July 13, 1965 D. O. ALEXANDER 3,193,853

PRESSURIZED MEMBRANE CONTAINER

Filed March 30, 1964

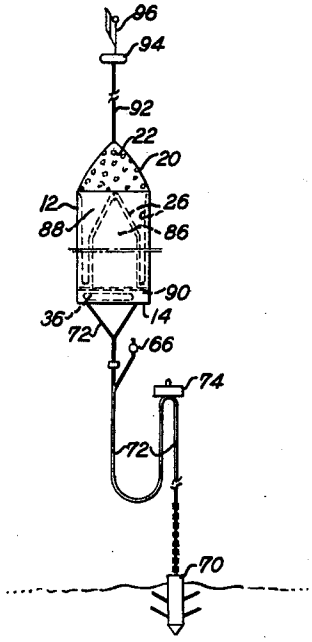


Fig. 4

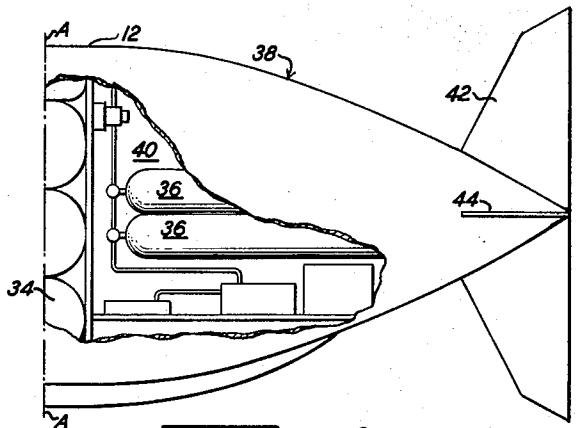


Fig. 2

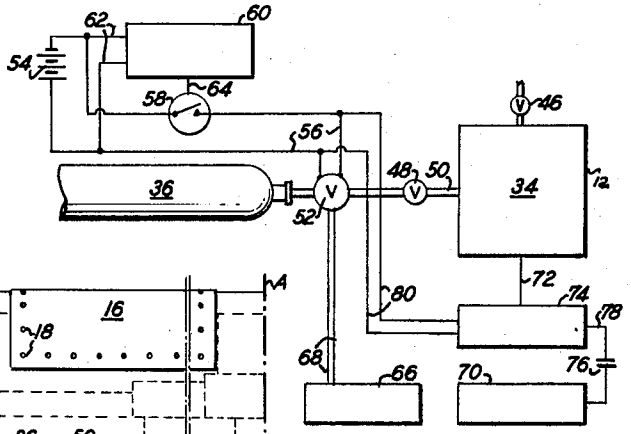


Fig. 5

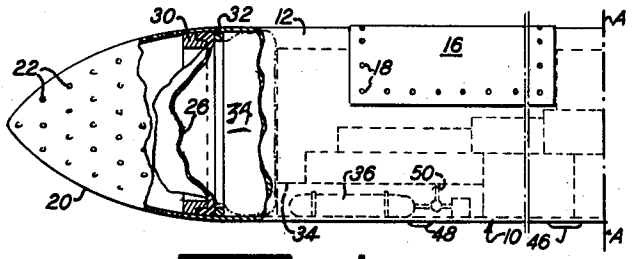


Fig. 1

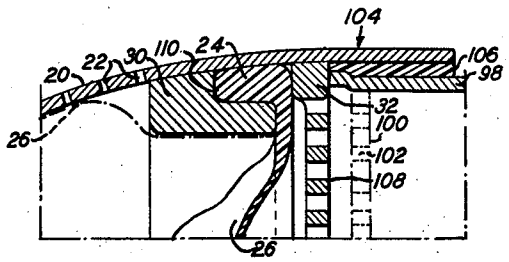


Fig. 3

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PRESSURIZED MEMBRANE CONTAINER

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This is a continuation-in-part of application Serial No. 178,524 filed February 26, 1962 now Patent No. 3,126,-559, issued March 31, 1964.

My invention relates to improved submersible protective membrane containers for submersibly packaging various products in solid or liquid form for ready submersion and buoyant recovery from intermediate level underwater storage of the packaged product. Particularly, my invention includes submersible caching and buoyant movement or recovery of underwater stored strategic materials, explosives such as mines, and missiles as well as underwater cargo storage or carrying means. My invention is directed to improved flexible membrane protected rigid container structures for underwater anchorage at a preselected depth and retrieving such underwater stored products by remote control.

In one important aspect of this invention I make use of the flexible membrane principle to stably store a missile ready for firing from a preselected depth under water. For this purpose I may make use of a missile which is partially enclosed in a flexible membrane, the assembly being surrounded by a rigid walled container having water transmission vents in a wall portion whose passage into and out of the container is controlled by the flexible membrane which protects the cargo from wetting by the water and which may be expanded by gas around the cargo, or missile, expelling water and adjusting the buoyancy of the assembly. As an improvement over the structure indicated in my parent application, only part of the missile or cargo may be protected by a membrane mounted across a vented wall. The remainder of the missile or cargo is encased in a rear wall container filled with the buoyancy controlling gas.

A submerged missile or other cargo, according to this invention, is combined with means for anchoring the same at a controlled position under water or on the bottom, or at a preselected intermediate hydrostatic pressure and depth and combined with elements which will release the missile from its underwater storage position, allowing it to ascend and be fired at any selected depth after release up to the point where the missile is ejected from the water. Any cargo-carrying package or missile may be released from its anchorage by a signal from a remote point on land, sea or from underwater craft by controllable signals.

My flexible membrane herein protects only a portion, an openly exposed rigid wall portion, of a container having cargo therein, the flexible membrane being mounted protectively between a portion of a wall vented for communicating with the sea so that the cargo may be protected by the membrane or diaphragm only from one end, the remaining metallic wall of the container being impervious to the water. Of course two opposite ends of the container may each have vents protectively separated from a central cargo carrying portion of a metallic container, the vents in each end allowing ingress of water with the flexible membranes mounted protectively between the cargo and the vented ends. As in my parent application, means are provided for evolving gas under pressure to expand the membrane against either or both ends, against the vented wall to expell water and thereby provide buoyancy as needed.

The pneumatically pressurized environment about the cargo or missile affords a pressure against the metallic

walls of the container so as to obviate the need for extremely heavy metal usually indicated for a pressure vessel, and which requires no external buoyancy elements. In my first application I showed means whereby the cargo or missile can be enclosed by a membrane, all of which is placed in a rigid metal, but vented, outer container. In the present invention only a small vented portion of the container wall, usually at one end is capped with a flexible diaphragm expandable to afford my flexible separating surface required within the internally pressurized environment and sea water interface. The purpose for this diaphragm as stated in my parent application is two-fold. One to allow for adjustment of buoyancy under water by adjusted expansion and/or contraction so as to allow for a continual adjustment of bulk density with respect to the surrounding water and secondly to provide a type of container for cargo that is not pneumatically sensitive to the degree that it cannot withstand the pneumatically pressurized environment that would exist inside of such a container. The intense internal pressurization, in a cargo that is pneumatically pressure sensitive, counteracts the external sea pressure so that a balanced pressure condition exists between internal and external pressures so that the need for an extremely heavy pressure vessel to protect such cargo is obviated.

In my parent application the cargo was completely enclosed in a membrane which in turn was surrounded and protected by a metallic wall of a reenforcing container which carried vents allowing admission and expulsion of water for desired regulation of buoyancy.

As there pointed out, the membrane is compressed in various positions under water by the hydrostatic pressure of the water entering through the vents. That pressure compresses the membrane about the cargo so that the pressure both within and without the membrane is equalized.

According to the present modification a portion of the cargo is encased or covered by a metallic container wall and only a portion of the container is protected by a diaphragm or sheath. Water under hydrostatic pressure variable with the depth at which the container is disposed presses upon the outside of said membrane, diaphragm, sheath or it may further press in about the cargo or at least may compress the air in about the cargo whereby pressure both within and without the container is substantially equalized. Although the container may be of metal it does not need to be heavy gage metal since internal and external pressures are substantially equalized and the metallic container provides only such additional rigidity needed to overcome any differential of pressure.

The invention is further described in relation to the drawings wherein:

FIG. 1 shows a cargo container having a substantial but not heavy pressure resistant wall of metal (or other strong structural material) with a buoyancy compartment separated from the cargo by a diaphragm at one end;

FIG. 2 shows a modification of the container of FIG. 1 with the after end of the device being faired as a submarine device and which carries the source of inflating gas to provide buoyancy control, underwater stability and dirigibility;

FIG. 3 is a modified form in which a buoyancy controlling element may be separably mounted upon a drum in which is deposed the cargo and stored bottles of pressurized gas;

FIG. 4 is a diagrammatic elevation illustrating a missile mounted for storage and/or firing under water; and

FIG. 5 is an electrical hook-up useful in the operation of the several units herein.

The several figures are largely diagrammatic. The "containers" here may be conventional thin walled sheet metal or may be of heavy gage stock, if desired, although

following the principles of this invention large external hydrostatic pressures, as pointed out above, are largely balanced by pressures developed on the inside of the diaphragm whereby the rigid wall, at least partially enclosing the commodity, is subject only to the pressure differential existing at the particular storage condition. Such wall materials may be of metal such as steel or aluminum or of wood or plastic, etc.

As shown in FIG. 1 the underwater storage device 10 may have a sheet metal wall 12 of moderate "shipping container" strength and as shown may have cylindrical sides and a circular bottom 14. It may be fitted with a hatch or cover 16 fastened around its edges at 18 to secure the same in water-tight closure over the container wall, sealing the entrance to the container 12. While the hatch 16 is shown in the container curved wall, it may equally well be formed as a circular disc applied to the bottom 14, etc. One or both ends 20 of the container wall 12 may be rounded or faired to a point or bullet shape rounded or dished for minimal water resistance in passage through the water. The end 20 has several or numerous small holes 22 which act as vents to allow free transfer or passage of water from the exterior of the container nose 20 to the interior for adjustment of buoyancy as will appear.

An intermediate frictional ring element 30 is provided for frictionally securing to the container wall 12 the annular edges of a flexible diaphragm 26, the diaphragm 26 extending around its periphery to the partitioning element 30 for water-tight securement to the annular walls of the container. The edges 24 of the diaphragm 26 are held between an upper rim 30 and a lower rim 32, both rims 30 and 32 frictionally engaging the annular wall 12 of the container securing the circumferential edge 24 water and gas tight therebetween and to the container wall 12. The diaphragm element 26 may comprise a large loose fold at its center or it may be made of quite flexible rubbery material and of substantial strength to withstand considerable expansion, wear and sometimes unbalanced pressures.

In preferred construction, as shown in FIG. 1, the diaphragm under normal atmospheric pressure may be loosely folded and shaped sufficient to fit against the outer walls of the rounded end 20 and covering vents 22 therein, as indicated in the alternate dotted line position of FIG. 3. When submerged in underwater storage, variable somewhat with the hydrostatic pressure available at a selected depth, the diaphragm 26 will be pressed inward toward the cargo chamber 34 and will be pressed around commodity or cargo elements disposed therein and/or by inward movement of the diaphragm 26 under the hydrostatic pressure will compress the air about the commodity until the internal pressure of the compressed gases about the cargo approximately balances the hydrostatic pressure at the underwater depth.

A container 36 for compressed gas such as carbon dioxide is disposed usually in the air space on the cargo side and within the cargo area of the container, but as shown in FIG. 2 the compressed gas cylinders 36 may be disposed in a separate after compartment 38. Such after compartment may be suitably shaped or faired to form a streamlined after continuation of the cargo compartment 34. That after compartment provides storage space 40 for housing of the compressed gas containers and other electrical and mechanical operating elements, as will appear. The after shell 38 of the container when the alternate construction of FIG. 2 is used may be fitted with stabilizer fins 42 or a rudder 44 for balanced, including steered, movement of the container body 10 under water. Thus, it will be understood that the container 10 may comprise a continuous storage container having a rounded nose cone portion 20 continuing into a cylindrical container body, as shown in FIG. 1, which may alternately be fitted with a flat circular bottom 14 as shown in FIG. 4 or a faired conical stern portion 38 for dirigible movement under water as shown in FIG. 2.

The container body may have fitted for communication between the inside and outside of the outer wall, a manually or automatically (as shown in my prior application) operable venting valve 46. It may similarly have a manual compressed gas releasing valve 48, both valves 46 and 48 extending outside of the container so that the container is subject to manual control externally. By manipulation of valves, gas pressure within the chamber 34 may be released manually by opening of valve 46, or gas pressure within the chamber 34 may be increased by manual opening of valve 48 which releases gas from the cylinder 36. Finally the pressure within the container may be controlled automatically as described in my parent application and shown diagrammatically as diagrammatic control elements in FIG. 5.

As shown in FIG. 5, the chamber 34 communicates by a duct 50 connected in turn to the compressed gas bottle 36. A manually controlled valve 48 allows release of gas to the chamber 34. Otherwise the system is pressurized and operated automatically by the circuitry shown in this figure. The container 34 communicates with the source of compressed gas 36 by the duct 50. The duct 50 passes to an intermediate pressure flow and control valve 52 which serves to release gas from the storage tank 36 for supply of pressurizing gas to the chamber 34, thereby expanding the diaphragm 26. The control valve 52 can merely be a servo control type of reciprocating stem valve operated by a solenoid. It may be fully or partially open or closed, responsive to the current supplied by a battery 54 connected thereto through lines 56 when the circuit is closed by a switch 58. The switch 58 may be manually or locally operated by a time mechanism (not shown) which makes or breaks the circuit at a pre-set time interval; or remotely operated by a radio or sonar signal control unit 60 of conventional construction, connected through lines 62 and 64. Thus, the inflating valve 52 may be controlled manually, mechanically by timer, or remotely by radio or sonar signal.

As a further control, a variable pressure sensor diaphragm unit 66 responsive to the hydrostatic pressure may be placed in circuit with the valve 52 through lines 68 and serves to control the flow of the gas and inflation of the diaphragm 26 responsive to the hydrostatic pressure sensed by diaphragm unit 66 in the system, thus to maintain a selected buoyancy in the container 12. Such buoyancy may also be controlled by a similar pressure sensor device (not shown) mounted within the chamber 34 and pre-set to maintain a slight pressure against the diaphragm 26 sufficient to offset the surrounding hydrostatic pressure whereby complete collapse of the diaphragm upon the stored items therein is prevented. Such sensor shown in my parent application operates to increase the pressure within the diaphragm by control of valve 52 through lines 68 in the same manner as diaphragm unit 66, but is responsive to the air pressure within the chamber 34.

The container 12 may be weighted by an anchor 70 connected thereto by a cable 72 fastened to an intermediate anchor release mechanism 74. The anchor release device may operate an electromagnet 76 which electrically holds it secure, or the actuating current in line 78 may be cut off to release the anchor 70 and part of the cable 72. The actuating current is connected to the circuit through lines 80 and may be made equally responsive to either the timer mechanism or radio or direct electrical control means or sonar signal.

As indicated, the sheath 26 may have sufficient large loose folds to extend by hydrostatic compression of water entering through vents 22 downward substantially about and at least partially enclosing a stored cargo object to be protected. For instance, as shown in FIG. 4, a missile 86, mine or explosive shell, may be mounted coaxially within a metallic sheath 12, maintained vertically erect

with the conical nose 20 having vents 22 therein allowing water to enter into the space 88 depressing the loose folds of the diaphragm 26 about the missile 86, protectively. The space 90 below the missile 86 may have the operating elements such as the compressed gas tanks 36 and other wiring units, valves and the like, as shown in FIG. 5, disposed in the area 90. That area will be filled with whatever gas remains under the pressure developed by collapse of the diaphragm 26 upon or about the missile or outer cargo under the hydrostatic pressure of water entering vents 22 when submerged. As noted, the pressure within the chamber 34 may be adjusted to maintain the missile suspended at a selected underwater depth. The device of FIG. 4 may have a line 92 connected between the tip of the nose 20 and a marking buoy 94 with a visibly attractive element such as a flag 96 attached thereon for marking the water surface position of the submerged missile if desired. In certain strategic uses the device may have the marking buoy and flag cable support 92 omitted.

The lower end of the device may have an anchor 70 attached to the container 12 by lines 72. A variable pressure sensor diaphragm 66 connected through lines 68 (FIG. 5), forming a part of the cable 72, supplies the electrical control for adjustment of the depth of the missile and intermediate anchor release element 74 may be activated by lines 80 (FIG. 5), and also carried by the cable 72, serves for remote controlled release of the anchor. The automatic depth control and the anchor release means are further described in detail in my parent application, that phase of the disclosure being herein incorporated by reference. The device shown in FIG. 4 may contain a missile controlled for remote firing thereof combined for this purpose with electrical, radar or sonar signalling to effect firing from a remote position. Alternatively remote controls may be applied to release the anchor and allow modification of the buoyancy sufficiently to allow the entire assembly to rise to the surface, as described above for imparting buoyancy for any packaged commodity using the principle of this invention.

As shown in FIG. 3 the diaphragm unit may comprise a separable unit adapted for mounting as a seal about one end of a packaged commodity. Such commodity may be packaged within a casing 98 comprising the outer wall of a typical metallic drum which may or may not have a closed cover element 100 as shown in the dotted line position. In any case, if a cover 100 is used, it will have perforations or vents 102 cut therein to allow free transfer of gas from the interior of the container 98 through to the underside of the diaphragm 26. The compressed gas supply bottles and electrical means for gas release may be mounted either in the container 98, as shown in FIG. 1, or it may be housed within the nose 20 of an attachable and removable shell 104. For forming a temporary seal of the shell 104 suitable sealing material such as a rubber or plastic sleeve 106, dimensioned to seal the inner side of the element 104 against the annular wall 98 of the drum as an effective gas and water-tight seal under rubbery sealing pressure. The container 98 might not have a perforated cover 100, but instead the friction ring 32 may be of modified structure from that shown in FIG. 1, to have a center perforated as a grating 108, which forms a bed or restraining element upon which the compressed sheath 26 will lie in hydrostatically compressed position. When friction ring 32 contains a perforated grating center 108, the cover element 100 will be omitted since the same function is performed by the grating 108 of friction ring 32.

In overall operation of the device of FIG. 3 the buoyancy imparting shell 104 is adapted to be frictionally inserted over the open or perforated top of a cylindrical drum 98 which carries cargo elements as well as the compressed gas bottles and electrical elements for operation as in FIG 1. Under normal atmospheric conditions with the assembled shell 104 mounted over drum 98, the diaphragm 26 loosely fills the outer nose element 20 bearing against and closing off the vents lightly. Indeed, before submersion, the interior of the container 98 assembled with the buoyancy device 104 may have some gas released from its bottles therein to produce a substantial positive pressure therein which will expand the sheath 26 as a diaphragm to totally fill the tip 20 and lie expanded over and sealing each of the perforations 22. Thereafter, upon submersion, the hydrostatic pressure of the water will be sufficient to depress the sheath 26 away from the vents 22 and water will enter the cone space 20, compressing the sheath 26 down against the grating 108 of the friction ring 32. Alternatively if a friction ring 32 is used having no grating 108, as in FIG. 1, then the sheath 26 in underwater pressure will lie against the perforated cover 100. As a third alternative, if neither a grating 108 or perforated cover 100 are used, as in FIGS. 1 and 4, then the sheath 26 will expand flexibly until the hydrostatically compressed gas in the container by expansion of the diaphragm is under substantially the same pressure as the hydrostatic pressure.

FIG. 3 further illustrates in some detail the type of diaphragm support that may be used. For instance, the edge of the diaphragm may have an enlarged bead 24 and the friction rim 32 has a groove 110 in which the rim or bead 24 of the diaphragm 26 will fit. The friction ring 32 is fitted on the underside of the bead 24 so that it remains securely fastened in the groove 110. In that manner the entire diaphragm is frictionally fitted in a selected axial position inside of the metallic shell 12 or 20.

As thus described cargo elements may be housed in a rigid container and a diaphragm may seal a part of that container so that the assembly may be disposed under water. The water under the hydrostatic pressure developed is allowed to enter at least through a vented portion of the metallic housing shell. The diaphragm is positioned to separate the entering water from the cargo, maintaining the cargo dry. The hydrostatic pressure of the water may compress the diaphragm against the cargo and the gas surrounding the cargo until the compression upon that gas balances the hydrostatic pressure of the water on the opposite side of the diaphragm. With that arrangement the actual hydrostatic pressure of the water upon the metallic wall of the submerged container is reduced by the amount of air pressure developed by expansion of the diaphragm on the inside of the container. For this reason the metallic walls of the container need not be of very heavy gage or strongly pressure resistant. A supply of compressed gas is present in the container in gas storage bottles and associated with the valves and electrical mechanical and/or manual controls whereby gas is released to the area surrounding the cargo under a controlled pressure as desired. The released gas may be sufficient to expand the diaphragm thereby increasing the practical displacement volume and thereby the buoyancy of the container. That buoyancy may be sufficient to cause the container to rise in the water or it may be negative buoyancy insufficient to allow the package to float in water. Nevertheless, the negative buoyancy is so slight that the entire container becomes readily moved manually by underwater divers. Alternatively the buoyancy may be closely adjusted to allow the container to remain suspended at any selected depth by use of a pressure sensor or by use of remote controls which operate valves 52 through the electrical system as described above, so that the device stored under water may be given a positive buoyancy and will float to the surface as actuated by a remote signal. Again, by use of the manually extending valves 46 and 48 the buoyancy may be controlled by a diver manually manipulating such valves either to release gas from the chamber 34 and impart a greater negative buoyancy or to allow more gas to be released from bottles 36, expanding the diaphragm 26 within the nose 20 which expresses water therein through the vents 22 and imparts a greater positive buoyancy, manually, as desired.

Various modifications will occur to those skilled in the art and, accordingly, it is intended that this disclosure be regarded as illustrative and not limiting except as defined in the claims appended hereto.

I claim:

1. The combination of a relatively rigid container, fluid transfer vents in said container allowing communication through its walls of the interior with the exterior for free flow of water through said vents, a commodity stored within said container, a gas and watertight expandable membrane within said container protectively separating said commodity from the water entering through said vents, and means for passing gas into the storage area of the commodity confined by said membrane under sufficiently high pressure to inflate said membrane to expel water through said vents and impart buoyancy to the combination.

2. In combination, a relatively rigid container for underwater storage of a commodity packaged therein, several vents in the wall near one end of the container allowing communication between the interior and exterior for free flow of water entering the container as the body sinks in underwater storage, and leaving as the container is made buoyant, a commodity in said container, a protective membrane separating said commodity and the vents in said wall as an expandable partitioning element therebetween, and means for inflating said membrane with gas of a sufficiently high pressure to expel water through said vents and impart buoyancy to the combination.

3. The combination defined in claim 2 wherein the means for inflating said membrane is a pressure-resistant gas supply container connected to the protected commodity area of said container by duct means and an actuating valve in said duct means for release of gas from said container for inflating said membrane with a supply of gas to provide buoyancy.

4. The combination of claim 3 wherein said valve is automatically controlled from a point remote from said container.

5. The combination defined in claim 3 wherein said valve is manually controlled from a point outside of said container.

6. The combination defined in claim 3 wherein said valve is automatically controlled by pre-set means within said container.

7. The combination defined in claim 3 wherein said valve is automatically controlled by means responsive to the hydrostatic pressure about the container when submerged in water.

8. The combination defined in claim 3 further including a venting valve manually operable from outside of said container.

9. The combination defined in claim 2 wherein the commodity is ejectible from said container under water by means remotely controlled.

10. The combination defined in claim 2 wherein the container is anchored by extraneous means under water, and the anchoring means is releasable by a remotely actuated signal.

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