

[54] UNDERWATER STORAGE DEVICE

[72] Inventor: Charles M. Hix, Jr., Bryan, Tex.
[73] Assignee: Arcadia Refining Company, Tyler, Tex.
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Primary Examiner—Peter M. Caun
Attorney—Lane, Aitken, Dunner & Ziems

[52] U.S. Cl.....61/.5
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[58] Field of Search 61/0.5, 46, 1 F, 46.5

[57] ABSTRACT

An underwater storage device for storing fluids lighter than water wherein a tank is formed of a cylindrical wall having a top closure and an open bottom so that the fluids will enter into the tank and pass upwards toward the top closure. The tank is adapted to be positioned in the water without any rigid restraints.

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8 Claims, 6 Drawing Figures

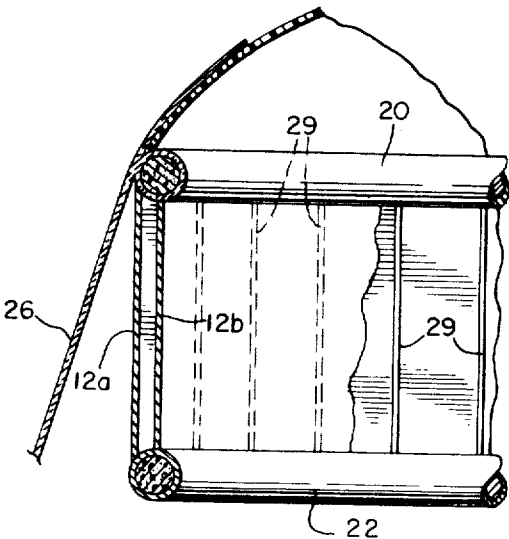


FIG. 1.

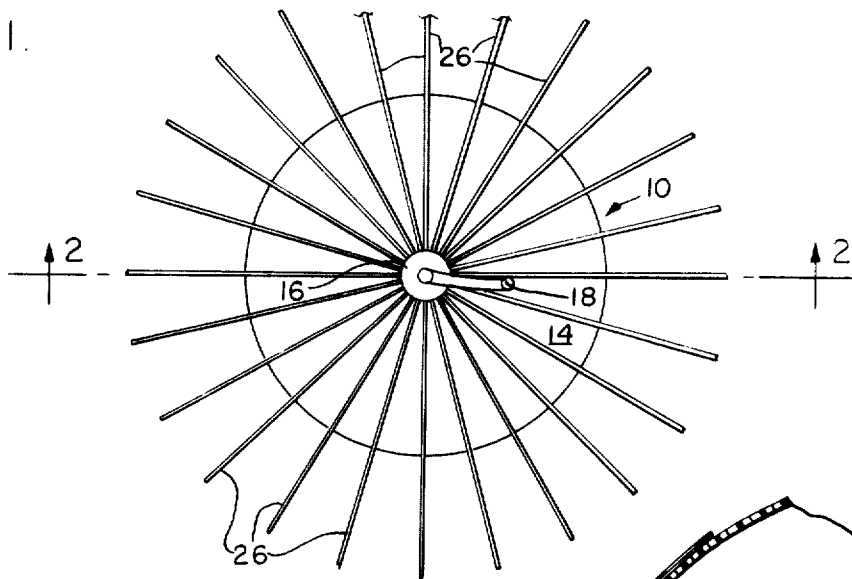


FIG. 3.

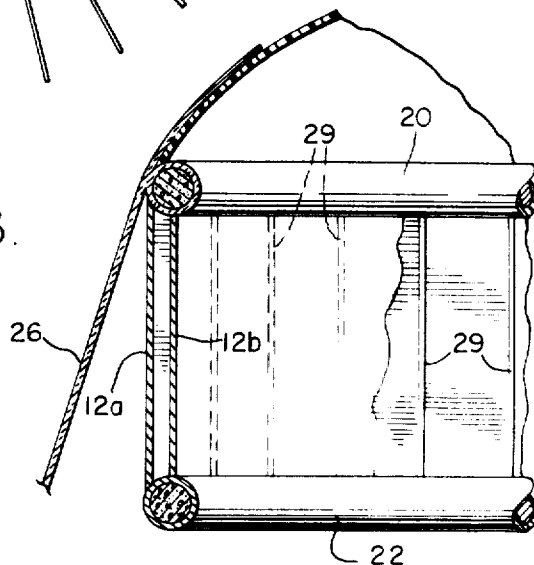
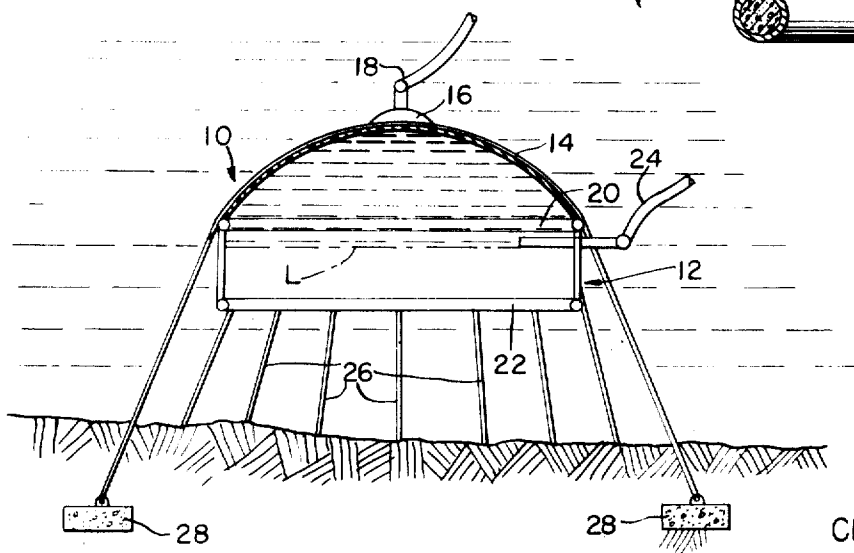


FIG. 2.



INVENTOR

CHARLES M. HIX, Jr

BY *Lane, Aitken, Dunner & Zieme*
ATTORNEYS

FIG. 4.

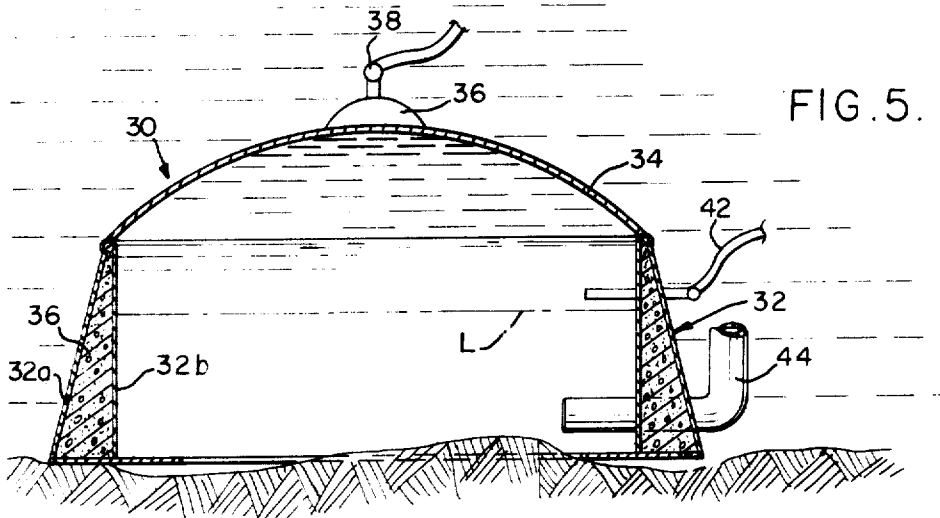
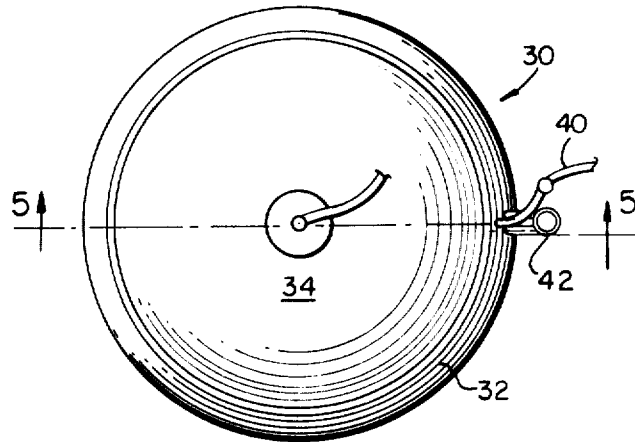


FIG. 5.

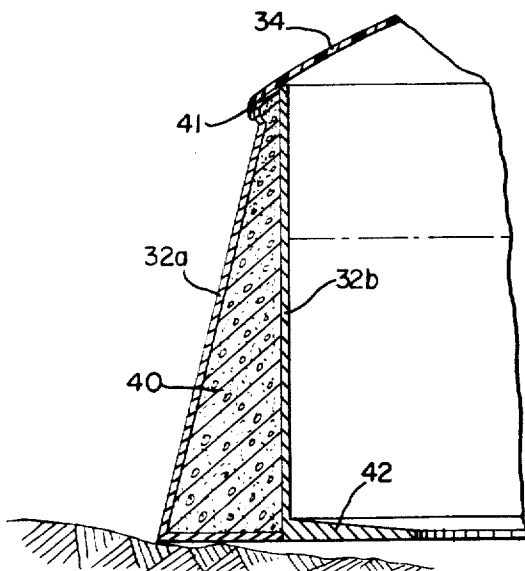


FIG. 6.

INVENTOR
CHARLES M. HIX, Jr.

BY *Lane, Aitken, Dunner & Zieme*
ATTORNEYS

UNDERWATER STORAGE DEVICE

BACKGROUND OF THE INVENTION

This invention relates to an underwater storage device and, more particularly, to such a device for storing fluids lighter than water.

Several proposals have been made for underwater storage of fluids, such as petroleum products. Some of these proposals utilize a structure rigidly anchored to the water bed. However, earthquakes and similar disturbances cause not only displacements of the earth, but create water waves of substantial magnitude which render any rigidly anchored structure susceptible to complete failure.

Also since some known types of underwater storage devices are extremely heavy and cumbersome to transport, they must be constructed on site, which substantially increases the difficulties and cost of assembly.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an underwater storage device which is not susceptible to damages resulting from earthquakes or high waves, and which may be easily transported to the desired location.

Toward the fulfillment of these objects, the underwater storage device of the present invention comprises an open bottomed tank formed of a generally cylindrical wall, a top closure member sealingly connected to the wall, and fluid outlet means extending through the top portion of the tank. The tank may rest on the bottom surface of the body of water or may be horizontally suspended at a predetermined height in the water by means of cables and anchors.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying drawings for a better understanding of the nature and objects of the present invention. The drawings illustrate the best mode presently contemplated for carrying out the objects of the invention and are not to be construed as restrictions or limitations on its scope.

In the drawings:

FIG. 1 is a plan view of the underwater storage device of the present invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged partial sectional view of the device of FIGS. 1 and 2;

FIG. 4 is a plan view depicting another embodiment of the device of the present invention;

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 4; and

FIG. 6 is an enlarged partial sectional view of the device of FIGS. 4 and 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring specifically to the embodiment of FIGS. 1-3, the reference numeral 10 refers in general to a tank formed of a generally cylindrical wall 12, and a flexible dome 14 enclosing the top of the wall. A rigid top portion 16 is fixed to the central portion of the dome 14, and receives an outlet connection 18 which extends through it and the dome 14, to enable petroleum products, such as oil, stored in the tank 10 to be withdrawn.

A pair of solid compression rings 20 and 22 are formed at the ends of the wall 12 in order to resist compressive stresses that occur, and to add stability to the tank. An inlet connection 24 is provided for the introduction of the oil into the tank.

A plurality of flexible cables 26 are attached to the top portion 16 and extend along the flexible dome 14 and outwardly from the tank 10 whereby they are connected to a plurality of anchors 28 embedded in the water bed. Alternatively, instead of embedded anchors, dead weight anchors or piles driven in the ocean floor may be used. Anchors are preferable because piles may not be able to resist the forces applied thereto.

As better shown in FIG. 3, the wall 12 is formed of a pair of cylindrical sheets 12a and 12b which are spaced apart, and which are divided into a series of vertical watertight buoyant chambers by a plurality of partitions 29 extending around the circumference of the wall at spaced intervals. In this manner, the chambers thus formed not only permit the tank 10 to float in water without oil stored in the tank, but increase the section modulus of the wall 12.

The oil to be stored in the tank is admitted through the inlet connection 24, and since it is lighter than water, it will rise towards the top of the flexible dome 14 whereby it can be withdrawn through the outlet connection 18. The open bottom provided in the cylindrical wall 12 permits water to enter the lower portion of the tank, and any additional oil in the vicinity of the open bottom will pass therethrough and gravitate upwards in the tank in the same manner as discussed above. An interface between the oil and water will thus occur along a line within the tank such as shown by the line L in FIG. 2. The oil stored in the tank will add to the buoyancy of the tank increasing the tension in the cables 26.

In the embodiment of FIGS. 4-6, a tank 30 is provided which consists of a cylindrical wall portion 32 and a flexible dome 34. As in the previous embodiment a rigid top portion 36 is fixed to the flexible dome 34, and an outlet connection 38 is provided which extends through the dome 34 and the top section 36 to permit withdrawal of oil from the tank. The tank is not fixed to the sea bed but merely rests on the sea bed maintained in place substantially only by gravity.

As better shown in FIG. 6, the wall portion 32 is formed by a pair of cylindrical sheets 32a and 32b, with the sheet 32a extending at an angle with respect to the sheet 32b. These sheets are spaced apart as shown to provide a form for casting concrete, shown by the reference numeral 40. The sheets define an enlarged portion 41 at the top of the cylindrical wall, which functions as a compression ring to resist the compressive forces applied at this point as a result of the buoyant force of the oil on the dome 34. The bottom end of the tank 30 is open, and a rigid fiberglass skirt 42 is provided to cut off the flow of water around the bottom to prevent scour. An inlet connection 42 for the introduction of the oil to be stored is provided through the wall 32, and since the tank normally rests on the bottom of the water bed, an inlet connection 44 is provided through the wall for the introduction of water into the bottom portion of the tank 30.

Thus as shown in FIG. 5, the oil will gravitate to the upper portion of the tank and the interface between it and the water will lie somewhere within the tank as shown, for example, by the line L.

Thus since the apparatus of the embodiment of FIGS. 1-3 and the embodiment of FIGS. 4-6 is not rigidly attached to the bed of the water, it therefore is not susceptible to damage by earth displacements as well as water waves, etc. Preferably in both of the above described embodiments, the flexible domes 14 and 34 are made of neoprene reinforced with fiberglass and the rigid top portions 16 and 36 are made of a fiberglass reinforced polyester. In the embodiment of FIGS. 1-3, the wall sheets 12a and 12b are also preferably made of a fiberglass reinforced polyester and the rings 22 preferably comprise concrete cores enclosed in fiberglass reinforced polyester sheets. In the embodiment of FIGS. 4-6, the sheets 32a and 32b are preferably made of fiberglass.

The structure of the present invention as described above can be constructed onshore and would still be light enough to be floated to the site and lowered to the water bed either by adding weight to, or by positioning anchors around, the structure. In the case of the embodiment of FIGS. 4-6, the concrete formed between the walls could be poured on site, which also facilitates transfer and assembly.

Several variations may be made in the foregoing without departing from the basic scope of the invention. For example, the size and shape of the tank form may vary in accordance with particular requirements. In this regard, if the water is shallow, a long horizontal cylindrical tank with a flat dome may serve best, whereby, in deep water a tall vertical cylindri-

cal wall with a spherical or ellipsoidal top may be more desirable. Instead of using a flexible dome top, the dome may be rigid. Instead of the tanks being open at the bottom, they may be closed with a membrane. When a membrane is used to close the bottom of the tank, the bottom portion of the tank will still contain seawater so that an oil-water interface defines the bottom surface of the stored oil. Whether the bottom of the tank in the embodiments of FIGS. 4-6 is open or closed with a membrane, its construction is such that irregularities in the sea bed can protrude up inside of the cylindrical sidewall past the bottom edge thereof.

Of course, other variations of the specific construction and arrangement of the invention disclosed above can be made by those skilled in the art without departing from the invention as defined in the appended claims.

What is claimed is:

1. An underwater storage system for storing fluid lighter than water comprising a tank including a flexible dome-shaped top, and a compression ring fixed to said dome-shaped top and extending around the periphery of said dome-shaped top, means positioning said tank completely underwater in a surrounding body of water buoyantly suspending said tank from the bed of said surrounding body of water, the bottom of said tank being formed to provide fluid communication between surrounding water and the inside of said tank so that an interface is formed in said tank between the body of fluid stored in said tank and the water in which said tank is suspended whereby changing the amount of stored fluid in said tank will displace said interface in said tank, said compression ring being placed in and resisting compressive stress applied by the buoyant force of the lighter than water fluid stored in said tank transmitted to said compression ring by

said flexible dome-shaped top.

2. An underwater storage system as recited in claim 1 wherein said tank includes a cylindrical sidewall fixed to said compression ring extending downwardly from said compression ring and sealed to said dome-shaped top.

3. An underwater storage system as recited in claim 2 wherein a second compression ring is fixed to the bottom of said cylindrical sidewall.

4. An underwater storage system as recited in claim 2 wherein said cylindrical sidewall includes an outer cylindrical rigid wall member and an inner cylindrical rigid wall member defining a hollow water tight space therebetween, whereby said tank is buoyant in water without any fluid lighter than water stored therein.

5. An underwater storage system as recited in claim 1 wherein said means for buoyantly suspending said tank comprises a plurality of cables fixed at one end to the top of said dome-shaped top and held at the other end at the bed of the body of water in which said tank is located.

6. An underwater storage system as recited in claim 5 wherein said cables are held at said bed by anchors.

7. An underwater storage system for storing fluid lighter than water comprising a tank having a flexible dome-shaped top, and means for buoyantly suspending said tank completely under water comprising cables each extending to and fixed at one end to the top of said dome-shaped top and extending to and held at the other end at the bed of the body of water in which said tank is located.

8. An underwater storage system as recited in claim 7 wherein anchors hold said cables at said bed.

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