United States Patent [19]

Furth et al.

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[45] **Jan. 21, 1975**

[54] **CONTROLLABLY SUBMERSIBLE BUOY**

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[73] Assignee: **Cameron Iron Works, Inc.**, Houston, Tex.

[22] Filed: **Oct. 12, 1971**

[21] Appl. No.: **188,473**

Related U.S. Application Data

[63] Continuation of Ser. No. 873,038, Oct. 31, 1969, abandoned.

[52] **U.S. Cl.** ..... **9/8 R** 114/16

[51] **Int. Cl.** **B63b 21/52**

[58] **Field of Search** ..... 9/8 R, 8 P; 114/50, 51, 114/16 E, .5 T, 16.8, 16.4

[56] **References Cited**

UNITED STATES PATENTS

1,201,051	10/1916	Jack	114/51
1,310,877	7/1919	Schneider	114/16 E
1,815,904	7/1931	Grieshaber	114/16.8
2,422,337	6/1947	Chilowsky	9/8 R
3,103,020	9/1960	Bolton	114/230
3,111,926	12/1961	Shatto	114/230 X
3,257,672	6/1966	Meyer et al.	9/8 R
3,293,676	12/1966	Link	9/8 R

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[57] **ABSTRACT**

A mooring buoy of sufficient size to permit mooring of ships thereto and a control system to control the rate of ascent and descent of the submersible buoy.

28 Claims, 6 Drawing Figures

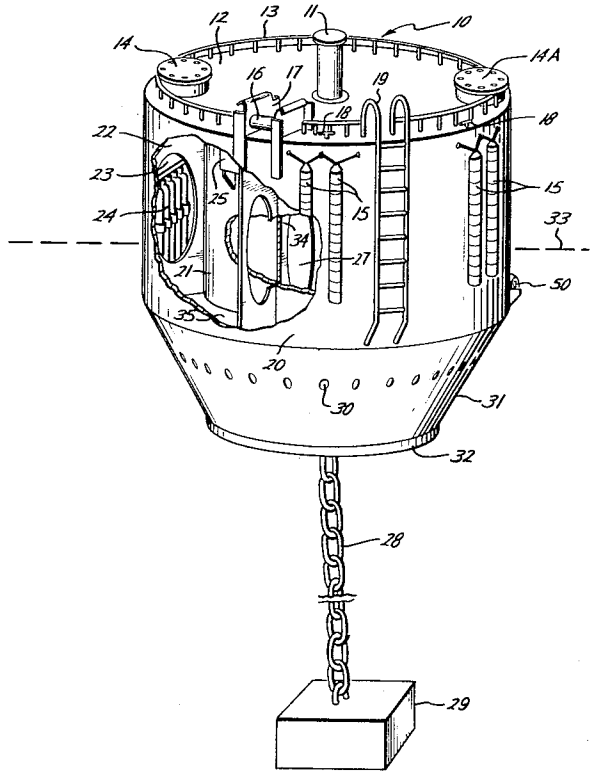


Fig. 1

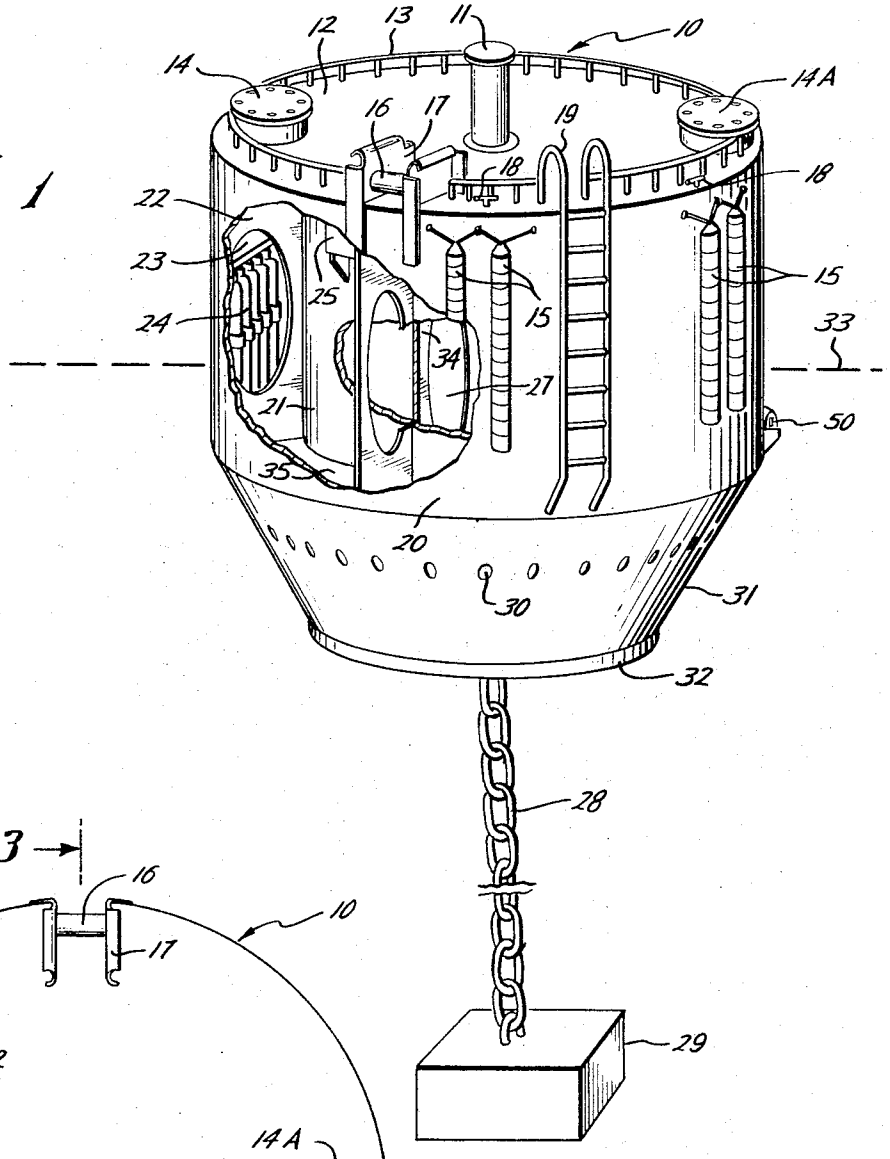
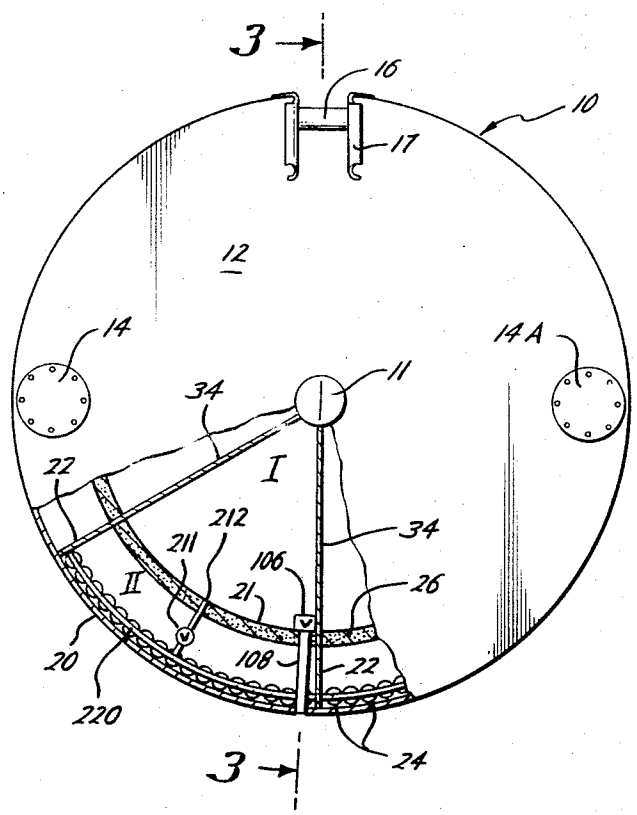


Fig. 2



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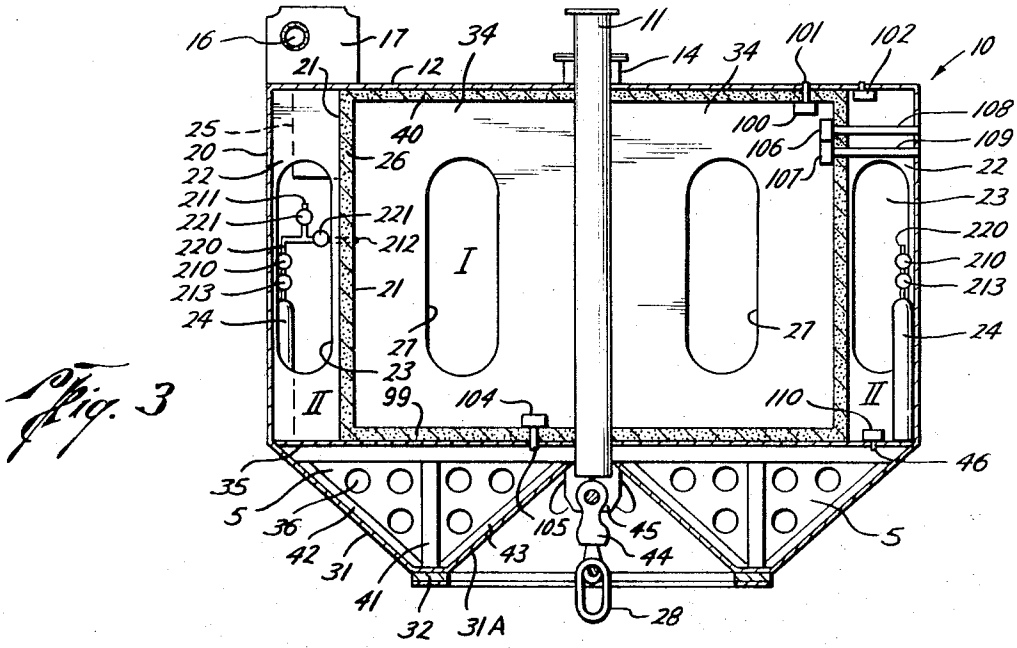


Fig. 3

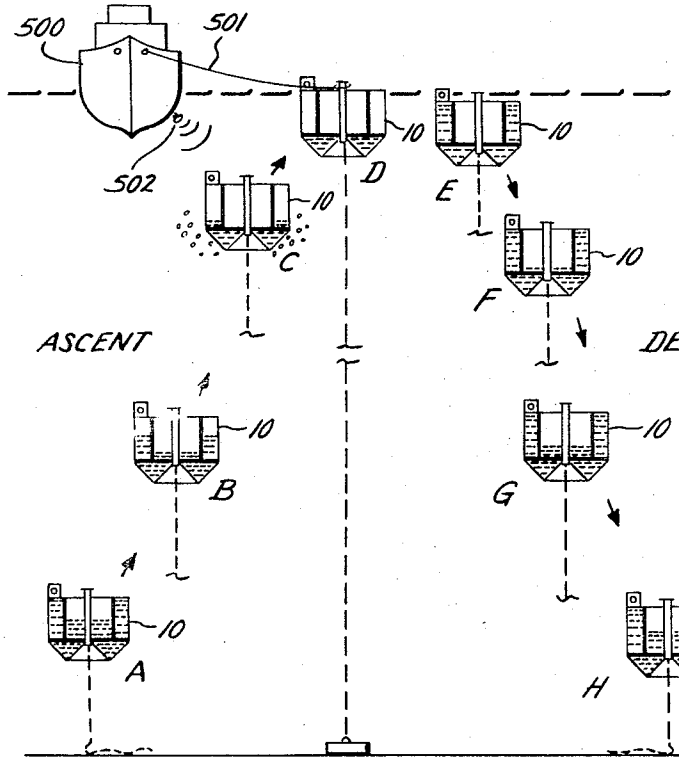


Fig. 5

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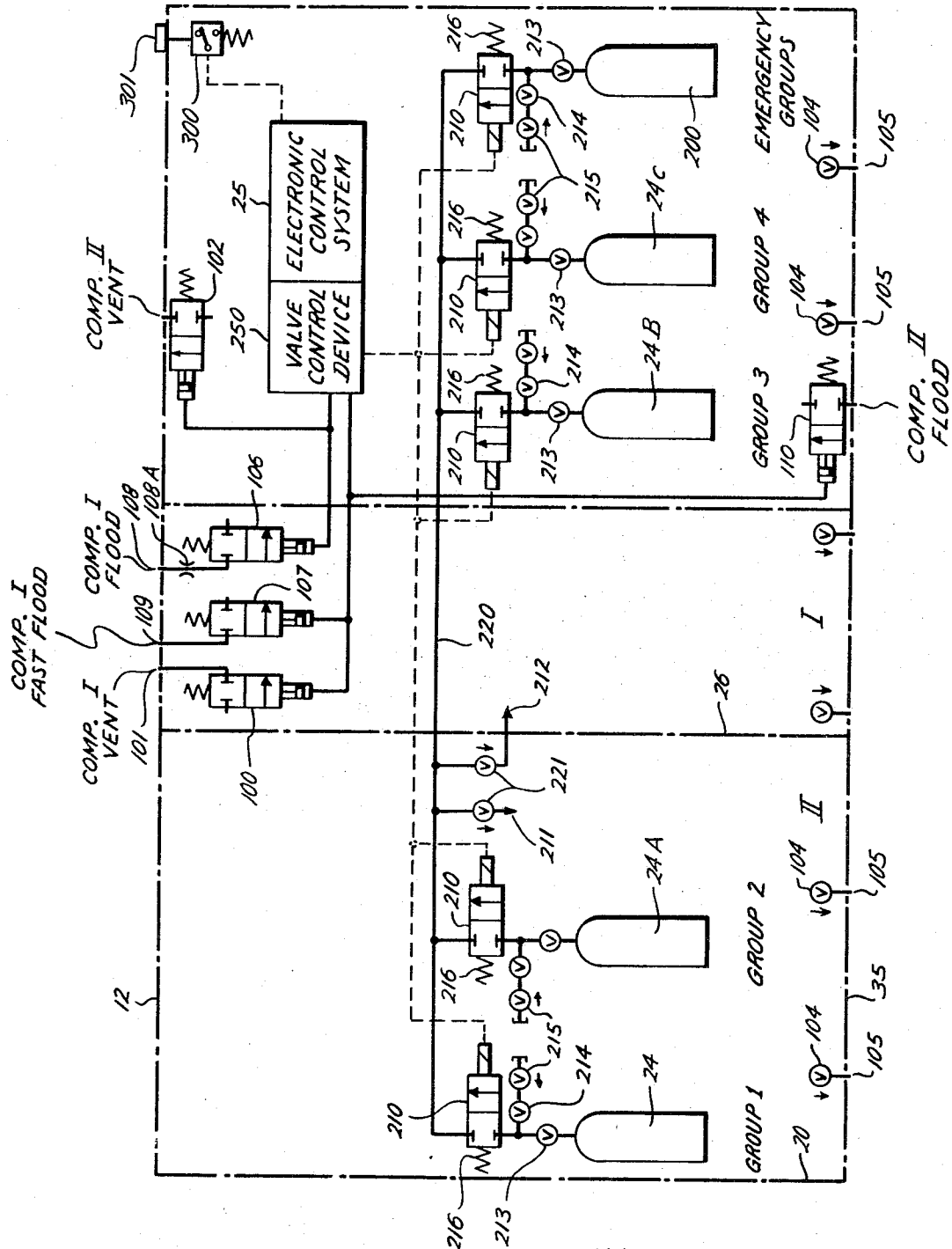


Fig. 4

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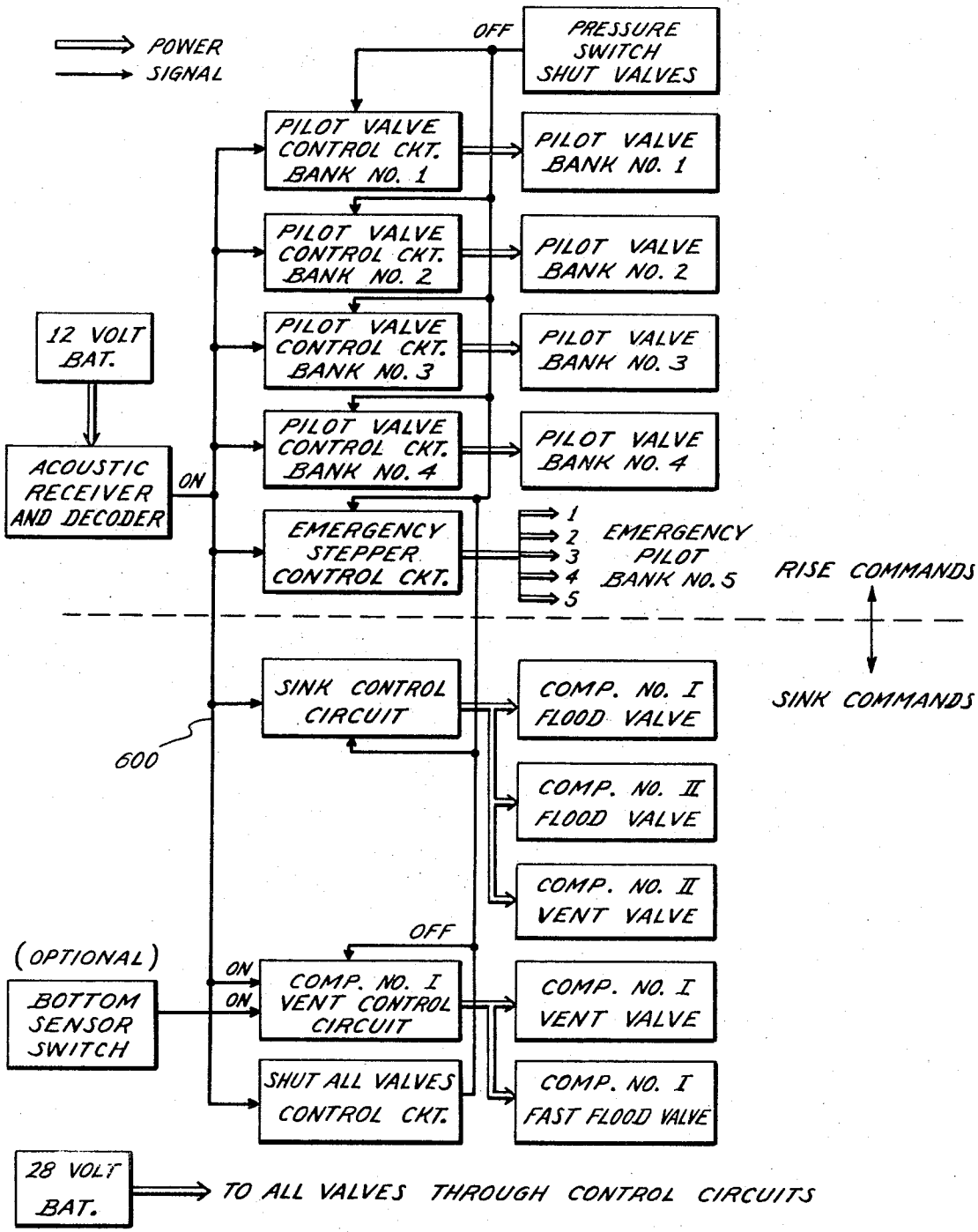


Fig. 6

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CONTROLLABLY SUBMERSIBLE BUOY

This is a continuation of application, Ser. No. 873,038, filed Oct. 31, 1969, now abandoned.

CROSS REFERENCES AND BACKGROUND

Inflatable buoys are known in the art. For example, U.S. Pat. No. 3,126,559 to D. O. Alexander shows an acoustically controlled inflatable buoy. In this patent, a collapsible bag is included within a suitable superstructure. The bag is controllably and selectively inflated by means of a gas or air cylinder which is controlled from a unit at or near the surface of the water. Other retrievable type buoys are shown in U.S. Pat. No. 3,199,070 to W. E. Baier, Jr. and U.S. Pat. No. 2,594,702 to S. W. Woodard. Each of these patents suggests a buoy arrangement which may be controllably released from an anchored position subsea. In addition, other patents show or suggest buoys which can be resubmerged by means of a winch or the like. The winch is selectively operated to reel the cable for tethering the buoy whereby the buoy is submerged.

However, as is obvious, each of these buoys is a relatively small buoy such as a marker or tell-tale buoy which is utilized to mark a particular underwater location. These buoys are not sufficiently large to permit a large vessel to moor thereto. Moreover, the buoys are tethered by relatively small lines so that anchoring of a vessel would be impossible.

With the exception of the Alexander patent, the prior art shows buoys which normally have positive buoyancy relative to the water environment, these buoys are naturally inclined to float to the surface and must be restrained. In addition, the descent of the buoys is either uncontrolled or controlled only as a function of the winch operation which retracts or submerges the buoy.

Obviously, in an uncontrolled ascent and descent operation, pressure equalization within the buoy is virtually impossible. Furthermore, control of the manner in which the buoy lands upon the bottom is relatively impossible. In the winch-operated submerging system, great difficulties will normally be experienced with the winch both insofar as the powering thereof is concerned and the mechanical operation thereof with marine growth and the like.

In the subject invention, a large buoy is provided. This buoy is sufficiently large, for example on the order of **18** feet in diameter, to permit large ocean-going vessels to moor thereto. The large buoy is secured by means of a heavy chain such that a reliable anchor is provided between the mooring buoy and the bottom of the body of water. In addition, when submerged, the large buoy resists the forces applied thereto by passing ships, or the like, whereby the buoy does not inadvertently and undesirably rise from the bottom, possibly foul the props of the passing ships, and/or sustain damage upon descending back to the bottom.

The buoy is raised and lowered by means of an acoustically operated control system which selectively actuates suitable air or gas cylinders within the buoy whereby water is expelled from the submerged buoy until the negative buoyancy of the water filled buoy is effectively eliminated. As the buoy rises, the pressure thereon due to the environmental water decreases. Consequently, the air in the buoy tends to expand. It is desirable that air in excess of the amount required to maintain the pressure equalized be exhausted from the buoy.

Conversely, to accomplish descent, some of the air in the ballast chamber is vented and water is admitted into the buoy. When the ballast chamber is partially flooded, the buoy is neutrally buoyant wherein the weight of the buoy and the chain depending therefrom is approximately equal to the buoyancy of the buoy. Water is then permitted to enter the inner chamber at a slow, controlled rate. The weight deposition rate of the chain will be approximately equal to the weigth flow rate of water into the buoy. Consequently, the buoy descends at a controlled rate. Thus, a suitably "soft landing" of the buoy on the bottom may be attained. This type of landing prevents damage due to impact. As well, a hard landing wherein the buoy could conceivably be imbedded in a mud bottom is avoided.

Consequently, one object of this invention is to provide a buoy which is controllable as to ascent and rate of descent.

Another object of this invention is to provide a buoy which is suitable for mooring of large vessels.

Another object of this invention is to provide a submersible buoy which has few maintenance requirements.

Another object of this invention is to provide a submersible buoy which is remotely controlled.

DESCRIPTION OF DRAWINGS

The above mentioned and other objects and advantages of the subject invention will become more readily apparent when the following description is read in conjunction with the attached drawings in which:

FIG. **1** is a substantially pictorial, partially cut-away, drawing of the buoy of this invention;

FIG. **2** is a top view of the buoy of the instant invention, partially in section;

FIG. **3** is a side veiw of the buoy of the instant invention taken along the line **3—3** of FIG. **2**;

FIG. **4** is a schematic diagram of the hydraulic control system for the buoy of the instant invention;

FIG. **5** is a schematic showing of the sequential operation of the buoy during the ascent and descent thereof; and

FIG. **6** is a block diagram of the control circuitry associated with the buoy of the instant invention.

In each of the drawings, similar components bear similar reference numerals.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to FIG. **1**, there is shown a pictorial representation of a mooring buoy such as described herein. The showing is partially cut away to show some of the interior detail. Buoy **10** is shown floating substantially at the surface **33** of a body of water. A chain **28** is connected to a suitable anchor device **29** which may be a large concrete block or any similar suitable device. Chain **28** is connected (as better shown in FIG. **3**) to a central mooring strong back element **11.**

Buoy **10** is a substantially right circular cylindrical unit and typically has a diameter of **18** feet. Top deck **12** is substantially flat. Guard rail **13** is affixed to deck **12** in a suitable manner. On or more cleats **18** are affixed to deck **12** in a suitable manner whereby small work boats or the like may be moored thereto. A guard channel **17** is affixed to deck **12** of the buoy. Guard channel **17** includes two opposing members which are

formed, as for example by rolling or the like, whereby no sharp edges are presented in the space between the sides of channel **17.** A suitable cross-member **16** is connected between the sides of channel **17.** Cross-member **16** is a rod or tube which is affixed to the side members of channel **17** by any suitable method such as welding or the like. Cross-member **16** is spaced from deck **12** by a distance which is sufficient to permit passage therebetween of standard mooring hawsers. The hawser is then looped over the central mooring element **11** which, as shown, extends above the deck **12** and includes a flanged end portion. With these elements and the cooperation therebetween, the hawser is prevented from slipping off mooring element **11** and, as well, does not tend to tip buoy **10** significantly from the vertical position.

Outer shell **20** of buoy **10** is fabricated of a suitable material such as carbon steel with appropriate corrosion protection being afforded by marine primers and paint. Bottom deck **35** is attached to peripheral wall **20.**

Interior wall **21** also has a substantially right circular cylindrical configuration concentric with outer wall **20.** The compartment defined by wall **21** may have an outside diameter on the order of 10 feet. Inner wall **21** may be fabricated of concrete, steel, or a concrete-filled steel annulus. The latter wall material is suggested for both strength and ballast.

Thus, there are two, concentric, right-circular, cylindrical compartments defined by the inner and outer walls **21** and **20,** respectively. A plurality of bulkheads **22** is connected between the inner and outer walls to provide structural strength as well as to properly space the compartmental walls. Each of the bulkheads **22** has an opening **23** therein. The openings permit communication between the sections of the outer compartment. Thus, in the flooded condition, water may flow from one section to the next via the openings **23.** However, the openings **23** are designed to prevent excessive sloshing of water in the outer compartment, especially when the outer compartment is only partially filled.

A plurality of bulkheads **34** are located in the inner compartment between the inner surface of inner wall **21** and the axial strong back mooring element **11.** Bulkheads **34** may be aligned with bulkheads **22** or, in the alternative, they may be arranged at different spacing. Bulkheads **34,** include openings **27** therein for the same purpose as openings **23** in bulkheads **22.**

A plurality of pressurized gas cylinders **24** are provided in buoy **10.** In the preferred embodiment, cylinders **24** are disposed adjacent the inner surface of outer wall **20.**

A pair of access ports **14** and **14A** are provided in deck **12.** The number of access ports is not limited to two; any desirable number may be utilized. Acess ports **14** are provided such that the interior of buoy **10** may be reached by maintenance personnel. Thus, the air bottles may be recharged or any other internal gear may be serviced as necessary.

An electronic control package **25** is mounted in the outer compartment between the inner and outer walls. The electronic control package is described in more detail hereinafter. However, it is noted at this point that the electronic control package is utilized to control the operation of the pressurized gas bottles, vents associated therewith, and valves for selectively admitting water and thereby flooding the respective compartments of buoy **10.**

Suitable marine fenders **15** are disposed around the periphery of buoy **10.** A suitable ladder **19** is provided to permit access to deck **12** of buoy **10.** A hydrophone **50** is mounted at the periphery of buoy **10** at a location which will remain below the water surface even when buoy **10** is surfaced. Hydrophone **50** receives signals from the surface control unit and communicates same to electronic control package **25.**

Below the right circular cylindrical portion of buoy **10** is a substantially frusto-conical section **31.** A landing surface which, as will be seen hereinafter, is in the form of a ring **32,** is formed at the tapered end of conical section **31.** A plurality of ports **30** are provided in the outer surface of the frusto-conical section **31.** As will appear hereinafter, ports **30** may comprise vents or ports for the venting of air and water or intake of water into the system.

Referring now to FIG. **2,** there is shown a top view of the buoy partially broken away to show some interior detail. Some of the external detail has been omitted for purposes of clarity. As noted, a centrally located strong back element **11** such as a rod or pipe-like unit is axially located relative to buoy **10.** The access ports **14** and **14A** are shown. The covers for these access ports may be bolted or otherwise fastened to the buoy. As shown in FIG. **2,** the outer surface **20** may be fabricated of a relatively thin material such as a sheet of carbon steel. The inner wall includes annulus **21** shown filled with concrete **26.** Thus, an inner and an outer compartment are provided. A plurality of bulkheads comprising outer bulkheads **22** and interior bulkheads **34** are positioned as described supra. The bulkheads extend radially from the center of buoy **10** toward the cylindrical wall unit which forms the periphery of each of the compartments.

Also shown in FIG. **2** is valve **106** and suitable conduit **108.** Valve **106** is shown on the interior of the inner compartment. In fact, valve **106** may be, alternatively, connected "in-line" with the conduit **108.** Conduit **108** extends between outer wall **20** and inner wall **21** and passes completely through each of these walls. Thus, depending upon the status of valve **106,** water can selectively pass into the inner chamber from the exterior of the buoy thereby flooding the inner chamber if the external opening of the conduit **108** is submerged.

Referring now to FIG. **3,** there is shown a side view of the buoy taken along the line **3—3** in FIG. **2.** The outer wall **20** and inner wall **21,** with concrete lining **26,** are more clearly shown. In addition, it is obvious that decks **12** and **35** include concrete reinforced portions **40** and **99,** respectively. Clearly, the reinforced portions **40** and **99** represent the bottom and top members of the right-circular, cylindrical device which encloses inner compartment I. The electronic package **25** is shown in dashed outline in a typical mounting.

The concical support section at the base of buoy **10** includes conical surfaces **31** and **31A.** These surfaces are stiffened by structural members **42** and **43,** respectively. Structural members **42** and **43** are representative of a plurality of similar stiffeners which are spaced and arranged to form a conical member when the outer sheath (such as surface **31** or **31A**) is applied. Bulkheads **35** are attached to the structural members **42** and **43** as well as to the vertical support member **41.** Holes **36** are provided both to permit passage of water from one section of the support cone to another, and to re-

duce the weight of structure included within the conical section.

Annular ring **32** is connected to the bottom end of upright supports **41.** At the opposite ends, the support members **41, 42** and **43** are connected to a suitable support structure **46** which substantially spans the entire buoy **10.** Structural member **46** is affixed to the bottom portion of buoy **10** by suitable means.

Vent **101** and valve **100** are disposed adjacent to deck **12** and support member **40.** Vent **101** permits air to escape from compartment I when vavle **100** is open. Vent **105** located in deck **35** and support member **99** permits water to be expelled from compartment I when check valve **104** is open. Conduits **108** and **109** (which may be pipes or the like) pass through walls **26** and **20.** Valves **106** and **107** are associated with conduits **108** and **109.** Thus, depending upon the status of valves **106** and **107,** water may selectively flow in compartment I. The different lines permit different rates of flow therethrough when the associated valve is open.

A suitable fitting **45** is attached to the central strong back column **11.** The column and fitting may be joined by welding or the like. A suitable coupling **44,** which is well known in the art, may be connected to fitting **45** by means of a pin or the like. Chain **28** is connected to coupling unit **44** by an additional pin or the like.

Referring now to FIG. **4,** there is shown a schematic representation of the hydraulic control system for the buoy. The heavy outlines represent decks **12** and **35,** inner wall **26,** and outer wall **20,** respectively. Since this is a schematic showing, a scale relationship is, of course, not utilized. A plurality of cylinders **24, 24A, 24B** and **24C** represent the gas bottles which are dispersed around the periphery of buoy **10.** Normally, as shown in FIGS. **1** through **3,** bottles **24–24C** are disposed adjacent the inner surface of outer wall **20.** In a typical embodiment, cylinders **24–24C** represent four separate groups of **24** bottles of compressed gas per group. The number of bottles per group is not limitative but suggests the necessary complement which permits the buoy to be raised when the bottles are rendered operative. Of course, the number of bottles is merely typical. Depending upon the buoyancy requirements, the size of the bottle and the like, other numbers of bottles of pressurized gas may be utilized.

A separate bottle **200** is representative of an optional emergency arrangement wherein a further plurality of pressurized gas bottles is utilized. The emergency bottles are utilized only in the event that the standard bottles **24–24C** are incapable of supplying sufficient gas to cause the buoy to rise either due to a defect in the bottles, leakage in the buoy or the like. Each of the bottles is shown to include a valve **213** connected thereto to regulate gas flow therethrough. A similar valve **214** is connected to a charging connector with an integral check valve **215** associated with each of the banks of bottles. Charging connector **215** is, when necessary, connected to a suitable external source for recharging the gas bottles with gas after usage. Valve **214** controls gas flow therethrough. A shut-off valve **210** is connected to each of the gas bottles. In one position, for example the position shown, each valve **210** is shut to prevent gas flow from the associated pressurized bottles. When energized, as described hereinafter, each valve **210** is opened so that compressed gas flows therethrough in the direction of the solid line arrow. Spring **216** or the like is associated with each of valves **210** in order to provide fail-safe operation to the closed position. That is, when the control signal is removed from the valve, spring **216** causes valve **210** to assume the position shown in the drawings.

As is seen, each of valves **210** is connected to common line **220.** Common line **220** is connected via check valves **221** to vents **211** and **212.** Vents **211** and **212** open into compartments II and I, respectively. Thus, when valves **210** are placed in the open position, the gas from pressurized bottles **24–24C** is supplied to common line **200** and, thus, to compartments I and II.

When the pressurized gas is applied to the respective compartments, the water contained in the compartments becomes, effectively, pressurized and passes through check valves **104** and vents **105** thereby to be vented to the sea. As suggested in the description of FIG. **3,** the pressurized water which is expelled through vent **105** effects a type of jetting action whereby the buoy is raised from the subsea surface. As noted supra, suitable conduits, or the like, may be connected from vents **105** to the ports **30** in the conical surface **31.** These jets will assist the buoy to be loosened from the bottom mud.

As is seen, the solenoid portion (or pneumatically controlled portion) of each of valves **210** along with the valves **100, 102, 106, 107** and **110** is controlled by valve control device **250.** As suggested, valve control device **250** includes electronic control system **25** which supplies an appropriate signal to the solenoid portion of the valve. Moreover, as may be required in some embodiments, valve control device **250** can supply electrical signals to valves **210** and pneumatic signals to the other valves or some suitable combination of electronic and pneumatic signals. The pneumatic signals may be required in the event that valves such as valves **100** and the like are large valves. The signals supplied to the valves are controlled by the electronic control system **25.** Electronic control system **25** receives signals from hydrophone **50** which is mounted at the exterior of the buoy. Thus, electronic control system **25** will supply signals to the valves in the proper sequence, as described hereinafter, so that the valves are properly positioned and the compartments purged or flooded as the case may be. A further control signal is supplied to electronic control system **25** via pressure switch **300.** Pressure switch **300** is connected to a suitable transducer **301** which detects, via pressure sensing techniques, the surfacing of the buoy. In particular, the signal from pressure switch **300** causes electronic control system **25** to supply a signal which closes valves **210** so that the solenoids do not discharge the batter after the buoy has surfaced.

Referring now to FIG. **5,** there is shown, schematically, the operation of buoy **10.** Typically, buoy **10** is located at or adjacent the bottom of the body of water with compartments I and II flooded, or substantially flooded, as shown in diagram A of FIG. **5.** Because of the inherent weight in the flooded condition, the buoy rests firmly on the bottom of the body of water where it is free from interference with or by passing ships. Upon the arrival of a vessel **500** which is desirous of mooring in the area, a suitable acoustical signal is generated either by means of a transducer **502** disposed at or adjacent the vessel or by a suitable signaling device located in the vicinity of the mooring buoy. The signal is received by hydrophone **50** (see FIGS. **1** through **4**) which causes electronic control system **25** to produce

suitable control signals. The control signals cause valve **210** to open wherein the pressurized gas in one set of bottles **24–24C** (see FIG. **4**) is discharged into compartments I and II. As discussed previously, the discharge of the pressurized gas causes the water in compartments I and II to be purged from the compartments via check valves **104** and vents **105.** As the water is purged from compartments I and II, a condition of positive buoyancy is effected in buoy **10.** Buoy **10** will then begin to rise toward the surface of the water.

It may be desirable, to have a gas discharge rate which is relatively large in order that mud around the buoy **10** may be "jetted" away. This operation overcomes any natural resistance which may be incurred due to a vacuum or suction created by a soft mud bottom.

After the buoy has started to rise (as shown in segment B), the positive buoyancy causes the buoy to continue to rise. Inasmuch as the external pressure will decrease, and the internal pressure will increase due to the continued operation of the air bottles, the volume of the gas in the purged compartments will tend to expand thereby hastening the purging process. In order to compensate for the increasing internal pressure (relative to the environment), check valves **104** will also permit the discharge of the pressurized gas therethrough as suggested in section C. However, the check valves will be properly defined so that positive buoyancy of the buoy is maintained after the buoy has surfaced.

When the buoy nears the water surface, pressure switch **300** (see FIG. **4**) closes all of the valves wherein pressurized gas from bottles **24–24C** is no longer supplied to the internal compartments of the buoy. Thus, an equilibrium condition is achieved across check valves **104** whereby the valves close and the buoy will float at a predetermined level as shown in Section D. For example, the top deck of the buoy will be several feet above the water surface. At this point, by means of a suitable crew boat, or the like, hawser **501** is affixed to the mooring buoy as described previously and as shown in Section D. It is understood that with tide changes and the like, the lines may tend to assume different geometrical configurations but, nevertheless, vessel **500** is securely anchored via hawser **501,** buoy **10,** and anchor chain **28** depending from the buoy.

When the necessity or desirability of mooring vessel **500** terminates, hawser **501** is removed from buoy **10** and a suitable signal is generated by transducer **502** or from a suitable control station. This signal is received by hydrophone **50** and is supplied to electronic control system **25.** This signal operates to provide signals via valve control device **250** to open valves **102, 106** and **110.** As will be seen, opening of valve **110** permits inflow of water into compartment II to flood this compartment. The concurrent operation of valve **102** permits the venting of compartment II whereby any entrapped air may be expelled. Valve **106** serves a similar function in allowing water to enter compartment I. However, the inlet port **108** is located high on the buoy and is connected through a restriction **108A** such that the rate at which water enters compartment I is controlled. Thus, as shown in sections E and F of FIG. **5,** compartment II will tend to flood substantially rapidly thereby causing the mooring buoy to have substantially neutral buoyancy and to float at or near the surface of the water. However, inasmuch as water is entering compartment I through valve **106** at a controlled rate, a controlled rate of descent of the buoy is effected as shown in sections F and G of FIG. **5.**

The rate of flooding via valve **106** is controlled by the restriction or nozzle **108A.** The rate is pre-determined and is a function of the size, weight and desired deposition rate of the anchor chain. That is, as the chain is deposited on the bottom, it is no longer supported by the buoy. Since the chain is no longer being supported by the buoy, an increased amount of water is required to cause the buoy to continue to sink at the predetermined rate. In a preferred embodiment, the rate of water input is preset to cause the buoy to descend or sink at the rate of approximately 0.5 feet per second. This rate of sinking is believed to avoid any damage to the buoy when striking a hard bottom as well as to avoid burying the buoy in a soft, muddy bottom.

When, as shown in section H of FIG. **5,** the buoy has reached the bottom, valves **100** and **107** are opened. Valve **100** provides a vent to permit the escape of the air which has been entrapped in compartment I. Concurrently, valve **107** is connected via port **109** to permit fast flooding of compartment I. The fast flood and vent permit substantially uncontrolled flooding which, while undesirable during the descent of the buoy, is advantageous when the buoy has reached the bottom.

The control of valves **100** and **107** can be effected by an acoustic signal which is detected by hydrophone **50.** This signal may be sequentially programmed automatically from the surface at a time which is subsequent to the descent period. For example, the descent may be known to take approximately **3** minutes. The flood signal would be generated after a period of about **5** minutes.

In the alternative, a sensing switch or the like, (not shown) could be disposed adjacent the bottom of the buoy. This switch could be operated when the buoy strikes the bottom of the body of water thereby supplying a signal via electronic control system **25** to valve control device **250** to cause valves **100** and **107** to open and thereby fast flood compartment I. After the flooding has been completed, an acoustic signal is transmitted to cause all valves to close thereby conserving electrical power.

Flooding of compartment I is desirable (and may be required) in order to securely maintain the buoy at the bottom. However, as noted supra, the fast flood is not desirable prior to the full descent of the buoy in order to prevent damage thereto.

Referring now to FIG. **6,** there is shown a block diagram of the control circuit which is utilized with the subject invention. A **12** volt battery is connected to the acoustic receiver and decoder to supply power thereto. When the acoustic receiver and decoder receive signals via a hydrophone or the like, the signal is decoded and a control signal is supplied to a plurality of functions via cable **600.** Cable **600** includes sufficient lines to supply the several functions. The battery and acoustic receiver and decoder are mounted in the buoy, for example in compartment II. To raise the buoy, the control signal is supplied to the pilot valve control circuit for bank **1, 2, 3** or **4** of pressurized gas bottles. The pilot valve control circuits are arranged to operate the associated pilot valves. The pilot valves are equivalent to valves **210** as shown in FIG. **4.** Banks **1, 2, 3** and **4** are equivalent to bottles **24–24C** as shown in FIG. **3.** The emergency stepper control circuit is connected to five emergency

pilot valves which are connected to emergency bottles **200** as noted supra. Bottle **200** represents five four-bottle emergency groups in a preferred embodiment. Pressure switch **300** (FIG. **4**), upon detecting a predetermined pressure condition, provides a signal which turns off the control circuits for each of the pilot valves and the stepper control circuit.

As shown in FIG. **6**, each of the above enumerated functions is associated with the "rise" commands which cause the buoy to ascend. The sink control circuit also receives a signal from the acoustic receiver and decoder via cable **600**. The sink control circuit supplies signals to the flood valves of compartments I and II as well as the vent valves of compartment II. It should be noted, that the flood valve associated with compartment I, as controlled by the sink control circuit, is equivalent to valve **106** which is the "slow flood" valve. The fast flood valve for compartment I, as well as the vent valve for compartment I, (equivalent to valves **100** and **107** in FIG. **4**) are connected to and operated by the compartment I vent control circuit which, as shown, can be operated either by an acoustic signal which is received by the acoustic receiver and decoder or by means of a bottom sensor switch. A control circuit to shut all valves is also connected to receive a signal from the acoustic receiver and decoder device and provide a signal which turns off power to all valves. Thus, the buoy is in condition for the next operation.

A 28 volt batter may be utilized to provide the necessary electrical power for the valves. This battery, along with the 12 volt battery associated with the acoustic receiver and decoder, is mounted in the buoy. In an alternate configuration, one battery may be used with voltage regulating devices to provide other voltages that may be necessary for the electronic system.

While not shown or described, it is understood that suitable electrical connections may be provided whereby the batteries may be recharged, the pressurized bottles recharged, and other maintenance be permitted from the exterior of the buoy. In addition, a connection may be supplied to the buoy such that pressurized gas may be inserted therein from an external source in the event that the buoy develops a leak after it has surfaced. Moreover, this external source would tend to conserve the bottled gas for futher usage.

Having thus described a preferred embodiment of the invention, what is claimed is:

1. A buoy, comprising a hollow body adapted to receive water to cause it to descend to a desired level therein, check valve means for venting such water from the body, a source of compressed gas within the body, means for releasing gas from said source into said body to force water from said body through said check valve means and thereby cause said body to rise to the surface, and means adapted to be located on said body above the normal water line of said buoy when surfaced for automatically closing said gas releasing means when said body reaches said surface.

2. A buoy of the character defined in claim **1**, wherein said gas releasing means includes a normally closed valve controlling the outlet from said gas source, a source of electrical power, and means powered by said power source to open the valve, and the means for closing the gas releasing means includes means for disconnecting the power source from the valve opening means to permit said valve to close.

3. A buoy, comprising a hollow body having inner and outer concentric compartments, means for admitting water to each compartment while venting gas therefrom to cause the body to descend, a source of compressed gas, means for admitting gas from said source to each chamber while venting water therefrom to cause the body to ascend, and a chain extending axially downwardly from the bottom of the body.

4. A buoy of the character defined in claim **3**, wherein the means for venting water is in the bottom of the body to cause a downward jetting action.

5. A buoy comprising a hollow body having at least two separate water compartments therein each adapted to receive water to cause the buoy to descend, the compartments of said buoy being arranged to permit the buoy to normally float with a positive buoyancy when said compartments are empty of water, first inlet means for flooding one of said compartments with water at a relatively fast rate to cause said buoy to have a substantially neutral buoyancy, second inlet means for flooding another of said compartments at a relatively slower, controlled rate to cause the buoy to have controlled negative buoyancy and to descend at a controlled rate, and outlet means for venting water from each of said compartments.

6. The buoy of claim **5** wherein said first and second inlet means are valves having inlet ports, and wherein the inlet port of said second inlet means provides a greater restriction to the flow of water than the inlet port of said first inlet means.

7. The buoy of claim **5** including an outer water compartment and an inner water compartment concentric with said outer water compartment, and wherein said first inlet means is connected to said outer water compartment and the second inlet means is connected to said inner water compartment.

8. The buoy of claim **5** further including anchor means extending downwardly from the buoy.

9. A submersible buoy having a controllable rate of ascent and descent comprising a body member having first and second buoyancy chambers therein, first water flow valve means to control the flow of water from outside said body member to said first chamber, said valve means including a flow conduit with a restriction therein so that water enters said first chamber at a relatively slow, predetermined controlled rate when said valve means is in an open position, second water flow valve means to control the flow of water from outside said body member to said second chamber, said valve means having an unrestricted flow conduit so that water enters said second chamber at a relatively fast rate when said valve means is in an open position, first and second gas vent means to permit the escape of gas from said first and second chambers, respectively, each of said vent means having valve means to control said escape of gas from the first and second chambers, first and second water vent means to permit the flow of water from said first and second chambers, respectively, to outside said body member, each of said water vent means having check valve means to control said flow of water from the first and second chambers, a source of pressurized gas positioned within said body member, gas flow valve means to control the flow of gas from said source to said first and second chambers, valve control means adapted to control in predetermined sequence the opening and closing of said first and second water flow valve means, said first and sec-

ond gas vent means and said gas flow valve means, so as to control the admission of water to said first and second chambers and the purging thereof during descent and ascent of said buoy, said valve control means including signal receiving means adapted for detecting signals from a remote source, and anchor means connected to said body member, said anchor means comprising an anchor chain having an anchor device connected thereto for positioning at the bottom of the body of water in which said buoy is to be located, whereby the buoy may be located at the bottom of said body of water with said first and second chambers flooded with water and may be caused to rise to the surface by a signal to said signal receiving means resulting in the opening of said gas flow valve means causing the flow of pressurized gas to said chambers, purging said water therefrom and creating a positive buoyancy so that said buoy rises to the surface, a further signal to said signal receiving means causing said valve control means to open said first and second water flow valve means and said gas vent means, the flow of water to said second chamber creating a neutral buoyancy of said buoy, the relatively slower rate of water flow to said first chamber causing the buoy to sink at a relatively slow, controlled rate, thereby avoiding damage to the buoy upon reaching the bottom of said body of water.

10. The buoy of claim **9** and including signal means for transmitting signals for selectively activating said valve control means, said signal means being located at a source remote from said valve control means.

11. The buoy of claim **10** in which said signal means is adapted to transmit acoustical signals and said signal receiving means is adapted to receive said acoustical signals.

12. The buoy of claim **9** and including third water flow valve means to control the flow of water from outside said body member to said first chamber, said valve means having an unrestricted flow conduit so that water enters said first chamber through said third valve means at a relatively rapid rate when said third valve means is in an open position, said valve control means being adapted to open said third water flow valve means when the body member has reached the bottom of said body of water and to close said third valve means together with said first and second valve means for subsequent ascent of said body member to the surface, said valve control means also being adapted to open said first gas vent means when said third valve means is opened, so that fast flooding of said first chamber is achieved after the body member has reached the bottom for more secure positioning at the bottom of said body of water.

13. The buoy of claim **12** and including pressure detection means positioned on said body member, said means being adapted to supply a control signal to said valve control means when said body member reaches the surface of said body of water, said valve control means being adapted to close said gas flow valve means upon receiving said signal from the pressure detection means.

14. The buoy of claim **13** and including a mooring element extending upward from said body member, said mooring element being adapted for the securing of a mooring hawser of a vessel desiring to moor to said buoy, said mooring element also extending downward beneath said body member and being adapted for connection to said anchor chain.

15. The buoy of claim **14** in which said first and second chambers are concentric, right-circular, cylindrical compartments and said mooring element comprises an elongated strong back element axially located with respect to said body member and said first and second chambers thereof.

16. The buoy of claim **15** and including below said body member a substantially frusto-conical section having a plurality of ports on the outer surface thereof and a landing ring positioned at the tapered end of said conical section.

17. The buoy of claim **16** in which said ports comprise vents for the venting of air and water from said body member and ports for the intake of water to said body member.

18. The buoy of claim **12** in which said valve control means comprises an electronic control system and said first and second gas vent valve means, said gas flow valve means and said first, second and third water flow valve means comprise solenoid valves.

19. A buoy, comprising a hollow body, means for admitting water to the body to cause it to descend therein at a controlled rate, means automatically responsive to the descent of said body to the surface beneath said water for admitting water to the body at a faster rate, and means venting gas from the body as water is admitted thereto.

20. A buoy of the character defined in claim **19**, wherein the means for admitting water includes means on the body for engaging with said surface beneath the water and admitting said water in response to said engagement.

21. A buoy of the character defined in claim **19**, wherein the means for admitting water includes means for timing the controlled descent of said body and admitting said water when said time has expired.

22. A buoy of the character defined in claim **19**, including means for closing said water admitting and gas venting means, a source of compressed gas within the body, means for releasing gas from said source into said body, means for venting water from the body as gas is released thereto so as to cause the body to rise to the water surface, and means for closing the gas releasing means when said body has ascended to the water surface.

23. A buoy of the character defined in claim **22** wherein said means for closing the gas releasing means includes means automatically responsive to ascent of said body to the water surface.

24. A buoy of the character defined in claim **19** wherein the body has a compartment into which water is admitted at said controlled and faster rates, and the gas venting means includes means for venting gas from said compartment upon descent of said body to said surface beneath the water.

25. A buoy of the character defined in claim **19** wherein the body has a first compartment into which water is admitted at said controlled rate and a second compartment into which water is admitted at said faster rate, and the gas venting means includes means for venting gas from the first compartment as water is admitted thereto at said controlled rate, and means for venting gas from the second compartment as water is admitted thereto at said faster rate.

26. A buoy of the character defined in claim 25 wherein said water admitting means includes means for also admitting water to said second compartment at a controlled rate.

27. A buoy of the character defined in claim 25 including means for closing said water admitting and gas venting means, a source of compressed gas within the body, means for releasing gas from said source into each compartment, means for venting water from each compartment as gas is released thereto so as to cause the body to rise to the water surface, and means for closing the gas releasing means into each compartment when said body has ascended to the water surface.

28. A buoy of the character defined in claim 27, wherein said closing means includes means automatically responsive to ascent of said body to the water surface.

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