, such as of concrete, is positioned along the lower or bottom edge portion of roof shell **10**. The ballasting ring serves to provide a substantial righting moment against significant tilting of the offshore structure while the ballasting ring is at least partly above sea level. The ballasting ring also serves to position the center of gravity of the offshore structure at a lower position than it would otherwise be, although the center of gravity will normally be above the center of buoyancy of the offshore structure when it floats with maximum buoyancy.

Projecting upwardly from the top central portion of roof shell **10** is circular tube or column **13** which extends to a height sufficient to project above the surface of the sea. A platform, not shown, can be mounted on

top of column 13 for supporting equipment for drilling oil wells. However, if the offshore structure is to be used solely for storing oil, it is unnecessary for column 13 to extend above sea level. In fact, it may not even be necessary for it to be on the structure at all in such instances.

Stabilization shell 14, which in the embodiment shown in the drawings, is a conical section joined at its top edge to the periphery of column 13 at a location spaced above the top of roof shell 10. Stabilization shell 14 slopes downwardly and outwardly from column 13 at a slope such as to keep the stabilization shell in spaced above or apart relationship with respect to the top or outer surface of roof shell 10 located therebelow. The peripheral or lower edge 15 of stabilization shell 14 is advisably circular and in a plane which is parallel to the planes in which lie the peripheral circular edge of roof shell 10 and the circular bottom edge 16 of ballasting ring 12. Furthermore, stabilization shell 14, column 13 and roof shell 10 are positioned to have a common vertical axis.

A plurality of spaced apart bulkheads or partitions 17 project vertically downwardly from the bottom surface of stabilization shell 14 and divide the space beneath the stabilization shell into compartments 18. Bulkheads or partitions 17 are furthermore advisably equally spaced from adjacent partitions and thereby enclose walled spaces of equal size. The bulkheads 17 furthermore are radially positioned with respect to the axis of stabilization shell 14. Although it is not essential, it is considered advantageous for partitions or bulkheads 17 to be joined at their top edge to the lower surface of stabilization shell 14 and at their lower edge to the upper surface of roof shell 10. In addition, the bulkheads 17 are advisably made sufficiently long to extend from column 13 to the peripheral edge of stabilization shell 14.

Communicating with each compartment 18 is a conduit 19. Each conduit 19 is provided with a valve 20 to control flow of air or water therethrough so that the contents of the compartment 18 can be regulated in either submerging the offshore structure or in later raising it from the sea floor.

Conduit 21, positioned in column 13, communicates with the space or volume 11 beneath roof shell 10 and can be used to vent air therefrom. It can also be used to fill such space with oil and to remove oil therefrom when the structure is used for oil storage after it is placed on a sea floor. Valve 22 is conduit 21 provides for control of fluid therethrough.

Conduit 23 communicates with the lower portion of space 11 and flow therethrough is controlled by means of valve 24. Water can flow out conduit 23 when space 11 is being filled with oil and when oil is being removed from such space the space vacated by the oil can be occupied by sea water permitted to flow inwardly through conduit 23.

FIGS. 3 to 8 illustrate the offshore structure of FIGS. 1 and 2 in maximum floating position and in various states as it is submerged to rest on a sea floor.

In FIG. 3, the offshore structure is shown floating with minimum draft with total static and dynamic stability. Floatation is achieved by means of air entrapped with space 11. Air is prevented from escaping by having valve 22 in conduit 21 closed. The offshore structure can be built onshore in a graving dock and thereafter floated to a location where it is to be submerged.

FIG. 4 illustrates the offshore structure in maximum tilted position. The offshore structure maintains static stability when tilted to such an extent because, before air can escape from space 11 beneath roof shell 10, buoyancy is picked up by means of the air confined in compartment 18 beneath stabilization shell 14. Thus no burping or escape of air from beneath the roof shell will take place and as a result the offshore structure is statically stable.

The offshore structure also has total static stability when a large amount of the entrapped air in space 11 is vented through conduit 21. As such air is vented, the center of gravity moves downwardly and the center of buoyancy of the offshore structure moves upwardly until the center of gravity is below the center of buoyancy. The structure is partially submerged by venting air from space 11 by conduit 21 to the position shown in FIG. 5 with total stability.

FIG. 6 illustrates the offshore structure with all of the air vented from space 11 beneath roof shell 10. The offshore structure as shown in this figure is more deeply submerged than in the position shown in FIG. 5. The offshore structure, when in the position shown in FIG. 6, still has all of the confined air in compartments 18 below stabilization shell 14. Such air provides the buoyancy required to prevent the offshore structure from settling out of control to the sea floor.

FIG. 7 illustrates the offshore structure with part of the air vented from compartments 18 by means of conduits 19. By venting air in this manner, further submergence of the offshore structure is achieved. It is not advisable to remove all air from compartments 18 in submerging the offshore structure. Additional submergence can be achieved by pumping a ballasting material, such as sea water, into column 13 and, as that is done, the offshore structure will settle with total control onto the sea floor.

The compartments 18 are so positioned and arranged to function as surge tanks during wave action and by so functioning the forces on the structure caused by waves are alleviated. The alleviating force is derived from partly filling and emptying the compartments, or surge tanks, and is vested in the translocation of mass, especially in the flow of liquid in the near vicinity of the structure.

With the offshore structure resting on the sea floor, the action of waves as well as water currents will force water up into compartments 18 and thereby compress the residual air in such compartments. This will result in the application of downward forces on roof shell 10 and give dynamic stability to the offshore structure on the sea floor.

As the waves come and go, water will flow into and out of the compartments 18 to a different degree and in a different timing for the separate compartments around the structure. The inlets and outlets of the compartments are placed to direct this flow in a path adjacent to the surface of the roof shell 10, or away from that surface to effect changes in the water pressure on that surface which will be opposite to the natural changes in pressures created by the passing wave. Thus, the same wave which creates a force tending to over-

turn the structure will at the same time perform work and establish forces which oppose overturning the structure. This feature of dynamic stability will be effective both during submergence and when the tank stands on the sea floor as well.

The structure can be raised from the sea floor by reversing the submergence operation. The compartments **18** are proportioned to carry the structure upwards from the bottom with a moderate force. Air spilled from the compartments will make a path for the structure to follow in upward motion. Because of the action of sea currents and wave forces, water is forced upwardly into compartments **18** and then it flows down and outwardly. By filling the compartments nearly full with air in raising the structure, wave action can cause a sudden burst or burp of air from beneath the compartments and this will cause the structure to be jarred loose from contact with the sea bottom.

If desired, after the compartments are made about full of air for raising the structure from the sea floor additional air supplied thereto can be conducted through suitable conduits to space **11** beneath roof shell **10** to aid in raising the structure by bringing it to an intermediate position of buoyancy. If desired, excess air in space **11** can be vented out to control buoyancy.

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 by submergence on the floor of a body of water comprising:

a domed roof shell enclosing a volume therebelow, said roof shell being open at the bottom and having 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;

a stabilization shell mounted adjacent to the upper part of the roof shell in fixed position relative thereto by connecting means joined to the roof shell, said stabilization shell being open at the bottom and enclosing a volume between the two shells;

a plurality of spaced apart bulkheads extending vertically between the two shells thereby dividing the space between the shells into compartments; and

means to remove air from beneath the roof shell and from said compartments in submerging the structure.

2. An offshore structure according to claim **1** in which the peripheral ballasting ring is at the lower edge of the roof shell and said edge is in a horizontal plane when the shell is in upright, nontilting position, and the stabilization shell has a lower peripheral edge in a plane parallel to the lower edge of the roof shell.

3. An offshore structure according to claim **2** in which the periphery of the ballasting ring and the periphery of the stabilization shell are circular, and the stabilization shell and roof shell have a common vertical axis.

4. An offshore structure according to claim **3** in which the bulkheads on the stabilization shell are radially positioned and are spaced apart equally from adjacent bulkheads.

5. An offshore structure according to claim **3** in which the bulkheads extend from the stabilization shell to the roof shell and are joined thereto.

6. An offshore structure according to claim **1** in which the roof shell has a hollow tubular vertical column extending upwardly from the top of the roof shell, and the submergence shell is joined to the vertical column.

7. An offshore structure according to claim **6** in which a conduit communicates with each compartment for removing air therefrom.

8. An offshore structure according to claim **1** in which the compartments are arranged to function as surge tanks during wave action and by so functioning alleviate the forces on the structure caused by waves.

9. An offshore structure according to claim **8** in which an alleviating force is derived form partly filling and emptying the surge tanks and is vested in the translocation of mass.

10. An offshore structure according to claim **8** in which an alleviating force is derived from partly filling and emptying the surge tanks and is vested in flow of liquid in the near vicinity of the structure.

11. An offshore structure according to claim **1** in which the compartments are effective to lower the structure to the bottom.

12. An offshore structure according to claim **1** in which the compartments are effective to raise the structure from the bottom.

13. An offshore structure according to claim **1** in which the compartments are proportioned to carry the structure upwards from the bottom with a moderate force, and air spilled from the compartments will make a path for the structure to follow in upward motion.

14. An offshore structure according to claim **1** in which the compartments are proportioned to carry the structure upwards from the bottom with a moderate force but are also designed to expell a quantity of air or water in a sudden burst which will cause the structure to be jarred loose from contact with the sea bottom.

15. An offshore structure according to claim **1** in which the compartments are effective to carry the structure upwards and air expelled from the compartments is captured under the main roof and retained there to bring the structure to an intermediate position of buoyancy.

16. An offshore structure according to claim **15** in which excess air below a certain point under the roof is released through a vent pipe.

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