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BUOY WITH BUOYANCY PRODUCED BY LIQUEFIED GAS VAPORIZATION

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Fig. II

Fig. 1

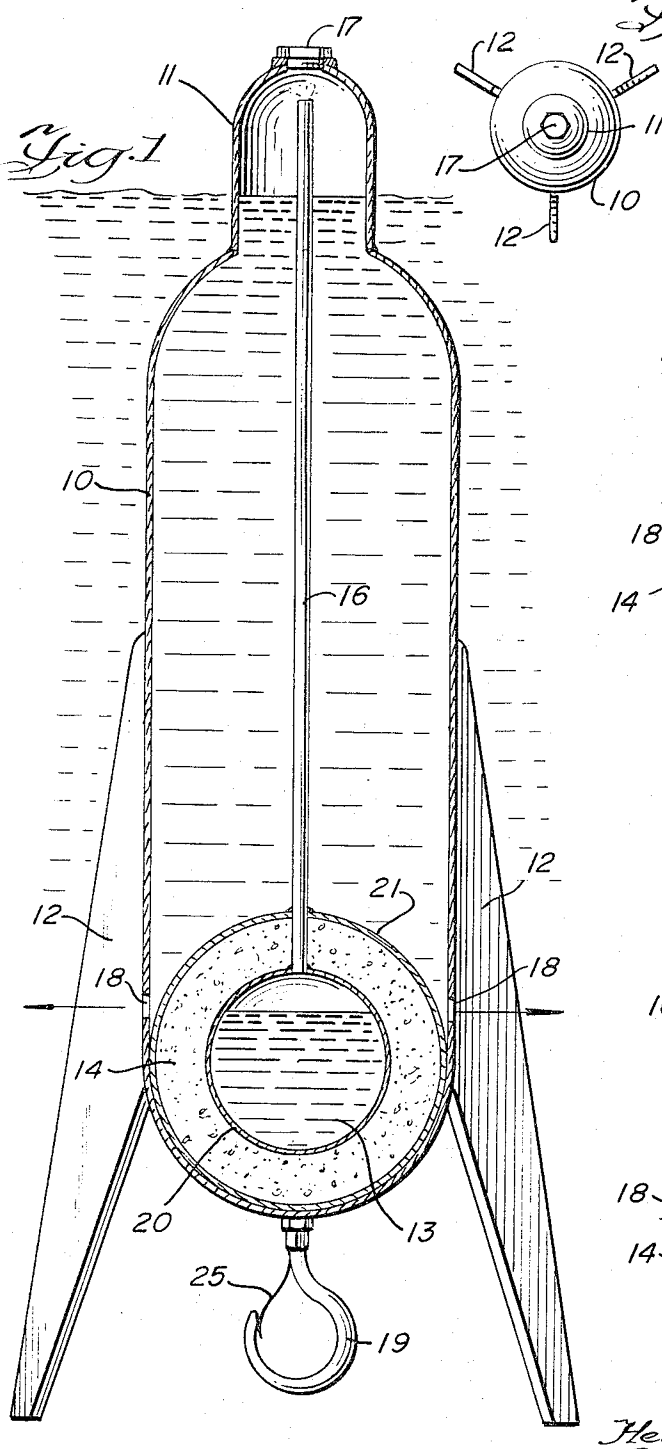


Fig. 2

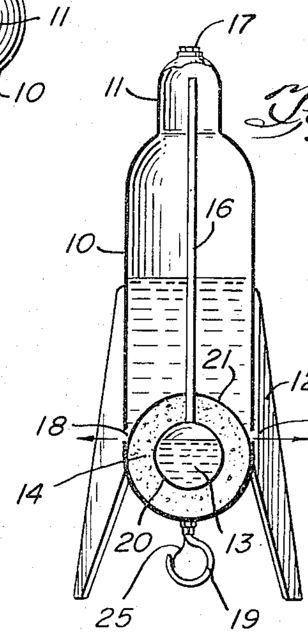
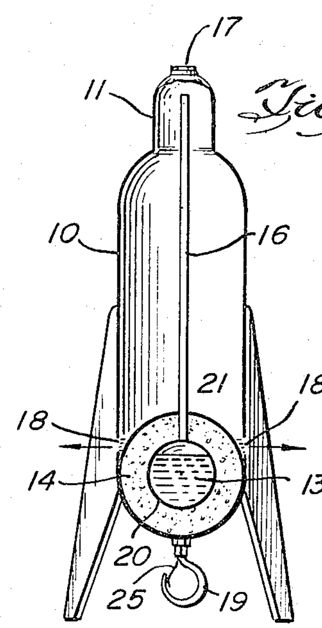


Fig. 3



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BUOY WITH BUOYANCY PRODUCED BY LIQUEFIED GAS VAPORIZATION

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ABSTRACT OF THE DISCLOSURE

Provided is a buoy which can be used to develop buoyancy in water. The buoy comprises a shell which may be either rigid or non-rigid and which is stabilized to maintain an upright position in water. A chamber associated with the shell for holding a liquefied gas, means for delivering vaporized gas from the chamber to the interior of the shell, and port means on the shell through which ballast and water in the shell is expelled to the surrounding body of water as the ballast water is displaced by expanding gas received from the chamber.

This invention relates to apparatus for achieving buoyancy in water. More particularly, this invention is concerned with a buoy-type vehicle for supporting objects at least partially submerged or totally submerged in water. In addition, the invention is concerned with a buoy which can descend to great depths in a body of water and then return upwardly, such as to the surface of the water, without extraneous assistance.

In the past, buoyancy problems in water were fairly simple and were satisfactorily handled by means of hollow vessels which could withstand the rather moderate pressures of water down to depths of about 200 to 300 feet. In more recent times, the seas have been penetrated to far greater depths, and the farther down an object goes, the more difficult it becomes to maintain buoyancy and withstand the pressures involved. As a result, handling and retrieving of equipment has become more complicated. Furthermore, vessels for buoyancy at the great depths must generally be so heavy to achieve the needed strength as to be costly to make and transport, as well as being difficult to handle satisfactorily.

One solution to the buoyancy problem was employed by Piccard in his bathyscaph in which he employed gasoline in a rather thin-walled vessel to obtain buoyancy control. The gasoline was lighter than water and only a thin-walled vessel was required to contain the gasoline because the internal pressure balanced the external pressure. Gasoline, however, is a flammable liquid and thus is dangerous to employ in routine operations. Also, the difference in densities between water and gasoline is a limiting factor on this method of achieving buoyancy.

Compressed gas in bottles or used in various types of pumping systems also have been employed but such methods are of low efficiency at depths beyond a few hundred feet.

According to the present invention, there is provided a buoy or vehicle for achieving buoyancy in water and a method of using such a buoy to support an object in water. The buoy provided by this invention achieves buoyancy by the conversion of a liquefied gas to the vapor or gaseous state, particularly through heat transfer from the surrounding water and the liquefied gas.

This buoy, which can be used in a body of water, such as an ocean, lake or river, to develop buoyancy comprises a rigid or non-rigid shell, advisably stabilized to maintain an upright position in water, a chamber associated with the shell for holding a liquefied gas, means for delivering vaporized gas from the chamber to the interior of the shell, and port means on the shell through which ballast water in the shell is expelled to the surrounding body of water as the ballast water is displaced by expanding gas received from the chamber.

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

FIGURE 1 is a vertical section through a buoy provided by this invention, showing the inside of the shell full of water;

FIGURE 2 is a vertical section on a reduced scale, similar to FIG. 1 except that part of the water in the shell has been displaced by vaporized gas from the liquefied gas contained in the chamber;

FIGURE 3 is similar to FIG. 2 except that essentially all of the water in the shell of the buoy has been expelled by displacement by gas generated by vaporization of the liquefied gas in the chamber through heat exchange with the surrounding water; and

FIGURE 4 is a plan view of the vehicle as shown in FIGS. 1 to 3.

In each of the figures of the drawing, the same reference numbers will be used for similar parts.

In FIGS. 1 to 4, it will be seen that the buoy is comprised of a shell **10** shown as rigid in the drawing. The shell can be rigid and made of any suitable material, particularly metal or plastic, including plastic reinforced with glass fibers, or it can be nonrigid such as a balloon, which is expansible or nonexpansible, made of rubber, polyethylene, water-proof cloth or other suitable material. The upper portion of the shell has a rounded nose **11** of somewhat reduced diameter compared to the shell **10**. Both the nose **11** and the shell **10** are of generally cylindrical shape and axially positioned to each other. Fins **12** are provided on the lower portion of the shell to stabilize the buoy and maintain it in a more or less vertical position when it is descending in water or is being raised by buoyancy developed through vaporization of the liquefied gas as will be further explained subsequently. Fins of a symmetrical shape with respect to the buoy shell can be used, if desired, or if the buoy is properly ballasted, the fins can be eliminated completely. The number of fins provided can be varied as desired although three vertical fins equally spaced about the periphery of the shell are suitable. The fins desirably extent below the bottom of the shell to provide a stand means for supporting the buoy upright on a load-bearing surface. Inside of shell **10**, in the bottom portion thereof, is located enclosed chamber **13** shown here as formed by hollow spherical member **20**. The chamber can be surrounded with insulation **14** around sphere **20** and the insulation coated or further surrounded with an appropriate shell or membrane **21** to keep water or other liquids from coming in direct contact with the insulation. Instead of placing insulation around sphere **20**, a surrounding shell may be used and the space between it and sphere **20** evacuated, thus forming a vessel in the nature of a DeWar flask. Alternatively, an evacuated area containing insulating material can be used to retard heat transfer. Leading from chamber **13** is conduit **16** which conveys gas vapor from the chamber to the upper inside area of the buoy.

On the top of nose **11** is provided cap **17** which can be removed and replaced in a water-tight manner to seal an orifice leading inside the nose. Instead of a cap **17**, a suitable valve may be used. Positioned about the periphery of shell **10**, along the lower part thereof, are ports **18** which provide passages between the inside of the shell and the outside. On the bottom of the buoy is attached a hook **19** having spring **25** to prevent accidental unhooking. The hook can be used for attaching a payload to the buoy in order that the buoyancy developed by the buoy can be used to perform a useful task, such as raising an object upwardly in the sea.

In operating the buoy, cap **17** is first removed and by means of a long-stemmed funnel, a liquefied gas is poured into the chamber **13** until it is at least partially full. The filling funnel is then removed and cap **17** repositioned loosely in place. The buoy is then placed in water with the nose portion **11** projecting above the surface. Water ballast enters shell **10** through ports **18** and displaces at least part of the air in the buoy but desirably up to the water surface as shown in FIG. 1. Cap **17** is secured in a liquid-tight manner and the buoy will then partially sink or descend in the water according to the inherent weight of the buoy when ballasted with water. Unless heat exchange between the sea and the liquefied gas in the chamber **13** is regulated to be rapid, and the buoy is adequately ballasted with water, the buoy will sink to a great depth before buoyancy is developed sufficiently to overcome the downward force of the buoy due to its inherent weight in water. Since most seas are at least 40° F. or higher, there is sufficient latent heat in the sea to effect heat transfer with the liquefied gas and vaporize it. The resulting vapor is conveyed by pipe **16** up into the inside of nose portion **11**. The vapor volume continues to increase as heat exchange continues, thereby causing displacement of water from shell **10**. As shown in FIG. 2, water has been displaced from approximately one-half of the inside of the shell, while in FIG. 3 essentially all the water has been expelled from inside shell **10** through ports **18** leaving the interior of the shell **10** full of vaporized gas. By displacing the water from shell **10**, the buoy has achieved buoyancy equal to the amount of water displaced. Accordingly, the buoy can raise a total load approximately up to the amount of buoyancy generated by displacement of the water from the inside shell **10**.

The liquefied gas used in the buoy is to a considerable extent a matter of choice since a number of liquefied gases can be employed, including liquid nitrogen, liquid hydrogen, liquid propane, liquid butane, liquid helium and liquid oxygen. The rare gases, such as argon and neon are generally not employed because of their expense. In general, those gases which when liquefied are considered cryogens constitute the most suitable group for obtaining the advantages of this invention. Presently, liquid nitrogen is the preferred liquid gas for use in the buoy. Since cryogens are considered the liquefied gases of choice, the buoy of this invention might properly be named a cryofloat when it obtains its buoyancy by vaporization of a liquid cryogen.

Oxygen can be used below water to sustain life of a human crew in a vessel and thereafter employed for effecting buoyancy in a buoy of this invention. Furthermore, propane or methane together with oxygen can be used for welding under water and thereafter used to obtain buoyancy.

Since the internal pressure on the buoy is in approximate balance with the external water pressure at all times, the shell **10** need only be a thin wall and can be rigid or non-rigid but capable of withstanding handling and the temperatures to which it is subjected. This is true even though water is expelled from the buoy by vaporized gas in creating buoyancy since the pressure of the vaporized gas is only slightly higher than the pressure of the sea at the location of the buoy below the surface at any particular time or at any particular place.

The buoy may be used as a conventional float for supporting submerged or partially submerged objects, as an undersea buoy for supporting instrumentation at a predetermined depth in the sea with whatever ancillary anchoring means is required, for transporting prospecting and mining equipment and tools to and from the bottom of a sea and also for rescue operations.

The invention also provides a method for raising objects from below the surface of a water body. The float or buoy of this invention will sink by gravity to a great depth, such as to an ocean floor, where it can be connected to a submerged object. The object, thus, becomes a payload cargo to be raised toward the water surface. Through heat exchange, the buoyancy of the buoy increases as already described and lifts itself and the cargo object upwardly. The sea water in the buoy can be considered as the ballast. On the way down, the float contains a small volume of liquefied gas and a large volume of water ballast. On the way up, the buoy rises because it contains a large volume of vaporized gas and little, if any, water ballast.

The speed at which buoyancy is developed in the buoy, at or over any portion of its mission, is regulated by controlling the heat exchange rate. This can be done by adjusting the amount of insulation or evacuated area around the chamber containing the liquefied gas. For rapid heat exchange the insulation can be eliminated completely. Also, it is feasible to provide an auxiliary heater operated by electric storage batteries or by combustion of a carbonaceous fuel, such as liquid propane, to speed vaporization of the liquefied gas in chamber **13**. In addition, the ascent of the buoy can be controlled by suitable positioning of the outlet ports **18**. Also, by varying or adjusting the position of the ports, a predetermined limit can be imposed upon the buoyancy of the buoy by restricting the amount of gas retained in the shell **10**. The rate of ascent can be regulated in this way as can the total buoyancy be controlled to hover the buoy at a specific depth below the surface.

The buoy is so constructed that it is capable of floating upright in water when the water ballast is low. This permits charging of the buoy with liquefied gas while the buoy is floating. Thereafter, it can be flooded internally with ballast water for descent into the water.

Additional buoyancy is achieved by the accumulation of ice on the buoy exterior because of the low temperature at which the liquefied gas is stored and vaporized.

Various changes and modifications of the invention can be made and, to the extent that such variations incorporate the spirit of this invention, they are intended to be included within the scope of the appended claims.

What is claimed is:

1. A buoy for use in the sea to develop buoyancy comprising a shell stabilized to maintain an upright position in water, a chamber associated with the shell for holding a liquefied gas, means for delivering vaporized gas from the chamber to the interior of the shell and port means on the shell through which water in the shell is expelled to the sea as it is displaced by expanding gas received from the chamber.

2. A buoy for use in the sea to develop buoyancy comprising a rigid shell stabilized to maintain an upright position in water, a chamber in the shell for holding a liquefied gas for heat exchange relationship with the sea when submerged, means for delivering gas generated in the chamber to the interior of the shell, and port means near the lower part of the shell through which water in the shell is expelled to the sea as it is displaced by expanding gas received from the chamber.

3. A buoy according to claim **1** in which the chamber is provided with means to retard heat transfer from outside to inside the chamber.

4. A buoy according to claim **2** in which the chamber is insulated to retard heat transfer from outside to inside the chamber.

5. A buoy according to claim **1** in which the chamber is surrounded by an evacuated area to retard heat transfer from outside to inside the chamber.

6. A buoy for use in the sea to develop buoyancy comprising a rigid cylindrical shell having a rounded upper nose portion and stabilizing fins on the lower portion, a chamber in the shell positioned in the lower part thereof for holding a liquefied gas for heat exchange relationship with the sea when the buoy is submerged, a conduit from the chamber to the upper inner part of the shell for delivering vaporized gas generated in the chamber to the interior of the shell, port means near the lower part of the shell through which water in the shell is expelled to the sea as it is displaced by expanding gas received from the chamber.

7. A buoy according to claim **6** in which the chamber is provided with means to retard heat transfer from outside to inside the chamber.

8. A buoy according to claim **1** in which the shell is rigid and the chamber is provided with means to retard heat transfer from outside to inside the chamber.

9. A buoy for use in the sea to develop buoyancy comprising:

a rigid cylindrical shell having a rounded upper nose portion and stabilizing fins on the lower portion;

a spherical chamber postioned in the lower portion of the shell for holding a liquefied gas for heat exchange relationship with the sea when the buoy is submerged;

insulation around the spherical chamber to retard heat transfer from outside to inside the chamber;

a conduit running from the chamber to the upper inner nose part of the shell for delivering vaporized gas generated in the chamber to the interior of the upper nose portion of the shell;

port means near the lowermost part of the shell through which water in the shell is expelled to the sea as it is displaced by vaporized gas received from the chamber;

and a removable and replaceable cap sealing an orifice in the nose portion which permits liquefied gas to be poured therethrough, when the cap is removed, into the conduit for filling the chamber.

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