

United States Patent

Davidson et al.

[15] 3,659,299

[45] May 2, 1972

[54] VARIABLE DISPLACEMENT RECOVERY DEVICES

[72] Inventors: William M. Davidson; Howard W. Cole,
Jr., both of Mountain Lakes, N.J.

[73] Assignee: Proteus, Inc., Mountain Lakes, N.J.

[22] Filed: Dec. 29, 1969

[21] Appl. No.: 888,345

[52] U.S. Cl.9/8 R, 114/54

[51] Int. Cl.B63c 11/00, B63c 7/00

[58] Field of Search.....9/8 R, 9; 114/54, 53, 16.3

[56] References Cited

UNITED STATES PATENTS

2,451,002 10/1948 Sturteuant114/54
2,635,574 4/1953 Sturteuant114/54

3,372,996 3/1968 Barrett et al.....114/53
3,471,877 10/1969 Bayles.....9/8

Primary Examiner—Milton Buchler

Assistant Examiner—Gregory W. O'Connor

[57] ABSTRACT

This invention provides controlled buoyancy at depth displacement of water. The apparatus includes an expansible lift bag, a gas source, with a gas delivery device connecting the gas source with the lift bag. A valve controls the supply of gas from the source, while another valve vents gas from the lift bag. Both valves are controlled by ascent velocity sensing devices controlling the supply and vent valves in sequence either to regulate ascent velocity or to suspend a load at depth. An outer container is provided for packing all components and for attachment of loads.

8 Claims, 6 Drawing Figures

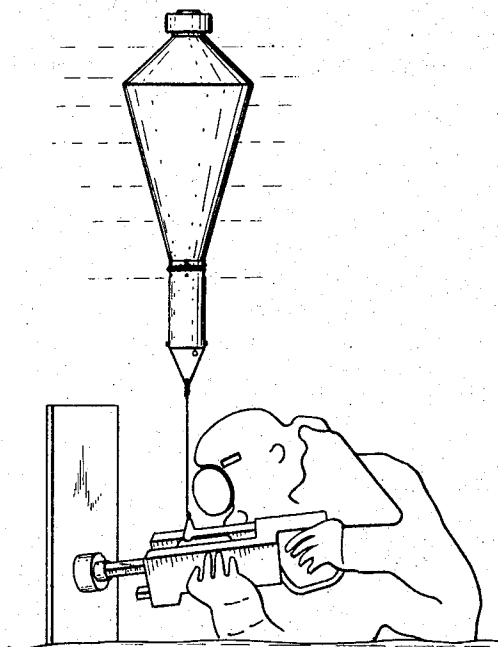


FIG. 3D.

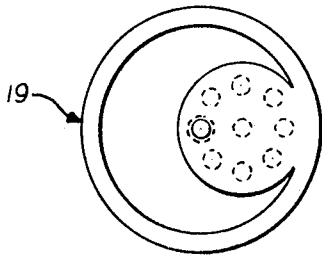


FIG. 3B.

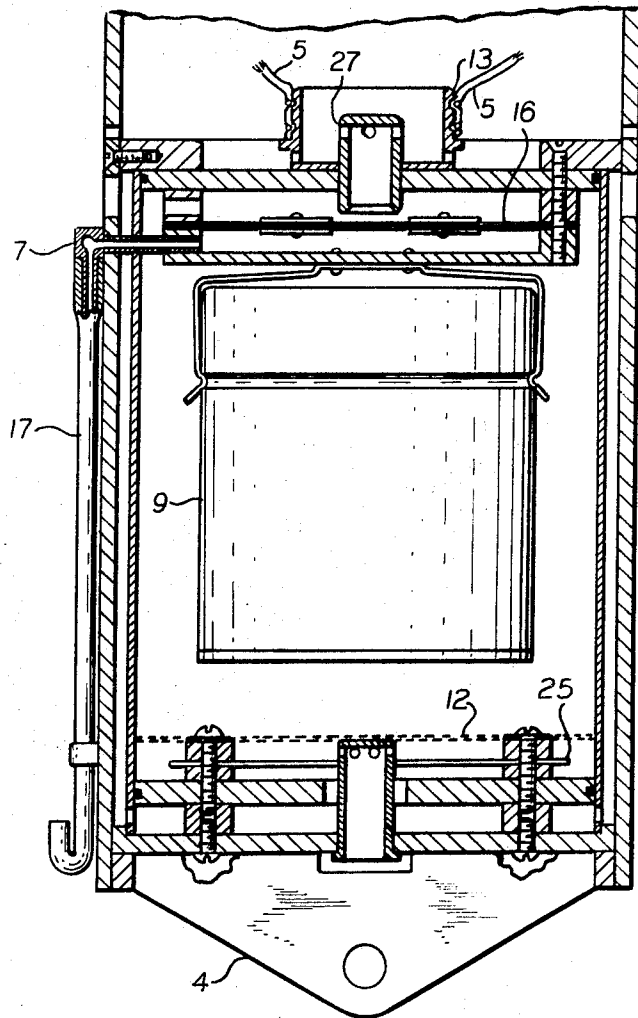
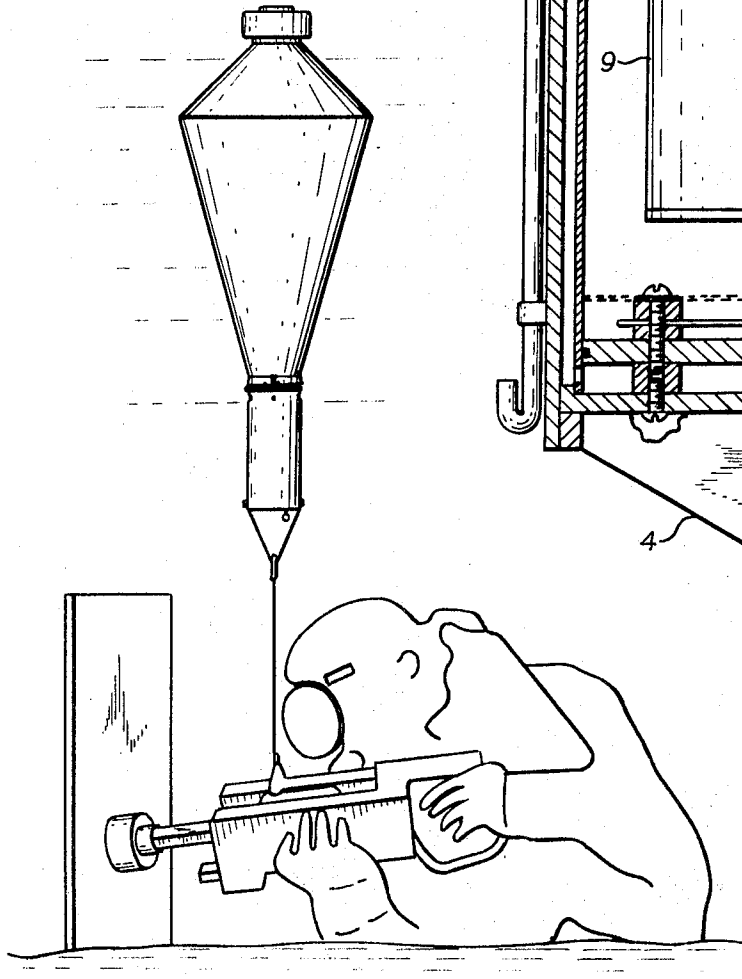


FIG. I.

INVENTORS
WILLIAM M. DAVIDSON
HOWARD W. COLE, JR.

FIG. 3A.

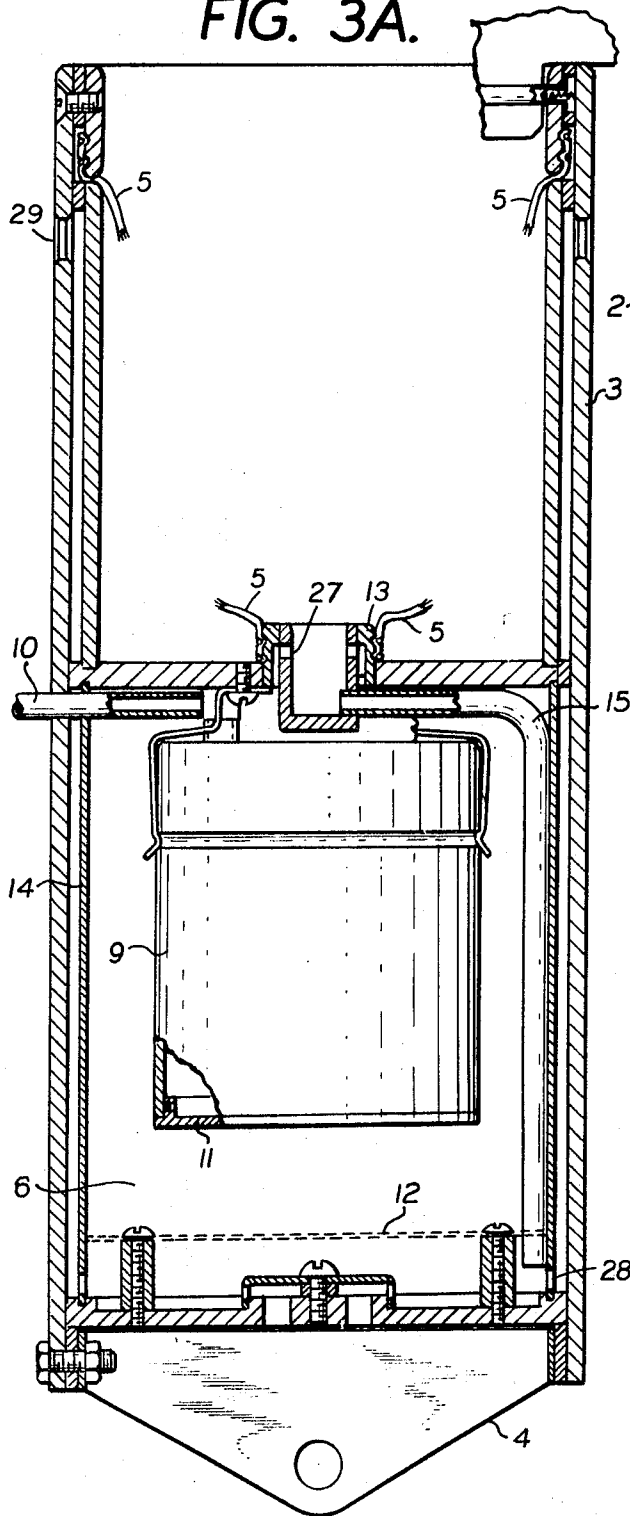


FIG. 3C.

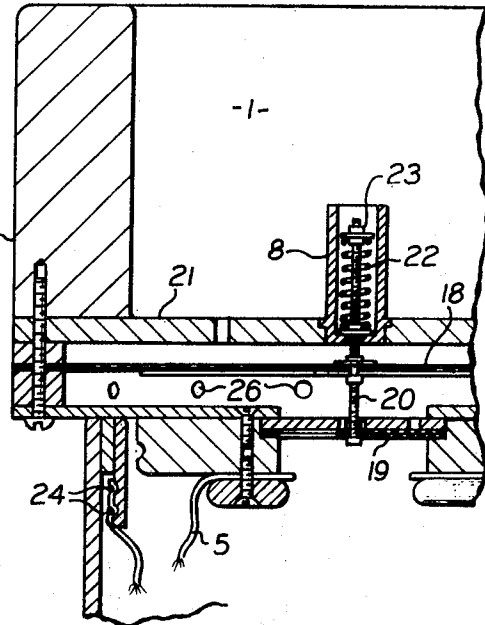
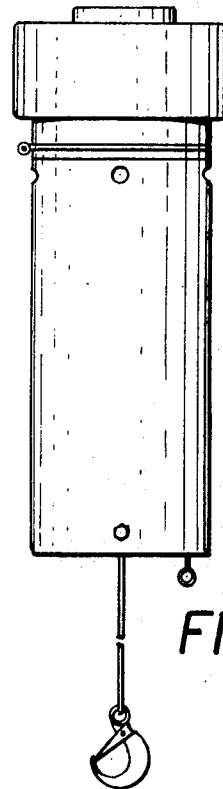


FIG. 2.

INVENTORS
WILLIAM M. DAVIDSON
HOWARD W. COLE, JR.

VARIABLE DISPLACEMENT RECOVERY DEVICES

This invention relates to an inflatable flotation device useful for lifting, transporting, suspending or recovering submerged loads, such as, instruments, tools, markers, lights and other equipment.

The flotation device described herein comprises a cylindrical container enclosing an inflatable lift bag, a chemical gas generator and controls for operation of the device. The lower end of the inflatable bag is fixed inside of the container to the outlet of the gas generator, while the upper end of the inflatable bag is fixed to the inside of the upper cover, which may be a fixed float. Gas generating means, preferably made up of a solid chemical compound reactive upon contact with water to generate a gas, such as hydrogen gas, is provided within the container adjacent to the lower cover. The container is free flooding and when the gas generating means is activated to expose said chemical compound, such as a hydride of a metal selected from the group consisting of a lithium, sodium, calcium, potassium and aluminum and mixtures thereof, to contact with water, the resulting generated gas releases the top cover from the container and deploys the bag which is then inflated by the gas and thereby displaces water surrounding the inflatable bag so as to lift the submerged object to which the device is attached.

This invention further relates to floatation devices and elements and compositions useful therefor. In accordance with one embodiment this invention relates to a light-weight, readily transportable flotation device useful for divers for attachment to a submerged load for lifting, transporting, suspending or recovering the same when the device is actuated. In accordance with another embodiment this invention is directed to a method of inducing water to flow into and through the reaction zone of the generator for purposes of completing the reaction and to remove heat as well as reactants, such as the hydroxide of the metal fuel, on a continuous basis by thermo-syphon action.

In accordance with another embodiment this invention is directed to chemical compositions capable of reacting upon contact with water, including sea water, to generate a gas, such as hydrogen gas, and in addition are capable of controlled reactivity such that the rate of gas generation can be controlled at any desired rate including stopping and restarting the reaction.

In accordance with yet another embodiment this invention is directed to a method of stopping and starting the gas generator as a function of the vertical velocity of the elevator device.

In accordance with another embodiment this invention is directed to a method of venting the inflatable bag as a function of the vertical velocity of the elevator device.

In accordance with yet another embodiment this invention is directed to a method of controlling rate of ascent of the elevator device and load, suspending a load or cycling the load up and down by means of the said velocity controls, used individually or in combination.

In accordance with another embodiment this invention is directed toward a compact, light-weight, simple elevator device for lifting, transporting or suspending submerged loads where a compressed gas bottle and suitable regulator are incorporated in the container with the inflatable lift bag in substitution for the chemical gas generator.

Flotation or recovery devices employed heretofore for lifting submerged loads have, for the most part, been ineffective or too heavy, cumbersome and complicated in operation or structure and expensive to manufacture. Alternatively, the simple diver bag used for lifting by inflating with compressed air or exhaled breathing air is often unsafe to use because of the runaway ascent produced by gas expansion during ascent of the load. A heavy, bulky or cumbersome lift system is undesirable for diver use.

Accordingly, it is an object of this invention to provide a simple, effective, readily transportable lift device for elevating, transporting, suspending or recovering submerged loads. It is another object of this invention to provide a light-weight,

substantially foolproof system and compositions useful in association therewith for diver use in lifting, transporting, suspending or recovering submerged loads.

It is also an object of this invention to provide a means for controlling rate of ascent, suspending a load or cycling the load up and down either by means of manual control or automatically by means of velocity controls.

In at least one embodiment of this invention at least one of the foregoing objects will be achieved.

How these and other objects of this invention are achieved will become apparent in the light of the accompanying disclosure and drawings wherein:

FIG. 1 illustrates schematically one use of the elevator device in accordance with this invention for supporting a tool at an underwater work site.

FIG. 2 is an outline view of the elevator device showing the closed or packaged configuration in the non-operating condition prior to activation of the gas generator.

FIGS. 3, B, and C show three vertical cross-section views of the elevator device including details of the gas generator and controls

FIG. 3D shows a plain view of a diaphragm in the velocity sensing control.

The elevator device in accordance with this invention is characterized by certain features which make it useful for a wide variety of applications. For example, since the device is simple, compact and relatively light-weight, it can be readily transported and delivered to the worksite for use. Further, since the elevator device when submerged exhibits substantially neutral buoyancy it can be readily employed by a diver or sent to the bottom on a down-line for either standby use or for attachment to a load to be elevated. If desired, the buoyancy of the elevator device, by suitable adjustment, such as by changing the amount of buoyant materials therein, can be modified to exhibit a positive or a negative buoyancy when submerged. In addition, the elevator device in accordance with one embodiment of this invention can be used to lift any load, up to its full rated lift capacity, without exceeding the desired preset rate of ascent.

FIG. 1 illustrates an operation wherein an elevator device in accordance with this invention is attached to a tool, such as an underwater wrench, and used for the purpose of suspending the tool so that the diver can concentrate on operating the tool rather than on supporting the weight of the tool.

FIG. 2 illustrates a fixed flotation collar at the top of the device and a pull ring extending from the lower extremity of the container that may be used for activating the gas generator.

FIG. 3 illustrates the detail components contained within one embodiment of this invention; the elevator device, generally referred to by numeral 1, comprises a top cover or fixed float collar 2, a cylindrical container 3, a bottom cover and load support bracket 4, an inflatable lift bag 5, a chemical gas generator 6, a velocity control 7 for the gas generator, and a velocity control 8 for venting inflatable lift bag 5. Fuel cartridge 9 contains a chemical compound, such as hydride fuel, which upon contact with water generates a gas, in this case hydrogen gas. Hydraulic line 10, which is connected to fuel cartridge 9, is used to apply a small differential pressure inside fuel cartridge 9 for the purpose of removing cover 11 to expose the fuel and thereby activate the gas generator. Hydraulic line 10 may be used as an alternate to the manual pull ring method illustrated in FIG. 1. When cover 11 is removed, fuel from inside of cartridge 9 is free to fall onto open-wire grate 12 where it can react with water that fills generator 6. The generator gas rises and passes around fuel cartridge 9 and into the open bottom end of lift bag 5 through port 13. Reaction of the fuel with water generates heat in addition to gas. Most of the heat is absorbed directly by the water and is conducted thereby to sleeve 14 made of a material having high heat conductivity, such as aluminum. Sleeve 14 transfers heat to the water occupying the annular space between sleeve 14 and container body 3. This annular space, referred to herein as a

"chimney" is connected to the reaction zone of gas generator 6 by means of radial holes 28 at the bottom and is vented to ambient water pressure by another set of radial holes 29 at the top through container body 3. Bottom cover 4 has holes located near its center that connect the reaction zone of gas generator 6 to ambient water pressure at the bottom.

In operation, upon submergence of elevator device 1, all internal volumes flood freely with water. Activation is initiated by command, either remotely or directly by manual means, such as by applying a small positive pressure differential, for example by mouth or with a squeeze bulb, to line 10. Removal of lid 11 and initiation of the gas reaction is thereby accomplished as described above. The gas, being light, displaces water from the reaction zone of gas generator 6 working against a head of water (approx. 10-12 inches of water) produced by the "chimney" between its upper and lower vent holes. The gas pressure developed by this head is sufficient to release cover 2 from its attaching clamp or other retainer and to deploy the inflatable lift bag 5 from container body 3. Gas then continues to enter lift bag 5 through port 13. Port 13 contains an orifice 27 that controls the rate at which lift bag 5 is inflated. Port 13 also functions as a gas/water separator that allows water to flow by force of gravity back to the reaction zone of gas generator 6 through tube 15. When lift bag 5 has inflated fully, the back pressure will expel water from the reaction zone of generator 6 to below the level of grate 12, thereby stopping the gas generation. This condition will prevail as long as the pressure head of the "chimney" is balanced against the gas pressure inside the reaction zone of generator 6. While generator 6 is operating, the thermo-syphon action of the "chimney" will continually pump fresh water into the reaction zone of generator 6 and purge reactants (hydroxide) up through the "chimney" and out through the vent holes at the top.

The foregoing discussion illustrates how the elevator device regulates the rate of gas generation automatically without the need for valves or other control devices. FIG. 3B illustrates one method of using velocity controls to relates the rate of gas generation to the rate at which the elevator device ascends. Velocity control 7 consists of diaphragm 16, located under port 13, and pitot tube 17, attached to the outside of container body 3. Gas from generator 6 passes through the cavity above diaphragm 16 before entering outlet port 13. The cavity under diaphragm 16 is connected to external velocity pressure at an elevation substantially the same as that of grate 12 through tube 17. Tube 17 is essentially a pitot tube that balances velocity pressure external to the elevator device against gas pressure inside lift bag 5. Vertical motion of the lift device thus causes pressure below the diaphragm to increase and forces diaphragm 16 to move upward and close the inlet to port 13, thereby preventing gas from entering lift bag 5 and increasing the back pressure in the reaction zone of generator 6. The entrapped gas will expel water from the reaction zone until the water level has dropped below grate 12 at which time the generator will cease to generate gas.

Stopping the supply of gas to lift bag 5, by itself, will not stop the vertical ascent of the elevator device because the gas already inside the inflatable lift bag will continue to expand with decreasing depth and hydrostatic pressure. In order to control or to stop the vertical ascent, it is, therefore, necessary also to vent gas from the inflatable bag 5. FIG. 3C illustrates a velocity sensitive vent control 8, located at the top of lift bag 5 for this purpose. Vent control 8 consists of diaphragm 18, seal 19, push rod 20, plate 21, spring 22 and nut 23. Flexible diaphragm 18 operates the poppet type vent valve seal 19 in the top of lift bag 5 by moving push rod 20. The cavity above diaphragm 18 senses velocity head pressure components through holes in plate 21. The cavity below diaphragm 18 senses hydrostatic pressure outside the elevator device through hole 26 in the periphery of float collar 2. Spring 22, with compression adjusted by means of nut 23, determines the pressure at which the velocity head will open the vent valve.

Vertical motion of elevator device 1 increases the pressure above diaphragm 18 until the force exerted on the diaphragm is equal to the preset load on spring 22. Diaphragm 18 then opens valve seal 19 by pushing on rod 20. Diaphragm 18 displacement and valve opening are proportional and gas vents accordingly from inflatable lift bag 5 through the static pressure vents 26 in float collar 2. Venting of gas from lift bag 5 decreases the displacement of elevator device 1 and thereby reduces its vertical velocity until the velocity head is overcome by the force on spring 22 and vent valve seal 19 closes. Thus, the ascent rate of elevator device 1 can be predetermined by proper calibration and setting of velocity vent valve 8.

The use of two independent velocity controls, providing for cut-off of the gas generator at an ascent velocity less than the velocity required for venting the lift bag, is a feature that enables the use of elevator device 1 for the lateral transfer of undersea equipment from one location to another. Such elevator operation can be accomplished either by manual or automatic control of the valves. Furthermore, equipment loads can be suspended at any desired depth, such as for example, the suspension of cameras or flood lights above a work site. Descent of the elevator device will cause the gas generator to restart, while vertical motion will adjust lift by venting lift bag 5. Another feature provided by the velocity controls is that the elevator device will have the same preset rate of ascent for a light load as for a load equal to full lift capacity. A light load will be elevated when inflatable lift bag 5 is only partially inflated; velocity controls 7 and 8 will act in sequence to control rate of ascent to the preset value. Lifting forces created by the partially inflated lift bag 5 are transmitted to container body 3 and thereby to load support cover 4 through a scrim or sleeve 24 that surrounds lift bag 5 and is attached between the top of container body 3 and the top of lift bag 5.

Referring now to FIG. 3B, the addition of plate 25 restricts the passage of water through bottom cover 4 to the centerline of elevator device 1. This feature permits the tilt angle for proper operation of the device to be markedly increased without exposing the gas to vents in bottom cover 4. Further, it is obvious that reaction pressure can be controlled by adjustment of the pressure head, such as by raising or lowering the position of grate 12 or by adjusting the location of upper discharge holes in container body 3 at the top of the "chimney."

Elevator device 1 in accordance with this invention has the ability to operate at substantially any depth and/or to lift any size load with substantially the same basic structure. Further, the relative volumes occupied by lift bag and fuel can be varied to suit the depth, load and duration of operation. Re-use of elevator device 1 is accomplished simply by replacement of fuel cartridge 9 and repacking of inflatable lift bag 5.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many modifications, alterations and substitutions are possible in the practice of this invention without departing from the spirit or scope thereof.

We claim:

1. An underwater lift device consisting of: (a) a gas container, such as an expansible lift bag, to provide buoyancy by displacement of water; (b) a gas source; (c) gas delivery means communicating said gas source with said gas container; (d) actuating means for said gas source to provide gas at the required pressure depth for said gas container; (e) a gas supply control valve for said gas source, responsive to contained gas pressure balanced against hydrodynamic pressure as determined by rate of ascent; (f) a gas vent valve affixed to said gas container responsive to contained gas pressure balanced against hydrodynamic pressure as determined by rate of ascent; (g) an outer container to house and protect the apparatus packaged within said outer container; and a (h) means for attachment of a load to said outer container.
2. An underwater lift device in accordance with claim 1 wherein said gas source is a chemical gas generator consisting of a chemical compound or fuel, such as an hydride of a metal

selected from a group consisting of lithium, sodium, calcium, potassium, aluminum and mixtures thereof, said fuel being packaged in a fuel cartridge with a sealed closure, which when opened by hydraulic means deploys said fuel into water surrounding said fuel cartridge whereupon said fuel reacts with the water to generate relatively pure hydrogen gas, said reaction being confined by a wire grate located under said fuel cartridge and by cylindrical metal sleeve surrounding said fuel cartridge, wherein the metal sleeve serves to transfer heat from the chemical reaction and by thermo-syphon action draw fresh water into the generator as well as to purge the generator of reacted materials, such as hydroxides of the metal.

3. An underwater lift device in accordance with claim 2 wherein the reaction rate and reaction pressure within said gas generator are controlled by gas pressure differential (relative to hydrostatic pressure) developed inside of said gas container, which pressure differential is balanced by the "pressure head" established by said cylindrical metal sleeve between radial holes located near the upper and lower extremities of said sleeve, the resultant pressure being sufficient to expel water from inside said sleeve to a level below said wire grate, thereby slowing or stopping gas generation until pressure changes permit water to reenter said sleeve.

4. An underwater lift device in accordance with claim 2 wherein said fuel cartridge may be opened, to expose said fuel contents to water, thereby activating said gas generator, by means of an hydraulic line connected to said fuel cartridge through which water is injected into said sealed cartridge, either by means of hydrostatic pressure or an applied differential pressure, to react with said fuel and to break and remove said sealed closure by means of gas pressure developed inside of said fuel cartridge.

5. An underwater lift device in accordance with claim 1 wherein the gas supply control valve is a pressure-balanced valve, such as a diaphragm valve, sensing hydrodynamic pressure on one side, as for example by means of a pitot tube with opening oriented toward the direction of travel during ascent of the device, and gas supply pressure on the opposing side of the diaphragm, said valve operating to close said gas delivery means communicating said gas source with said expansible lift bag whenever ascent rate exceeds a prescribed velocity and the resultant hydrodynamic pressure exceeds gas supply pres-

sure.

6. An underwater lift device in accordance with claim 5 wherein the gas vent valve affixed to said gas container is a pressure-balanced valve, such as a diaphragm valve with spring loaded adjustment means, sensing hydrodynamic pressure on one side, such as by means of apertures oriented toward the direction of travel during ascent, and contained gas pressure on the opposing side of the diaphragm, said valve operating to vent contained gas from said gas container whenever ascent rate exceeds a preset velocity as determined by spring bias holding said valve in the normally closed position, and resultant hydrodynamic pressure exceeds gas pressure inside said gas container in combination in said lift device in a sequential manner, first to close said gas delivery means thereby isolating said gas container from said gas supply and, second, to vent gas from said gas container until the desired vertical ascent velocity has been attained, including the suspension of loads at some predetermined depth.

7. An underwater lift device in accordance with claim 1 wherein the gas vent valve affixed to said gas container is a pressure-balanced valve, such as a diaphragm valve with spring-loading adjustment means, sensing hydrodynamic pressure on one side, such as by means of apertures oriented toward the direction of travel during ascent, and contained gas pressure on the opposing side of the diaphragm, said valve operating to vent contained gas from said gas container whenever ascent rate exceeds a preset velocity, as determined by spring bias holding said valve in the normally closed position, and resultant hydrodynamic pressure exceeds gas pressure inside said gas container.

8. An underwater lift device in accordance with claim 1 wherein the gas container consists of an expansible lift bag employing an inner bladder, constructed of thin, flexible plastic, rubber or rubberized material having low permeability to hydrogen gas, an outer sleeve, constructed of flexible but relatively inelastic material, such as vinyl coated Nylon reinforced fabrics, wherein the outer sleeve functions to protect and contain the inner bladder, as well as to support lifting loads, while the inner bladder is free to conform irrespective of load and amount of inflation, water being free to circulate between said sleeve and said bladder.

* * * * *

45

50

55

60

65

70

75