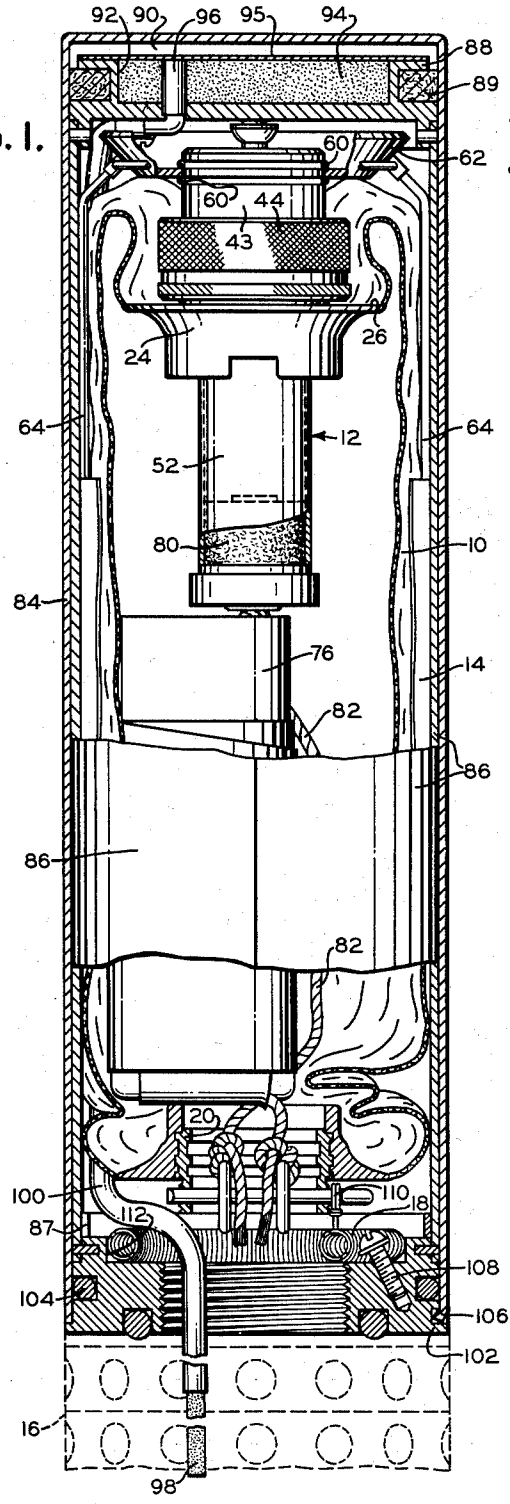
Jan. 17, 1961 R. M. GOGOLICK ET AL 2,968,053

BUOYANCY CONTROL

Filed March 14, 1946 2 Sheets-Sheet 1

FIG. 1.



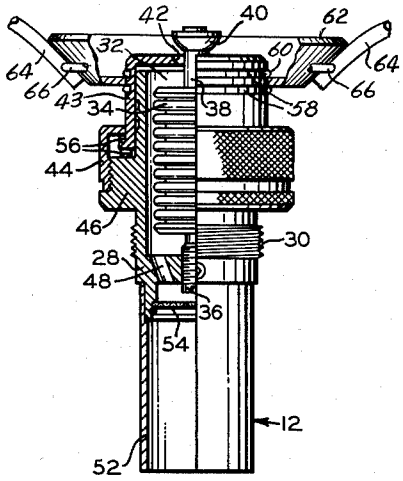


FIG. 5.

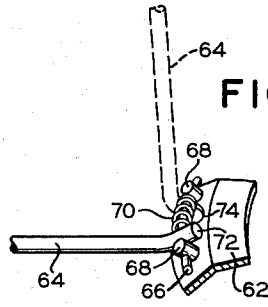


FIG. 6.

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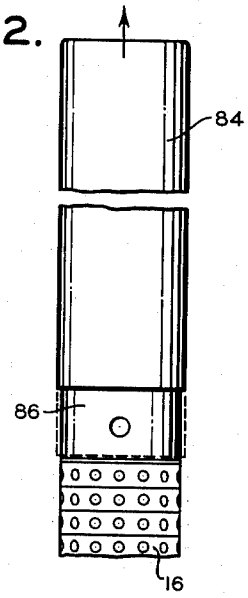
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Jan. 17, 1961 R. M. GOGOLICK ET AL 2,968,053

BUOYANCY CONTROL

Filed March 14, 1946 2 Sheets-Sheet 2

FIG. 2.



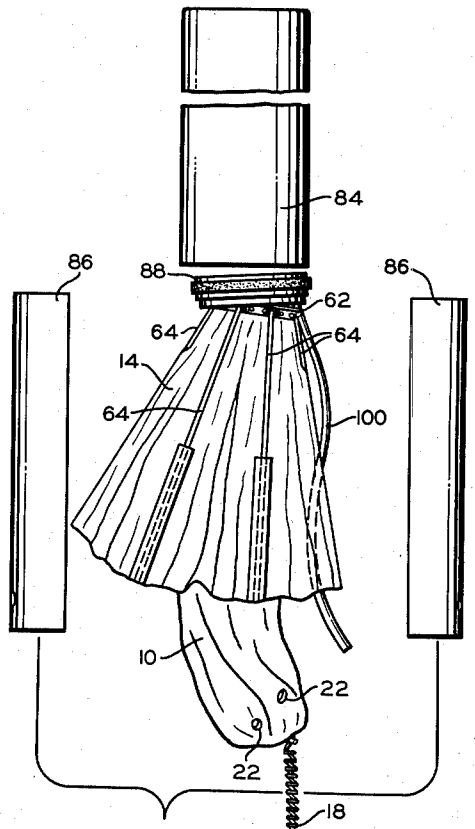


FIG. 3.

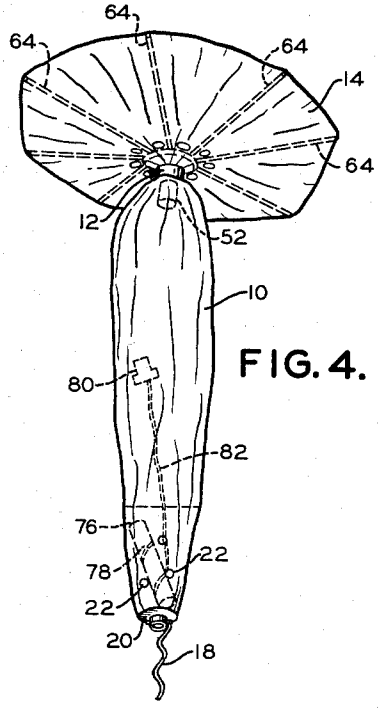
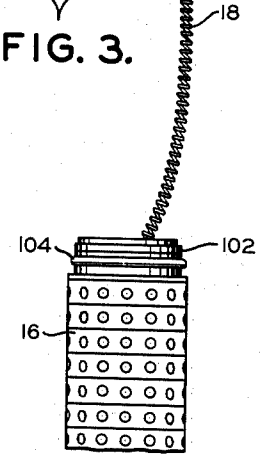


FIG. 4.



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BUOYANCY CONTROL

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13 Claims. (Cl. 9—8)

This invention relates to underwater suspension devices of the gas-operated type and more particularly to a buoyancy control therefor.

Underwater sound generating devices and the like require for their efficient operation that they reach their ultimate predetermined operating depth and become established and maintained in a stable equilibrium state at that depth with a minimum of hunting or oscillation. It is toward these ends that the present invention is directed.

It is an object of the present invention to provide a buoyancy control for a gas-operated, underwater suspension device that is quickly and efficiently operable to bring the device to its pre-set operating depth with a minimum of oscillation or hunting as it seeks said depth and to maintain the device and its suspended object with optimum stability in its equilibrum state.

Another object of the invention is to provide a control of this character that is responsive to velocity variations as well as pressure variations during the approach of the device and its suspended object to the predetermined operating depth.

A further object of the invention is to provide a damping means that cooperates with a venting means of the device in such manner that the control is effected by either ascent or descent of the device as it seeks equilibrium state.

With the above and other objects and features in view, the invention will now be described with reference to the accompanying drawings which illustrate a preferred embodiment of the invention and will be pointed out in the claims.

In the drawings:

Fig. 1 is a sectional elevation of a gas-operated suspension device with the improved control mechanism embodied therein, the parts being shown in collapsed condition within a container in readiness for firing from a signal tube, or the like, of a submerged vessel;

Fig. 2 is a side elevation showing an outer container for the device in the stage of removal therefrom;

Fig. 3 is a side elevation of the device completely removed from the container, the half sections of an inner container being shown falling away;

Fig. 4 is a perspective of the suspension device in operating condition, the damping vane or umbrella having expanded to operative position;

Fig. 5 is a detailed elevation, partly in section, of a release valve employed in the device for venting gas from the buoyancy chamber or enclosure, a portion of the damping vane being shown attached thereto; and

Fig. 6 is a detailed perspective of a section of the damping vane frame illustrating the hinge-type mounting for the ribs and the locking feature thereof.

Referring to Figs. 3 and 4 the suspension device comprises generally, a balloon or enclosure **10** having secured in its upper end a venting or release valve **12** to which is fastened an umbrella or damping vane **14**. The object suspended by the device is herein shown as an

underwater sound generator **16**, or what is otherwise known as an underwater noisemaker. The sound generator is preferably secured to the enclosure **10** by a tightly coiled spring secured at one end to the generator and at its opposite end to a fitting **20** attached to the lower end of the enclosure **10**. The enclosure is preferably made of pliant material such as neoprene-impregnated nylon and is provided at its lower end with a series of apertures **22** for a purpose to be later described.

The valve **12** (Fig. 5) comprises a cylindrical body section **28** externally threaded at **30** for securing the section within a fitting **24** (Fig. 1) fastened as at **26** to the upper end of enclosure **10**. Within a bore **32** of the section **28** there is mounted a Sylphon bellows **34**. The lower end of the bellows rests upon an adjusting screw **36** threaded in the base of the section **28**. The upper end of the bellows has conected thereto by an upstanding stem **38** a beveled valve disc **40**. Disc **40** is arranged to cooperate with a correspondingly beveled valve seat **42** formed in the end of a sleeve **43** telescopically mounted over the upper portion of the body section **28**. A bonnet **44** threaded over an enlarged portion **46** of the body section **28** aligns and secures the seat member **42** in position for slight movement axially of the body section **28**. The base of section **28** has provided therein an inlet aperture **48** for permitting the entrance of escaping gas therethrough into the bore **32**.

A depending cylindrical tube **52** is fitted securely over a reduced portion of the lower end of the section **28** and has a fine mesh wire screen **54** within the lower portion to provide a filter for preventing passage of substances with the escaping gas. Ring springs **56** bearing against a flange provided on the lower end of the valve seat **42**, the upper surface of the enlarged portion **46**, and the undersurface of the bonnet **44** provide means for holding the valve seat **42** in its normal position shown in Fig. 5, i.e., centrally of the clearance space provided between the internal upper surface of the bonnet **44** and the upper surface of the enlarged portion **46**.

The upper end of the sleeve **43** is provided externally with a pair of spaced annular grooves **58** for receiving a pair of spring retainer rings **60** that oppositely embrace and secure a circular frame **62** of the damping vane **14**. The vane **14** comprises a plurality of radially extending ribs **64** (Figs. 5 and 6) pivotally mounted on a wire ring **66** passing through spaced, projecting studs **68** secured in a beveled portion of the frame **62**. A coil spring **70**, there being one spring for each rib **64**, encircles the ring **66** between one of the studs **68** and the pivot end of its corresponding rib **64** and normally tends to urge the rib toward the next adjacent stud **68**. When, however, the ribs are in collapsed position as shown in Fig. **1**, their inner ends **72** project into corresponding apertures **74** provided in the beveled portion of the frame **62** as shown in dotted lines in Fig. 6, and thus hold the springs **70** compressed. Upon the ribs swinging outwardly from the position shown in Fig. 1 to the position shown in Fig. 4, their inner ends **72** are swung out of the confines of the openings **74**, whereupon, their respective springs **70** force the ribs laterally along the ring **66** against the next adjacent stud **68**. In this position the ribs are securely locked against vertical movement in either direction since their ends **72** are held flat against the beveled portion of frame **62** and out of alignment with apertures **74**. In this manner the fabric covering that is fastened to the ribs is securely held in its operative outstretched position as clearly shown in Fig. **4**.

The gas generating source herein shown comprises a stick **76** of chemical substance such as calcium hydride (CaH_2) which upon contact with water generates hydrogen. It will be understood, however, that any chemical suitable for generating a gas may be used. The stick may

be secured for retention in the bottom of the enclosure by any suitable means such as the cord fastenings **78** shown in Fig. 4. If desired, pulverized calcium hydride may be substituted for the stick or used as an adjunct thereto. In this latter event, the powder is merely placed loosely within the enclosure. In order to prevent crystals or particles which may become loosened from the stick from entering and fouling the operation of the valve **12**, a stopper or plug **80** of a diameter that fits snugly within the lower end of the tube **52** is inserted therein. This plug **80** is connected by a cord **82** to the fitting **20**. The cord **82** is of sufficient length to permit insertion of the plug within the tube when the enclosure **10** is in collapsed state within a container now to be described, but is insufficiently long to permit the plug **80** to remain within the tube **52** when the enclosure is in distended or operative position as shown in Fig. 4.

The container for the device includes a cylindrical tube **84** (Figs. 1, 2 and 3) that is closed at its upper end and open at its bottom end. It also includes two half-shells **86** arranged to be fitted together and slid into the tube **84**, the half-shells being somewhat shorter in length than the over-all length of tube **84**. In assembling the device within the container, the enclosure **10** is collapsed, the ribs **64** of the vane **14** are folded downwardly about the enclosure, the plug **80** is inserted in the tube **52**, and the half-shells **86** placed therearound. Before inserting this assembly within the tube **84**, a plunger disc generally indicated at **88** is first rammed into the tube into close proximity with the closed end thereof.

The disc **88** has a suitable packing washer **89** projecting externally therefrom for tightly engaging the internal surface of the tube **84** and effecting a gas-tight chamber **90** between the upper end of the tube and the plunger. The plunger is provided with a relatively large internal recess **92** in which is placed a charge of powder **94** preferably of the smokeless type, the powder being sealed in the recess by a disc **95** cemented in place over the recess. A heat transfer cup **96** is secured in the base of plunger **88** and extends upwardly into the powder charge **94**. A fuse **98** of the quickmatch type is connected at its upper end to the cup **96** and extends downwardly along the internal wall of the container through a flexible tube **100** preferably made of varnish-impregnated fiber glass, or other suitable heat resistant material. Following the insertion of the plunger **88** and its fuse connection, the assembled half-shells and the parts embraced thereby are forced into the tube as clearly shown in Fig. 1.

Next, a cylindrical base plug **102** having an external groove in which is mounted a water-seal ring **104** is forced into the lower end of the container to effect a watertight seal of the enclosed assembly. The lower end of the tube is then crimped as at **106** into an external groove formed in the lower portion of the plug **102**. The plug **102** is internally threaded to receive an upstanding threaded end of a coupling (not shown) rigidly secured to the uppermost section of the sound generator **16** that is to be supported by the suspension device. One end of the connecting spring **18** is secured to the plug **102** by a screw **108** and the opposite end of this spring is connected as at **110** to the fitting **20** that is secured at the lower end of the enclosure **10**. In assembling the parts, as just described, the spring **18** is coiled flat within a recess **112** provided in the upper surface of the plug **102**.

The entire assembly above described may be fired from a conventional signaling tube of the type generally found on underwater vessels and the firing gear or triggering mechanism used to initiate its ejection may be of any well known conventional construction. Suffice it to say here, that upon ejection of the device from the tube, the fuse **98** is ignited and, in turn, ignites the cap **96** and through it, the powder charge **94**. Explosion of the charge **94** develops a sufficient pressure of gas within the chamber **90** to cause the tube **84** to be blown off of the assembly in the manner progressively illustrated in Figs. 2 and 3. As soon as the tube **84** is blown completely free of the half-shells **86**, the latter fall away as shown in Fig. 3. If desired, a leaf spring **87** (Fig. 1) may be inserted between the half-shells during assembly to assure rapid release of the shells as soon as the tube **84** is removed.

Upon water entering through the apertures **22** it reacts with a hydride stick **76** and immediately fills the enclosure **10** with hydrogen thus rendering it positively buoyant. At the same time, the weight of the sound generator pulls downwardly upon the bottom of the enclosure, insuring that it turns topside up, and stretches the tight-coiled suspension spring to the desired operating length. Being positively buoyant, the suspension device rises. As it approaches the pre-set operating depth to which it has been adjusted by the setting of the screw **36** with respect to the Sylphon bellows **34**, the valve **40** releases hydrogen until the operating position and neutral buoyancy are reached.

Hydrogen is generated continuously at a slow rate by the stick **76**, and is released through the valve **12** at a rate which is just fast enough to maintain the device in a stable equilibrium state at the predetermined operating depth. If the device rises above its pre-set operating depth, the excess gas is released and the device immediately descends to its equilibrium position. With the velocity type of control provided by the damping vane **14**, the valve opens when the device rises and the opening is proportional to the velocity. Thus as the device is rising due to excess positive buoyancy, the valve is open.

With only a velocity component of control, marked oscillations of the device are occasioned by overshooting of the device at the mean extremities of its range of travel while it seeks a stable equilibrium state. This is due to inertia. Hence, the device can drift very slowly up or down to any depth. By the inclusion of the pressure-operated component of the control including the bellows **34**, this drift is avoided. Depending upon their relative sensitivities, the pressure component can be considered as a correction to keep the slow drift to zero, or the velocity component can be considered a correction to keep the hunting to a minimum. Appropriate sensitivity ranges for these velocity and pressure components exist which reduce both drift and oscillations to a minimum and thereby impart an optimum of stable equilibrium to the device.

It is noted that the vane **14** when in outstretched, operative position is effective to render a damping action and control the valve, either upon ascent or descent of the device and thus serves the double purpose of damping vertical motion of the device in either direction and actuating the velocity component of the valve action.

Having described the invention what is claimed as novel and desired to be protected by Letters Patent of the United States is:

What is claimed is:

1. In a buoyancy control for an underwater suspension device comprising, a supporting enclosure having gas generating means therein, a valve in said enclosure including opposed disc and seat sections cooperatively operable for regulating the flow of gas therefrom, pressure responsive means secured to said disc section, and velocity responsive means secured to said seat section, said pressure and velocity responsive means thereby being effective to regulate the opening of said valve conformably to the rate of ascent or descent of said enclosure as it seeks a stable equilibrium state.

2. In combination with an underwater suspension device including an enclosure having gas generating means therein, a buoyancy control comprising a valve in said enclosure having cooperatively operable disc and seat sections, Sylphon means secured to said disc section for controlling said valve by pressure, umbrella damping means secured to said seat for controlling said valve by velocity, said controlling means being constructed and

arranged to respond mutually to variations in pressure and velocity occasioned by the ascent or descent of the device as it seeks its pre-set operating depth.

3. In a buoyancy control for an underwater suspension device including a supporting enclosure having gas generating means therein, a valve in said enclosure including first and second opposed cooperating elements for regulating the flow of gas therefrom, pressure responsive means secured to said first element of said valve being operable to vent said enclosure at a varying rate, and damping means secured to said second element of said valve operable to control the venting rate conformably to the rate of ascent or descent of said enclosure as it seeks a stable equilibrium state.

4. In a buoyancy control for an underwater suspension device comprising, a supporting enclosure having gas generating means therein, a valve in said enclosure including first and second opposed sections cooperatively operable for regulating the flow of gas therefrom, pressure responsive means secured to said first element, velocity responsive means secured to said second element, said pressure and velocity responsive means being cooperatively operable to control the position of said opposed sections relative to each other in anticipation of the requirements of the gas volume maintenance or release necessary to establish a stable equilibrium state at a predetermined depth.

5. A submarine suspension device comprising, an enclosure, gas generating means within said enclosure, means for establishing said enclosure at a predetermined depth including a valve communicating with said enclosure for venting said gas, said valve including opposed disc and seat sections, a pressure operated Sylphon secured to said disc section and a vane secured to said seat section, said Sylphon and said vane thereby controlling the opening and closing of said valve in response to variations in pressure and velocity of travel.

6. In a buoyancy control for an underwater suspension device comprising, a supporting enclosure having gas generating means therein, a valve in said enclosure having opposed disc and seat sections cooperatively operable for regulating the flow of gas therefrom, pressure responsive means secured to said disc section, velocity responsive means secured to said seat section, said pressure and velocity responsive means thereby being effective to regulate the opening of said valve conformably to the rate of ascent or descent of said enclosure as it seeks a stable equilibrium state, and means for presetting said pressure responsive means to determine the depth at which said enclosure is in equilibrium.

7. In combination with an underwater suspension device including an enclosure having gas generating means therein, buoyancy control means in said enclosure comprising, a cylindrical member having one end open and communicating with said enclosure and the other end having a valve seat therein, a pressure-responsive Sylphon disposed within said cylindrical member, a valve disc disposed in opposed relationship to said seat and secured to said Sylphon, and umbrella damping means secured to the exterior of said cylindrical member for controlling said valve in response to the velocity of movement of said enclosure, said Sylphon and said damping means thereby controlling the opening and closing of said valve in response mutually to variations in pressure and velocity of travel.

8. In an underwater suspension device including an enclosure having gas generating means therein, a valve in said enclosure including opposed cooperating elements for regulating the flow of gas therefrom, means secured to one of the elements of said valve for venting said enclosure at a varying rate dependent on the depth of said device, and means secured to the other element of said valve and responsive to the rate of ascent or descent of said enclosure for controlling the venting rate.

9. In an underwater suspension device including an enclosure having gas generating means therein, a valve in said enclosure including opposed cooperating sections for regulating the flow of gas therefrom, pressure responsive means secured to one of said sections and velocity responsive means secured to the other of said sections, said pressure and velocity responsive means of said valve cratively operable to control the opening of said valve conformably to the rate of ascent or descent of said enclosure.

10. An underwater suspension device comprising, an enclosure, gas generating means within said enclosure, a valve in said enclosure including opposed disc and seat sections, pressure responsive means secured to said disc section, and velocity responsive means secured to said seat section, said pressure and velocity responsive means being cooperatively operable to control the flow of gas from said valve in response to variations in pressure and velocity of travel.

11. An underwater suspension device comprising, an enclosure, gas generating means within said enclosure, a valve in said enclosure including opposed disc and seat sections, pressure responsive means secured to said disc section, velocity responsive means secured to said seat section, said pressure and velocity responsive means being cooperatively operable to control the flow of gas from said valve in response to variations in pressure and velocity of travel, and means for pre-setting said pressure-responsive device to determine the depth in the water at which said enclosure is maintained in equilibrium.

12. An underwater suspension device comprising, an enclosure having gas generating means therein, a valve in said enclosure including opposed cooperating sections for regulating the flow of gas therefrom, pressure responsive means secured to one of said sections and a normally collapsed vane secured to the other of said sections, said vane when moved into operative position being operative cooperatively with said pressure responsive means for controlling the opening of said valve in response to changes in depth of said enclosure and the velocity of travel thereof in either ascending or descending direction.

13. Apparatus in accordance with claim 12 including means for pre-setting said pressure responsive means to determine the depth at which said enclosure is maintained in position.

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