

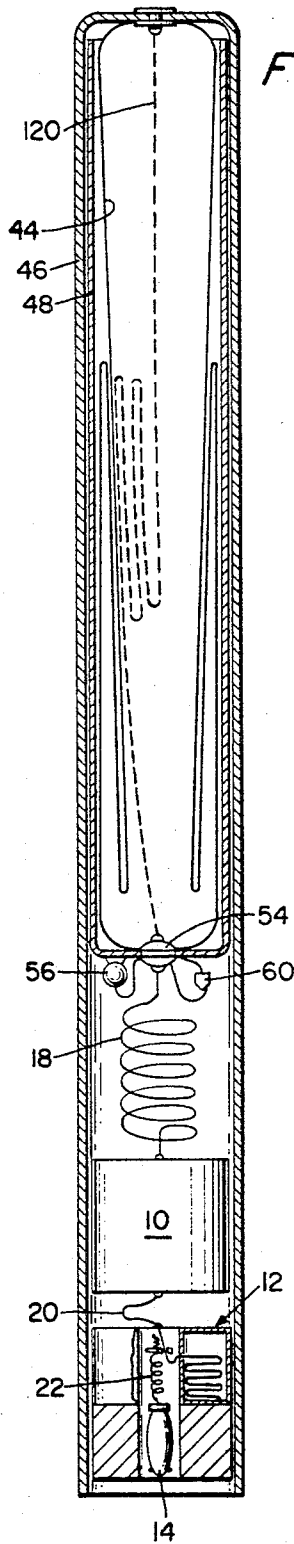
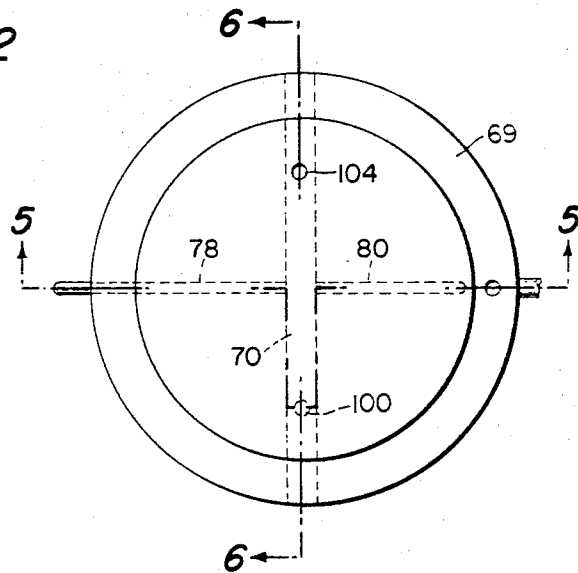
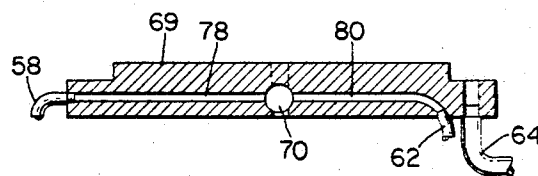
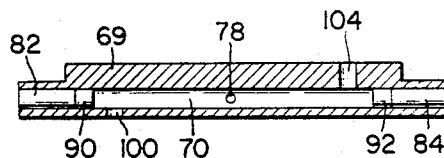
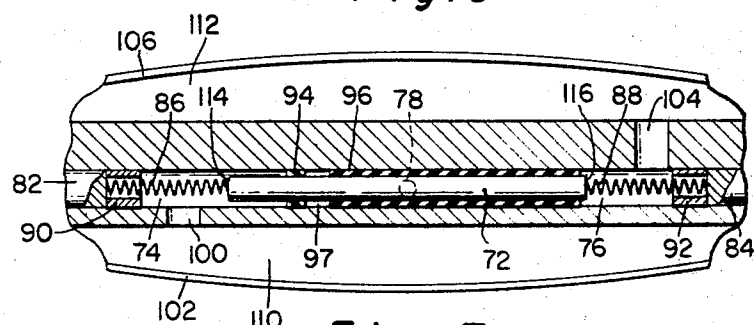
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APPARATUS FOR MOORING INSTRUMENTS AT A
PREDETERMINED DEPTH

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AT A PREDETERMINED DEPTH

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9 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for mooring a container at a predetermined depth which may include: a pair of interconnected telescoping shells; a resilient bag disposed in the inner shell; the package being disposed in the outer shell and connected to the inner shell; a gas pressure source and a novel pressure responsive regulator for filling the bag with gas to extend the shells and expel the package from the outer shell; an anchor weight connected below the package; and a plummet connected below the weight at a length to set the mooring depth of the package.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Field of invention

This invention relates to a mooring apparatus and more particularly to an apparatus for mooring an instrument package at a predetermined depth in the ocean.

Description of the prior art

For military purposes it may be desirable to place an instrument package at some predetermined depth below the ocean surface. It may be even more desirable if the instrument package could be placed without detecting the vessel from which the instruments are ejected. Hence the problem was to develop an apparatus which could be placed easily from a submerged as well as a surface craft and yet fulfill the function of mooring an instrument package at some predetermined depth, perhaps for an extended period of time. Two attempts to solve the problem have met with failure due to the inability to construct a suitable collapsible buoyant structure. One attempt sought to utilize a rigid extendable container fabricated from aluminum, the other attempt sought to utilize a filament wound rigid structure. Both structures required pressurization to 900 p.s.i. prior to launch. The close tolerances necessary to contain 900 p.s.i. in addition to the problem of bending moments upon extension of the container caused both attempts to be abandoned as impractical.

Summary of the invention

My invention solves the abovementioned difficulties by providing a simple operating apparatus which is relatively compact and free from the requirement of close machining tolerances. Additionally, my invention is flexible and is suitably protected against the ocean environment so that it may function at station for an extended period of time. I achieve my advantages with an apparatus comprising an enclosure means for receiving a fluid to provide buoyancy and adapted to be connected to an instrument container, such an enclosure means may be an inflatable resilient bag which may have an extendable shell disposed about it; a pressure responsive fluid control valve connected to the exterior of the enclosure

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means and adapted to regulate the flow of fluid from a fluid source to the enclosure means, the fluid source may be a tank of liquid fuel which may pass a controlled amount through the valve to a gas generator from which the generated gas may be transmitted to the resilient bag. The control valve comprises a chamber container having an upper and lower portion, a pressure responsive movable chamber partition dividing the interior of the chamber into a first portion and a second portion with the partition being adapted to selectively open and close the fluid transmission conduit; a first pressure transmission means communicating the environmental sea pressure with the first portion of the chamber and a second pressure transmission means communicating the internal pressure of the resilient bag with the second portion of the chamber.

An object of my invention is to provide an instrument package mooring apparatus which is simply constructed, reliable and compact.

Another object of my invention is to provide an instrument package mooring apparatus which will suspend an instrument package at any preselected depth beneath the ocean surface easily and quickly.

Still another object of my invention is to provide an instrument mooring apparatus which is protected so that it may be stationed for extended periods of time.

Other objects, advantages and novel features of the invention will become apparent from the following description of the invention when considered in conjunction with the accompanying drawing wherein:

Brief description of the drawing

FIG. 1 is a diagrammatic view of a preferred embodiment of my invention during deployment;

FIG. 2 is a diagrammatic partial section view of a preferred embodiment of my invention illustrating the apparatus before deployment;

FIG. 3 is a diagrammatic partial section view of a portion of the FIG. 2 view illustrating a preferred embodiment of a resilient bag and a pressure responsive fluid control valve;

FIG. 4 is a diagrammatic top view of the pressure responsive fluid control valve;

FIG. 5 is a diagrammatic section view taken along line 5—5 of FIG. 4;

FIG. 6 is a diagrammatic section view taken along line 6—6 of FIG. 4;

FIG. 7 is an enlarged diagrammatic section view of part of the embodiment shown in FIG. 6;

FIG. 8 is a diagrammatic partially cut away view of a bottom sensing means within an anchor weight.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing wherein like reference numerals designate like or corresponding parts throughout the several views, there is shown in FIG. 1 a preferred embodiment of the present invention comprising generally an instrument package 10 which is to be held at some predetermined depth beneath the ocean surface, an anchor weight 12, an ocean bottom sensing means 14, an enclosure means 16 for buoyancy and various cables for connecting the above-mentioned elements, such as a cable 18 for connecting the instrument package 10 to the enclosure means 16, a cable 20 for connecting the instrument package 10 to the anchor weight 12 and a cable 22 for connecting the anchor weight 12 to the ocean bottom sensing means 14. While FIG. 1 illustrates the apparatus in a deploying extended position, FIG. 2 illustrates the apparatus in a pre-launch configuration emphasizing the compactness of the apparatus and thereby

its usefulness from either large or small vessels, whether the vessel is surfaced or submerged.

FIG. 8 diagrammatically illustrates the anchor weight 12 and the ocean bottom sensing means 14 as they would appear prior to launch. The ocean bottom sensing means 14 may be a streamlined plummet of sufficient weight to cause a tension in the cable 22 and may be chosen from among those plummets now commercially available. The plummet may be held in place by any convenient means such as by spring 24 which may be removed just prior to launching the device so that the plummet is allowed to fall freely.

The anchor weight 12 may be comprised generally of three sections, an upper section 26 which may be adapted to contain the cable 20 in a coiled position, a bottom portion 28 which may be of a solid metal, mercury, or an enclosure filled with water, and a hollow cylindrical portion 30 which may contain the plummet 14, the cable 22 and a mechanism for limiting the pay out of the cable 20.

The mechanism for limiting the pay out of cable 20 is illustrated diagrammatically as are all the other elements in FIG. 8 so as to illustrate functions desired but not necessarily the actual structure to achieve those functions and may comprise a rotatable arm 32, a pivot pin 34 connected to the portion 30 of the anchor weight, a spring 36 connected at one end to the portion 30 and at the other end to the rotatable arm 32, and a stationary wedging block 38. After launching of my apparatus the ocean bottom sensing plummet 14 will immediately begin to sink toward the ocean floor and will cause the cable 22 to begin unwinding. The cable 22 will be pre-cut prior to launch to correspond to the depth at which it has been calculated or is desirable to have the enclosure 16 beneath the surface. As the plummet 14 continues to drop it will eventually cause the cable 22 to be fully extended thereby causing a tension upon the rotatable arm 32. The spring 36 is of a suitable spring constant sufficient to cause the rotatable arm 32 to wedge the cable 20 against the wedging block 38 to prevent pay out and yet such that the falling plummet 14 will be of sufficient weight to be able to overcome the spring so as to rotate the rotatable arm 32 about its pivot pin 34 into the position shown in phantom lines to allow pay out of cable 20. Once rotation of the arm 32 has occurred the cable 20 will be free to be payed out to increase the distance between the instrument package and the anchor weight 12. The cable may be payed out through a pad eye support 40 located to keep the anchor weight 12 in a generally upright position.

Once the bottom sensing plummet 14 has reached the ocean floor the tension in the cable 22 will be released. Upon the tension being released the biased spring 36 will cause the arm 32 to be rotated into wedging engagement with the block 38 which, in turn, will cause the cable 20 to be locked in position thus fixing the distance between the instrument package 10 and the anchor weight 12.

While the plummet 14 and anchor weight 12 are falling through the water to the ocean bottom the buoyancy enclosure means 16 will begin to inflate and rise to the surface. The enclosure means may be comprised of an inflatable resilient bag 44, FIGS. 2 and 3, and two sections of an extendable shell, a first section 46 and a second section 48, the second section may be telescopically movable within the first section responsive to the inflation of the resilient bag 44. The resilient bag may be constructed of any suitable material which is now commercially available such as Uniroyal "Sealdrum" or "Sealdbin" (Uniroyal, U.S. Rubber Co. of Wayne, N.J.) and the extendable shell sections 46 and 48 may be fabricated from any corrosive resistant metal or plastic. The shell sections 46 and 48 are for the purpose of protecting the resilient bag against the environmental sea and marine life when it may be necessary for the apparatus to remain moored at its station for extended periods of time.

The resilient bag may be combined with a pressure relief valve 50 which may also act to connect the resilient bag 44 to the first section 46 of the extendable shell. Again, the connection may be of any suitable means such as by clamping. A similar clamping type connection may be made between the resilient bag and the second section 48 of the extendable shell.

Included in my invention is a pressure responsive fluid control valve 54, FIG. 3, which is adapted to regulate a flow of fluid from a fluid source to the resilient bag. The control valve may be made integral with the abovementioned clamping means for connecting the resilient bag 44 and the second section 48 of the extendable shell.

To cause inflation of the resilient bag 44 my invention may comprise a fluid source which may be a fuel container 56, a means connected to the fuel container 56 and the fluid control valve 54 for conducting fuel from the fuel source to the control valve, such as flexible conduit 58, a gas generator container 60 containing a catalyst which is adapted to react with the fuel to produce a gas, a means connected to the control valve 54 and to the gas generator container 60 for conducting the fuel from the control valve to the gas generator such as flexible conduit 62 and a means connected to the gas generator 60 and the resilient bag 44 for conducting the generated gas from the gas generator container to the resilient bag, such means may be flexible conduit 64. The fuel container 56 may be of any suitable design and preferably partially open to the ambient sea pressure such as by having a flexible diaphragm 66 separate the fuel from sea water but yet adapted to transmit the sea pressure to the fuel for causing the fuel to flow from the fuel container to the control valve and then through the gas generator to the resilient bag. The fuel container 56 may be conveniently attached to the second portion 48 of the extendable shell by a bracket 68. The fuel may be of any convenient type which is fluid under ambient ocean pressure and which may be combined with a catalyst to generate a gas to inflate the resilient bag. Such fuels as hydrazine (N_2H_4) and hydrazine-base fuel mixtures may be used, the fuels decomposing on the catalyst in the gas generator to produce a noncombustible exhaust gas consisting of hydrogen, nitrogen, and ammonia. A typical underwater fuel mixture is 68% hydrazine and 32% water; another is 95% hydrazine and 5% ammonia. Two types of catalyst pellets are used: spontaneous and non-spontaneous. Both are composed of alumina but are impregnated with different active metals. Shell 405 catalyst, obtainable from the Shell Development Company of Emeryville, Calif. is spontaneous. HA3 (a standard petroleum-industry catalyst) is nonspontaneous and requires an electric cartridge heater (700 to 1000° F.) or a hypergolic reaction to start the fuel decomposition.

The fluid control valve is connected to the resilient bag 44 but its exterior is, as already mentioned, adapted to regulate a flow of fluid from the fuel container 56 to the gas generator container 60. The control valve comprises a chamber container 69, FIGS. 5, 6 and 7, having an interior 70, an upper portion and a lower portion; the interior of the container may be elongated and generally cylindrical in shape. A pressure responsive movable chamber partition such as a piston 72, FIG. 7, divides the chamber 70 into a first portion 74 and a second portion 76. Communicating with the chamber 70 may be a fluid conduit 78 which may be adapted to receive fuel from the conduit 58. An exit conduit 80 may also communicate with the chamber 70 to allow fuel to communicate with the conduit 62 and the gas generator container 60. The piston 72 which may be elongated and cylindrical in shape is adapted to selectively open and close the conduits 78 and 80 and thereby regulate the flow of fuel from the fuel container 56 to the gas generator container 60.

Also within the chamber 70 and sealing each of the chamber ends are two end plugs 82 and 84, FIGS. 6 and 7. Located between the cylindrical piston 72 and each of

the end plugs 82 and 84 may be spring means such as compression springs 86 and 88, respectively, which tend to bias the piston 72 into a central position between the end plugs of the chamber. Piston stop means, such as an annular block 90 located within the chamber 70 and adjacent the end plug 82 and an annular block 92 located at the other end of the chamber and adjacent the end plug 84, may be provided to limit the motion of the piston. The piston 72 is of a cross-sectional area smaller than the cross-sectional area of the chamber 70 so that a spacing between the walls of the piston and the chamber exist to accommodate a sealing means as well as to act as an annular conduit for the fuel passing through the control valve.

Disposed about and connected to the piston 72 may be a first and a second sealing means. The first sealing means may be a seal ring 94 located very near one of the ends 114 of the piston while the second sealing means may be a sleeve seal 96 spaced from the seal ring 94 and extending the remaining distance of the piston to near the opposite end 116. Between the two seals may be an annular space 97 which when aligned with the fuel conduit 78 will allow fuel to pass from the conduit around the piston and into the conduit 80. The elements just mentioned within the control valve may be of any suitable material, preferably noncorrosive, and which may be determined by the period of time the apparatus is to remain on station and/or determined by the particular fuel used to generate the inflating gas (i.e., hydrazine fuels are classified as corrosive liquids).

Included as part of the pressure responsive fluid control valve is a first pressure transmission means communicating the environmental sea pressure with the first portion 74 of the chamber 70, such a pressure transmission means may comprise an aperture 100, FIGS. 6 and 7, in the lower portion of the chamber container 69 and a diaphragm 102, FIGS. 3 and 7, which may be spaced from the aperture 100 and enclose the lower portion of the chamber container 69 about the aperture 100. A second pressure transmission means communicating the internal pressure of the resilient bag 44 with the second portion 76 of the chamber 70 may be comprised of an aperture 104 through the upper portion of the chamber container and a diaphragm 106, FIGS. 3 and 7, spaced from the aperture 104 and enclosing the upper portion of the chamber container about the aperture 104. As is seen in the FIG. 3 diagram, two air pockets are formed, a lower air pocket 110 and an upper air pocket 112. These may be provided as a means for separating the internal mechanism of the control valve from the potentially corrosive sea water and the potentially corrosive gas that may be used to inflate the resilient bag.

The operation of the fluid control valve is responsive to the environmental sea pressure as well as the pressure existing in the resilient bag 44. When the apparatus is initially launched it will sink to a depth, or if the apparatus is launched from a submerged craft it is already at a depth, so that the ambient sea pressure is able to bear against the diaphragm 102 which will compress the air pocket 110 thereby communicating the sea pressure to the first portion 74 of the chamber 70. This pressure will bear against the face 114 of the piston 72 which, if sufficient to overcome the spring 88, will move the piston toward the end plug 84. When the space 97 aligns with the fuel transmission conduit 78 fuel will be transmitted around the piston to the conduit 80 and from the conduit 80 to the gas generator container 60. As the resilient bag is inflated the pressure within the bag will, of course, begin to increase. This pressure within the bag will bear against the diaphragm 106 and compress the upper air pocket 112. The increased pressure will be transmitted through the aperture 104 to the second portion 76 of the chamber 70 so as to act upon the opposite face 116 of the piston 72. As the pressure within the bag increases the piston will be forced back toward the end plug 82 closing the fluid trans-

mission conduit 78 to the flow of fuel. Once the pressure within the bag 44 is generally equal to the ambient sea pressure, the piston 72 will be centrally located once again and the bag will no longer receive any gas.

Since some excess fuel will remain in the conduit 62 or within the gas generator container 60 causing more gas to be generated, the pressure relief valve 50 may be set to open and relieve any excess pressure. A simple method of activating the pressure relief valve is to provide a link means, one end connected to the first section 46 of the extendable shell and the other end connected to the second section 48 of an extendable shell, the link means being of a definite length so that the sections may telescopically expand only a certain distance. Such a link means may be a chain 120, FIG. 3, cut to a predetermined length so that each time the resilient bag 44 expands the extendable shell sections to the length of the chain 120, a tension will be created in the chain to activate the pressure relief valve 50. A spring (not shown) may be used to bias the relief valve closed until a tension is created in the chain 120. It is to be understood that any suitable chain and any suitable relief valve may be used and that a relief valve may be placed at any convenient location (not necessarily the top of the bag 44 as shown) to communicate the interior of the bag 44 and the environmental sea. Also, a relief valve may be operated only by a pressure differential without the need for the chain 120; thus the chain 120 may function only to restrict the extendable length of the extendable shell.

A metal cage 122, FIG. 3, may be provided as a connector means for the chain 120 and at the same time provide a protection for the diaphragm 106 during the time that the resilient bag 44 is in a collapsed position. A metal cage 124, FIG. 3, may also be provided to protect the diaphragm 102 and may provide a convenient connector means for the cable 18, FIG. 2.

Initially, after the mooring apparatus is launched the ambient sea pressure will force itself between the loosely fitted shell sections 46 and 48 and collapse the resilient bag 44 about the chain 120. It is known that ambient sea pressure increases about $\frac{1}{2}$ p.s.i. for every foot in depth so that if a collapsed apparatus is 15 feet in height a sufficient pressure differential will exist between the top portion and bottom portion of the apparatus. Thus, it is readily apparent that with the control valve 54 located at the bottom of the resilient bag, FIG. 3, the diaphragm 102 will be in communication with the sea pressure at that depth while the diaphragm 106 will be in communication with a lesser sea pressure near the top of the resilient bag, the collapsed bag about the chain 120 acting as a conduit from the diaphragm 106 to near the top of the bag. Hence an initial pressure differential will be set up across the piston 72. It is noted that diaphragm 106 may be obviated by having a tube and a resilient sack (not shown) communicate the aperture 104 with the ambient sea pressure at the top of the resilient bag and perhaps act in conjunction with a relief valve. By having a means in conjunction with a relief valve, a dual function may be served in that a lower ambient pressure may be communicated to the control valve to open the control valve at the beginning of deployment and very high pressure may be communicated to the control valve to close the control valve when nearing the full deployment of the apparatus.

The cable 18 connecting the resilient bag 44 and the instrument package 10 may be precut to any desired length so that the sum of the lengths of the cable 22, the cable 18 and the expanded resilient bag 44 will give a good approximation of the depth beneath the ocean surface at which the instrument package 10 will be located.

Operation

In operation the apparatus will be transported to the deployment site with the resilient bag 44 in a collapsed position within the contracted extendable shell sections and with the fuel container 56 fully charged. The ap-

paratus may then be ejected overboard from a surface vessel or ejected from a submerged vessel whereupon it will begin to sink. The ambient ocean pressure will begin to press upon the diaphragm 102, FIGS. 3 and 7, and contract the air pocket 110 while the air pocket 112 will be in communication with a lower pressure near the top of the resilient bag 44. The increased ocean pressure will be transmitted through the aperture 100 to bear against the piston face 114 causing it to move toward the end plug 84. When the space 97 aligns itself with the conduit 78, fuel from the container 56 will begin to flow through the conduit 58 into the conduit 78 around the piston 72 through the conduit 80 to the conduit 62 and to the gas generator container 60. Once the fuel enters the container 60 it is chemically altered to a gaseous form and transmitted through conduit 64 to the bag 44 causing the bag to begin inflating. During this period of time the plummet 14 has begun to sink toward the ocean floor along with the anchor weight 12 causing the entire apparatus to be pulled downward. As the pressure of the gas inflates the bag 44 water in the spaces between the bag and the extendable shell sections 46 and 48 will be expelled through the spacing between the sections which are loosely joined. This expansion of water will have a dampening effect upon the extension of the shell sections preventing a shock effect as the shells reach their full extendable position. As the bag 44 inflates and becomes buoyant it will begin to rise toward the surface. Also, as the pressure within the bag increases to a point where it and the biasing force from spring 88 are sufficient to move the piston 72 toward the end plug 82, the conduit 78 will be closed off so that no more fuel will be transmitted to the gas generator. Movement of the piston 72 may occur as long as a sufficient pressure differential exists between the ocean environment and that within the bag. Thus the bag will continue to inflate to retain buoyancy.

Shortly after the apparatus has been launched it will assume a configuration as shown in FIG. 1 wherein the plummet 14 and the anchor weight 12 are moving downward and the resilient bag and instrument package 10 are moving upward. At this time the cables 22 and 18 are fully extended and the cable 20 is being payed out. The resilient bag 44 being buoyant will rise to the surface and remain there while the weight and plummet continue to drop toward the ocean floor. Upon the plummet reaching the ocean floor, the tension in the cable 22 will be relieved and the wedging mechanism will lock the cable 20 from further pay out thus defining the total vertical length of my apparatus. The anchor weight 12 will continue to fall to the ocean floor which will cause the bag 44 to be pulled beneath the surface of the water a distance substantially equal to the length of cable 22. When the anchor weight 12 has reached the ocean bottom the apparatus will be in a fully deployed position with the bag 44 holding the apparatus in a generally upright position while the anchor weight 12 generally fixes the location. Thus, the instrument package 10 has been stationed at a predetermined depth beneath the ocean surface from which it may receive and/or transmit data.

I claim:

1. Apparatus comprising:

an expansible enclosure means to provide buoyancy;
a gas generator for containing a material capable of producing a gas when combined with a liquid;
gas-delivery means communicating the generator with said enclosure means;
conduit means for admitting said liquid into said gas generator; and

a pressure responsive fluid control valve disposed in said conduit externally of said enclosure means for regulating flow of said liquid into said generator, said control valve comprising:

a chamber container having an upper and lower portion;

a pressure responsive movable chamber partition

dividing the interior of the chamber into a first portion and a second portion, said partition being adapted to selectively open and close said conduit means;

a first pressure transmission means communicating environmental sea pressure with the first portion of the chamber; and

a second pressure transmission means communicating the internal pressure of the enclosure means with the second portion of the chamber, whereby said chamber partition is selectively responsive to the pressures of the sea and the enclosure means to open and close said conduit means for controlling the production and delivery of said buoyant gas into said enclosure means.

2. An underwater instrument mooring apparatus as claimed in claim 1 wherein:

the first pressure transmission means comprises an aperture through the lower portion of the chamber and a diaphragm spaced from and enclosing the lower portion of the container about the aperture;

the second pressure transmission means comprises an aperture through the upper portion of the chamber container and a diaphragm spaced from and enclosing the upper portion of the container about the aperture; and

said apparatus further including a fluid source vessel adapted to subject its fluid contents to external environmental pressure for promoting flow through said conduit means.

3. An instrument mooring apparatus as claimed in claim 2 wherein the chamber interior is elongated and including:

end plugs sealing each of the ends of the elongated chamber;

the chamber partition is elongated and has end faces and a smaller sectional area than the sectional area of the chamber;

a first sealing means and a second sealing means connected about the partition for separating the fluid transmission conduit from the pressure transmission means;

a circular space about the partition and between the first and second sealing means; and

spring means disposed within the elongated chamber between and connected to the partition and an end plug.

4. An instrument mooring apparatus as claimed in claim 1 wherein the enclosure means comprises an inflatable resilient bag and including an extensible shell disposed about and connected to the resilient bag for protecting said bag from the ocean environment.

5. An instrument mooring apparatus as claimed in claim 4 wherein the extensible shell comprises a first and a second section, said second section telescopically movable within the first section responsive to the inflation of the resilient bag.

6. An instrument mooring apparatus as claimed in claim 3 including:

an instrument container;

a cable for connecting the instrument container to the extensible shell;

an anchor weight for lowering the instrument container toward the ocean bottom;

a cable for connecting the instrument container to the weight;

an ocean bottom sensing means for contacting the ocean bottom; and

a cable for connecting the bottom sensing means to the weight.

7. An instrument mooring apparatus as claimed in claim 6 wherein the cable for connecting the bottom sensing means to the weight is of a length generally equal to the depth below the ocean surface at which the resilient bag is to be located.

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8. An instrument mooring apparatus as claimed in claim 7 wherein:
the enclosure means comprises an inflatable resilient bag;
an extensible shell disposed about and connected to the resilient bag for protecting said bag from the ocean environment; and
the extensible shell comprises a first and second section, said second section telescopically movable within the first section responsive to the inflation of the resilient bag.
9. An instrument mooring apparatus as claimed in claim 8 including:
a pressure relief valve connected to and communicating through the resilient bag and the extensible shell for relieving excess pressure within the resilient bag; and

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a link means connecting the first section of the extensible shell to the second section and operatively connected to the pressure relief valve for opening said relief valve when an excessive pressure in the resilient bag causes the telescoping sections to expand a specific distance.

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