DEPTH-POSITIONING APPARATUS FOR UNDERWATER RESEARCH VEHICLES

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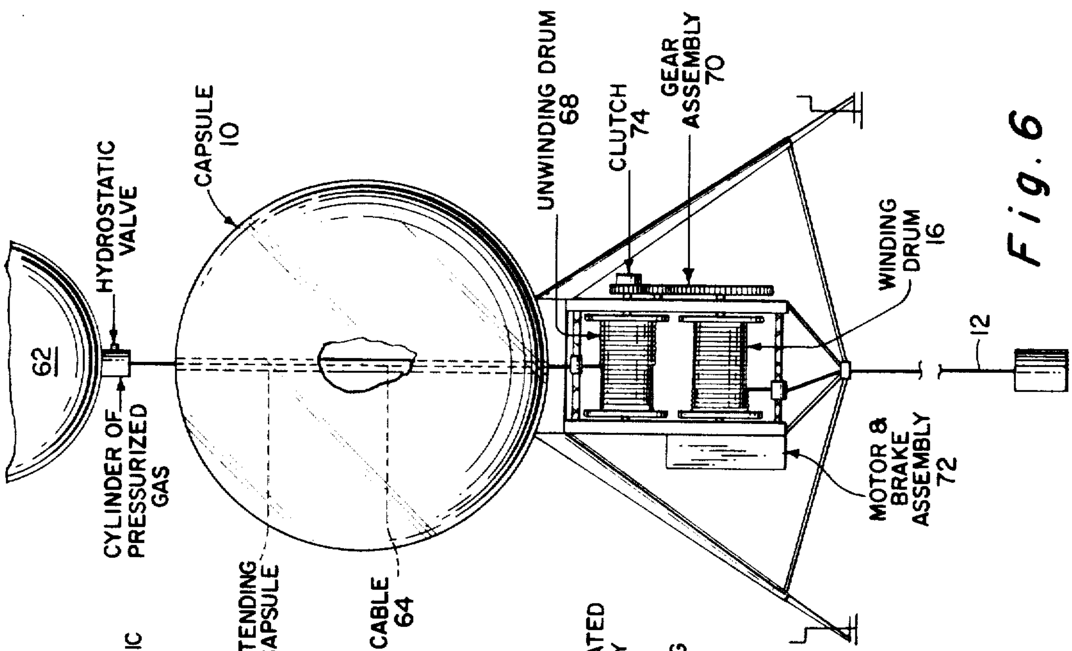

Fig. 6

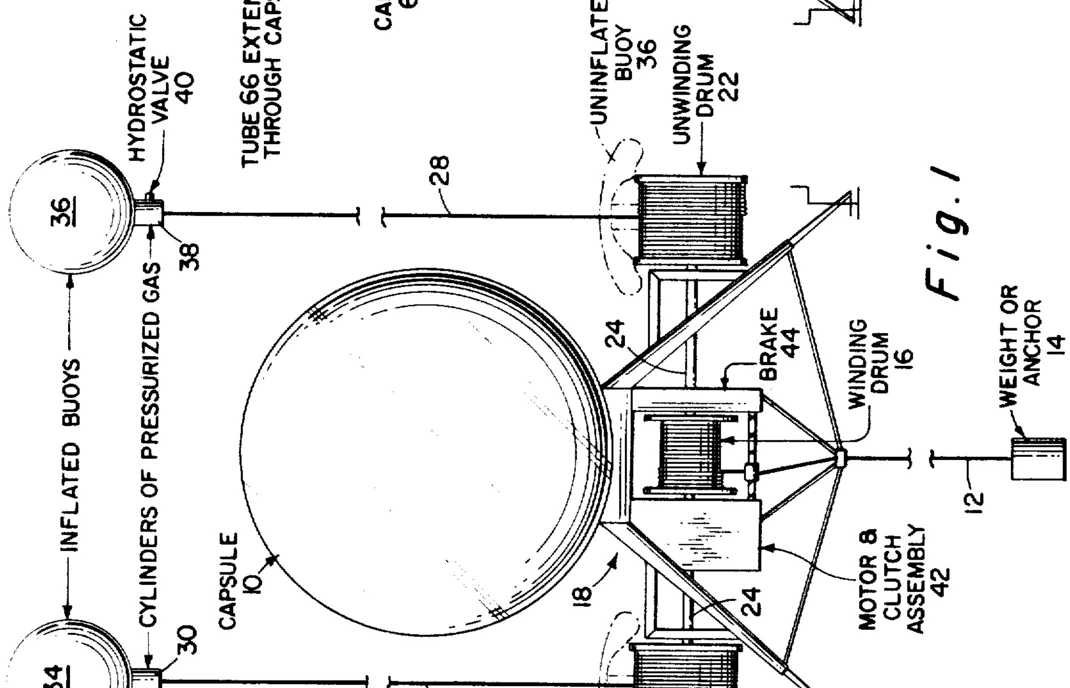

Fig. 1

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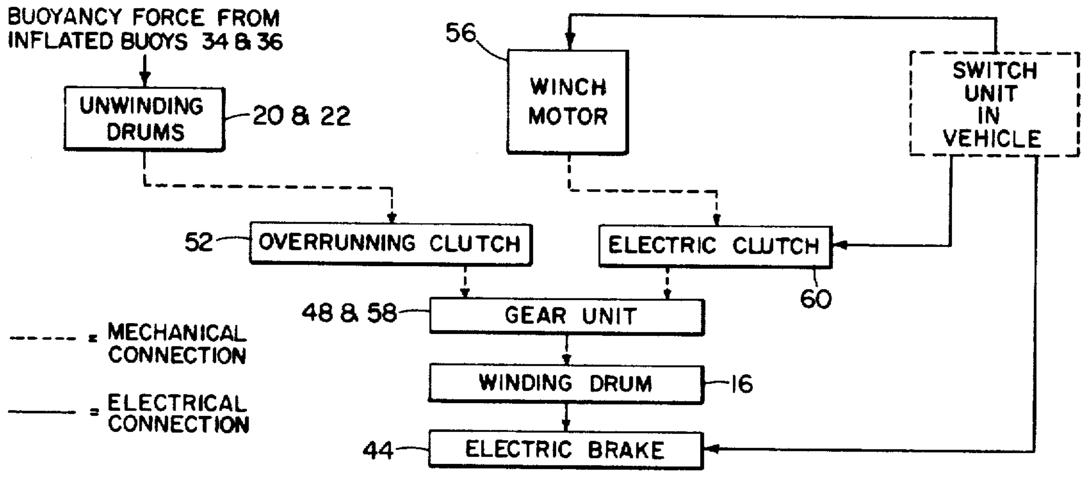

Fig. 4

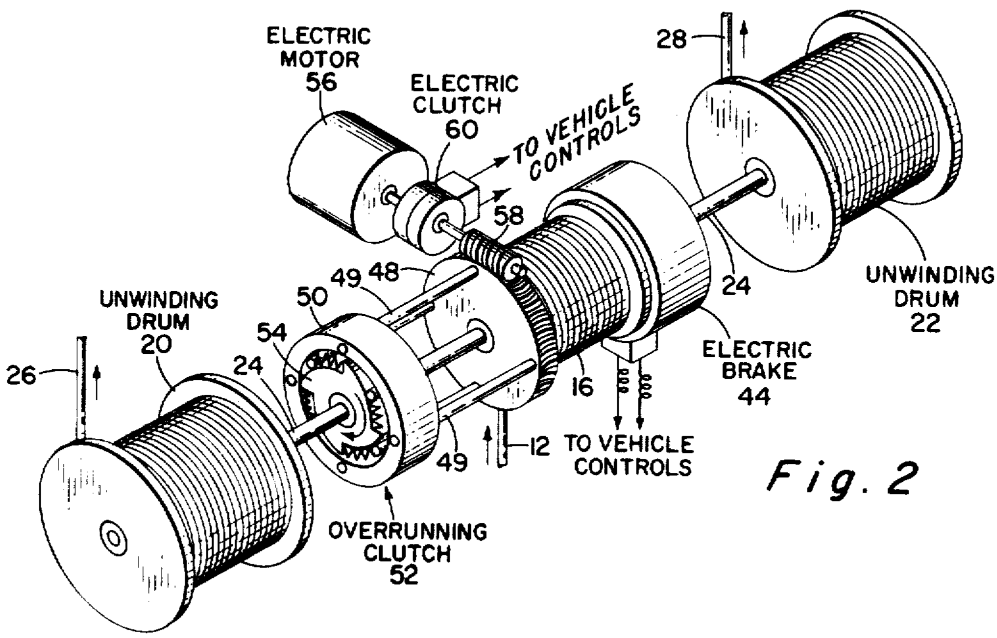

Fig. 2

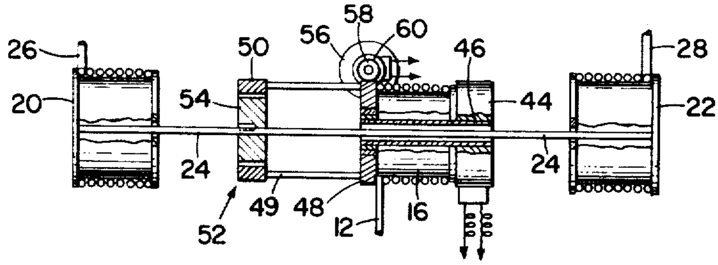

Fig. 3

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DEPTH-POSITIONING APPARATUS FOR UNDERWATER RESEARCH VEHICLES

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Fig. 7

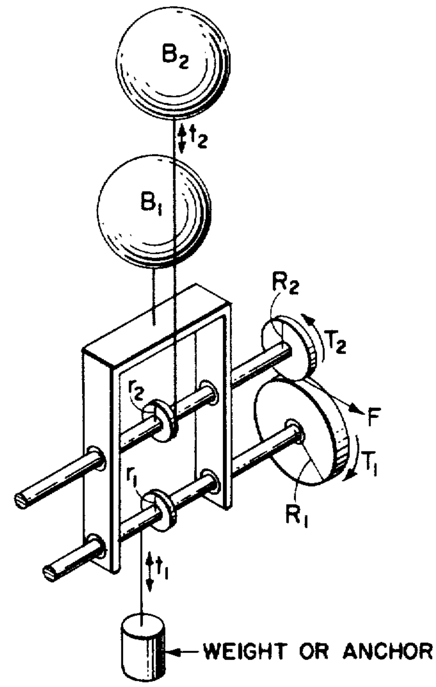
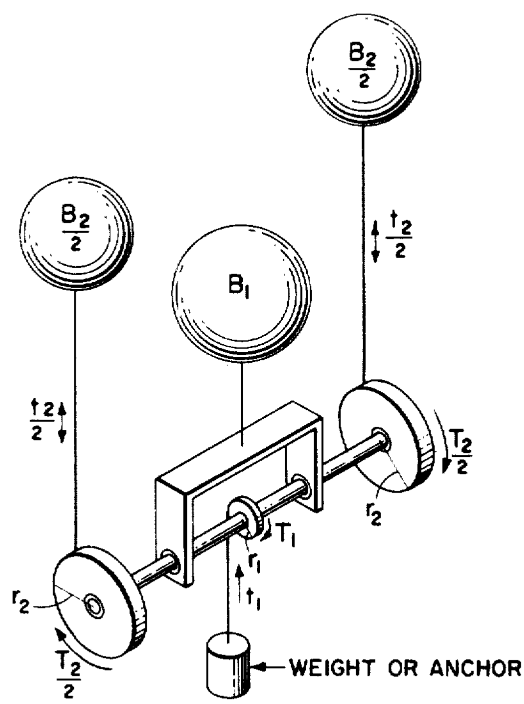


Fig. 5



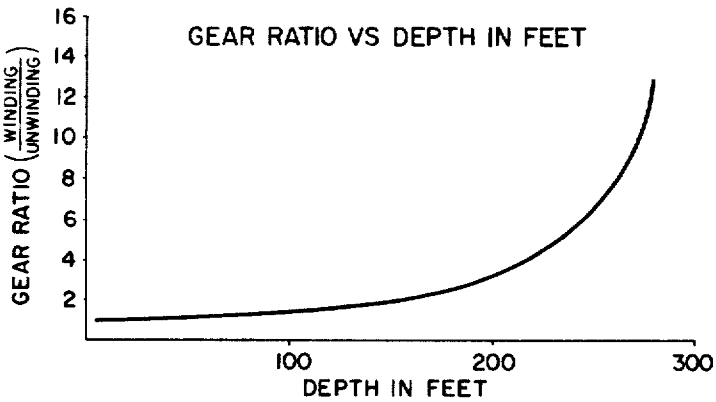


Fig. 8

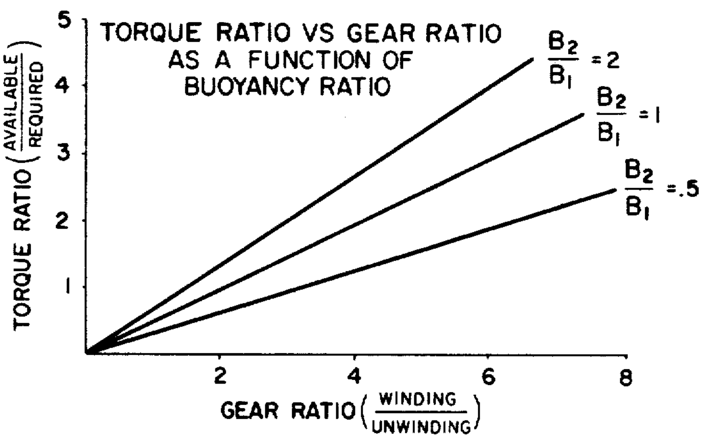


Fig. 9

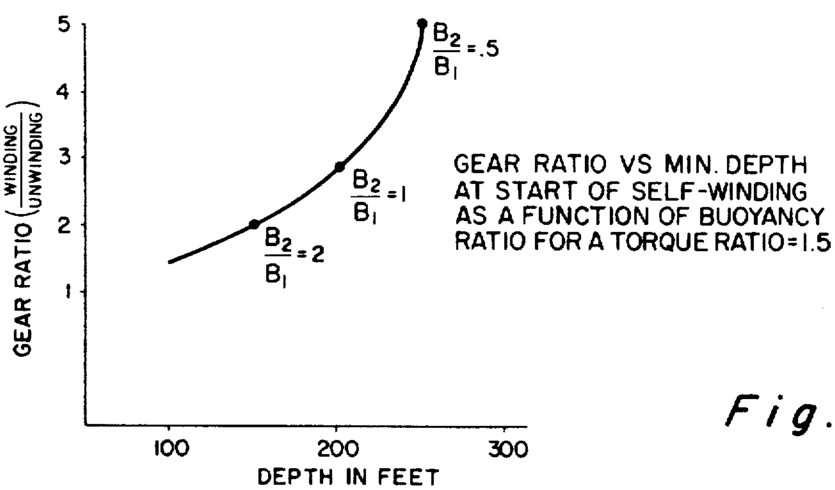


Fig. 10

United States Patent Office

3,402,687
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3,402,687

DEPTH-POSITIONING APPARATUS FOR UNDERWATER RESEARCH VEHICLES

Kiyoshi Tsuji, Camarillo, Calif., assignor to the United States of America as represented by the Secretary of the Navy

Filed Sept. 14, 1967, Ser. No. 668,310
12 Claims. (Cl. 114—16)

ABSTRACT OF THE DISCLOSURE

Apparatus for use with a positively buoyant underwater vehicle such as a manned observatory in order to lessen the internal power required to bring the vehicle to a desired depth. The concept utilizes the upward force created by the inflation of a buoyant member at a given depth in a body of water in order to unwind a cable from one drum of a rotating winch mounted on the vehicle. A second cable, tethered to a weight resting on the ocean floor, is wound on a second drum by the rotation of the winch, and this winding action pulls the vehicle downwardly as the buoyant member rises to the surface.

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

The present invention is concerned with underwater observation and exploration. In particular, it relates to apparatus suitable for use in conjunction with manned observatories of the type adapted for oceanographic studies of a relatively long-term nature.

The seas, and particularly the continental shelves, represent one of the world's remaining frontiers of which man has relatively limited knowledge. Because of ready accessibility, the continental shelves have been investigated to a greater extent than the ocean depths. However, the equipment used in these investigations has been designed primarily for short-term exploration, characterized by high mobility and allowing only limited observation of any single phenomenon.

The desirability of prolonging the time available for activity at selected underwater locations has been emphasized by current research such as the Sealab Project of the U.S. Navy. This work makes evident the importance of information-collecting through visual observation and/or photography of the underwater environment. The need consequently arises for an undersea observatory-laboratory designed to permit passive observation coupled with active experimentation over extended periods of time, either at a single location or at a variety of places within a selected area of limited extent.

In a copending U.S. patent application of Richard G. McCarty, James G. Moldenhauer, and Jerry D. Stachiw, Ser. No. 566,694 filed July 20, 1966, there is disclosed an underwater research vehicle which provides scientists and engineers with a comfortable housing while studying the marine environment or conducting experiments over extended periods at given sites. The vehicle therein described is in the form of a capsule fabricated of transparent plastic material, permitting panoramic visibility, and is of a size to accommodate a crew of two for a period of substantially ten days at a selected location. The individuals conducting the operation are not exposed to the liquid medium itself, and since it is contemplated that sea-level atmospheric conditions will be maintained within the capsule, elderly scientists and engineers may be accommodated without experiencing ill effects.

The above-described capsule comprises the buoyant envelope of a pressure hull, this envelope being constructed to withstand external loads during handling above the water, and hydrostatic pressures within the water. Contained within this envelope is the apparatus necessary to maintain the desired atmospheric conditions, as well as housekeeping facilities and research instrumentation. Since there is no requirement for horizontal propulsion, conventional self-contained power supplies are utilized, these power supplies being capable of supplying sufficient energy to operate an associated winch mechanism and thereby control the vertical positioning of the capsule. It is contemplated that the capsule will be tethered to the ocean floor by a cable leading to the winch, and, as the cable is selectively wound on the winch, the capsule will be drawn down against its natural buoyancy. Positioning of the vehicle at any point in a water column from the surface to a depth on the order of 1,000′ is thus possible. The positive buoyancy of such an edreobenthic manned observatory causes it to exert a pull against its bottom anchor, thus providing stability against ocean currents, undersea waves, and movements of the occupants.

The concepts involved in the design and construction of a vehicle such as above described have a sound technical foundation which is verifiable in practice. Insofar as the power supply is concerned, conventional 12-volt 200 amp.-hr. storage batteries may be employed, and, for a pressure hull having an outside diameter of ten feet, the power supply may comprise four layers of batteries with 22 batteries per layer, or 88 units in all. Although the average power requirement during a ten-day mission may approximate 800 watts, maximum or peak power output occurs during winch operation as the capsule descends, and may amount to nearly 5,000 watts over a 1-hour descent period. If it were not for this single factor, the number of batteries, and hence the overall size and weight of the power supply, could be drastically reduced, thereby simplifying design of the assembly and increasing the amount of space available for research equipment per se.

Summary of the invention

The present concept is directed to apparatus for use with an underwater vehicle designed to reach a desired depth in the ocean or other body of water, and which utilizes the upward force of one or more buoyant members to create a downward force on the vehicle, thereby reducing the internal power requirements of the latter. In one embodiment, this upward force is initiated by inflation of a bag or balloon after the vehicle has reached a predetermined intermediate depth, and the buoyancy of this member activates a winch connected by a tethering cable to a weight or anchor on the ocean floor. As the winch operates, the cable is wound on the winch drum, drawing the vehicle downward.

One object of the present invention, therefore, is to provide means for utilizing the natural buoyancy of an inflatable member to aid in bringing a vehicle such as a manned observatory that is also positively buoyant to a desired depth in the ocean or other body of water.

A further object of the invention is to utilize the force developed by a buoyant member in order to operate a winch carried by an underwater vehicle, the operation of this winch acting to draw the positively buoyant vehicle downwardly as the buoyant member rises to the surface.

An additional object of the invention is to reduce the winching power requirements of an underwater vehicle designed to descend into the ocean depths by utilizing energy developed by the controlled ascent of one or more inflatable members carried by the positively buoyant vehicle and which are rendered buoyant when the vehicle has reached an intermediate point in its powered descent.

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

Brief description of the drawings

FIG. 1 is a partly schematic illustration of one form of depth-positioning apparatus designed in accordance with a preferred embodiment of the present invention, and utilizing a pair of inflatable buoys;

FIG. 2 is a partly schematic view, in perspective, of one form of power generation and transmission equipment suitable for incorporation into the apparatus of FIG. 1;

FIG. 3 is an internal view of certain of the elements of FIG. 2 presented in schematic fashion in order to aid in an understanding of the manner in which the equipment functions;

FIG. 4 is a schematic diagram of the electrical and mechanical connections between certain of the components of the device set forth in FIGS. 1, 2 and 3;

FIG. 5 is a diagrammatic representation of certtin elements of the apparatus of FIG. 1 and indicating the respective forces acting thereon when the invention assembly is in its intended environment;

FIG. 6 is a partly schematic view along the lines of FIG. 1 but illustrating a modified form of depth-positioning apparatus employing a single inflatable buoy;

FIG. 7 is a diagrammatic representation in the manner of FIG. 5 but bringing out the forces acting on the apparatus of FIG. 6 when the assembly is in its intended environment; and

FIGS. 8, 9 and 10 are graphs bringing out certain operational characteristics of the apparatus of FIG. 6 as a function of variations in the gear ratio R_1/R_2 between the winding and unwinding reels schematically shown in FIG. 7.

Description of the preferred embodiment

In FIG. 1 of the drawings is illustrated an underwater vehicle of a type with which the present invention finds particular utility. This positively buoyant vehicle is in the form of a generally spherical capsule or pressure hull, generally identified by the reference numeral **10**, intended to move in essentially vertical fashion through the ocean or other large body of water. Inasmuch as the constructional details of such a capsule form no part of the present invention they will not be set forth herein, but reference is made to the mentioned copending application S.N. 566,694 for a discussion of one manner in which the unit may be fabricated. Purely as an example, the capsule **10** may comprise an edreobenthic manned observatory designed for underwater research over prolonged periods of time at a given site and capable of housing a crew of at least two individuals in a substantially one-atmosphere environment.

To bring a capsule such as shown in FIG. 1 from the ocean surface to a desired depth, considerable power is required to overcome the vehicle's natural buoyancy. This power may, of course, be supplied through electrical connections to a surface vessel, but it has been found that an independent arrangement is much to be preferred and yields increased flexibility of movement of the vehicle while at the same time freeing the surface vessel for other activity. On the other hand, a conventional self-contained power supply capable of bringing the vehicle to any considerable depth must of necessity be of relatively large size and weight. This detracts from the capsule's ability to house the large amount of equipment necessary to carry out an extended research program, as well as to restrict the space assigned to housekeeping facilities for the crew members. Consequently, at the present time a rather unsatisfactory compromise between these requirements is necessary. Suitable self-contained power supplies such as batteries unfortunately feature a reduction of available power as a function of power drain.

The present concept is directed toward reducing the internal power needed to bring about descent of such a vehicle when its self-contained power supply starts to run down by utilizing the natural buoyancy of one or more inflatable members to counteract the inherent buoyancy of the capsule. In one embodiment, a pair of inflatable bags or balloons are each filled from a source of compressed air or gas as soon as the vehicle has reached a predetermined depth under its own power. The resulting buoyancy of each bag acts to unwind a cable from a drum carried by the vehicle and to concurrently wind a further cable on a different drum. Inasmuch as the latter cable is tethered to a weight or anchor on the floor of the ocean or other body of water, the vehicle is drawn downwardly until such time as the inflated bags reach the surface. With proper choice of values for the components involved, the force developed by the rising buoyant members will be sufficient to position the vehicle at the proper depth to perform the research activity contemplated.

Referring again to FIG. 1 of the drawings, the capsule **10** is tethered by means of a cable **12** to a weight or anchor **14** resting on the floor of the body of water in which the capsule is immersed. Cable **12** is arranged to be wound on a drum **16** forming part of a winch assembly generally identified by the reference numeral **18**. This winch assembly is securely attached to the lower portion of the capsule **10** and moves as a unit therewith.

Also forming part of the winch assembly **18** is a pair of further drums **20** and **22** carried on opposite ends of a shaft **24**, the latter shaft being concentric with the axis of rotation of the drum **16** on which the tethering cable **12** is wound. However, as will subsequently appear, the drum **16** is not mounted on shaft **24** but on a hollow sleeve (shown in FIG. 3) concentric with shaft **24**. As illustrated, a cable **26** is wound on drum **20**, and a cable **28** wound on drum **22**.

Attached to the free end of cable **26** is a container or cylinder **30** of pressurized gas, which gas, when released from the container by operation of a hydrostatic valve **32** or by manually-actuatable control means (not shown) within capsule **10**, fills a bag or buoy **34**. Initiation of gas flow into bag **34** occurs while the bag is in a collapsed condition adjacent drum **20**, as shown by broken lines in the drawing. It is intended that the hydrostatic valve **32** operate after the capsule **10** has descended from the surface to a point about two-thirds of the total distance to the ocean floor or to its desired depth.

A second bag or buoy **36** is attached to the free end of cable **28**, and is designed to be filled with gas from a cylinder **38** when hydrostatic valve **40** operates. This assembly is identical in all respects to the one previously described.

Forming part of the winch **18** is a motor and clutch assembly **42**, the motor of this assembly acting to cause descent of the capsule **10** to a point where the hydrostatic valves **32** and **40** operate. Power for energization of the motor may be supplied from conventional sources carried within capsule **10**. When the motor is energized, the drum **16** rotates and winds cable **12** thereon, and, since the weight or anchor **14** is intended to remain stationary, the capsule **10** is drawn downwardly in the water column. A brake **44** holds the drum **16** against rotation and thus interrupts descent of the capsule whenever this is desirable. When brake **44** is holding drum **16** against rotation the motor of assembly **42** is normally not energized.

Ordinarily, the motor of assembly **42** would have to operate during the total capsule descent time, and power would be required to energize this motor for the full period necessary to bring the capsule to the ocean floor or to the depth desired for research activity. The power supplies necessary to do this would be of a size and weight such as to seriously detract from the vessel's capability of accommodating equipment and personnel. The present concept is intended to obviate the requirement for a power supply of a capacity greater than that necessary to cause descent of the capsule to a point approximately two-thirds of the total vertical distance to be traveled.

It has been stated that the bags **34** and **36** in their uninflated state lie adjacent their respective drums **20** and **22** as shown in broken lines in the drawing. When the capsule **10** has descended to a predetermined depth (such, for example, as two-thirds of the total vertical distance to be traveled) due to the action of the motor forming part of assembly **42**, the preset hydrostatic valves **32** and **40** are concurrently activated to initiate flow of gas from cylinders **30** and **38** into the respective bags **34** and **36**. When the latter become buoyant, they rise toward the surface, unwinding the cables **26** and **28** from their respective drums **20** and **22** and causing rotation of shaft **24**.

Referring now to FIGS. 2 and 3 of the drawings, there is shown one mechanism by means of which the objectives of the present disclosure may be achieved. As stated, the drums **20** and **22** are mounted on the opposite extremities of shaft **24**, this shaft extending through a hollow sleeve **46** (FIG. 3) on which the drum **16** is carried. Brake **44** is also mounted on this hollow sleeve **46**, the brake being preferably of the electric type controllable from within the capsule **10** by any suitable means (not shown).

Associated integrally with drum **16** is a gear **48** mounted on hollow sleeve **46** in a manner best shown in FIG. 3. The gear **48** is provided with a plurality of axially-projecting pins **49** disposed equidistantly in essentially circumferential fashion, and which serve to support an annular outer race element **50** of an overrunning clutch **52** the inner race member **54** of which is carried on shaft **24**. Clutch **52** may, for example, be of the conventional cam and roller type, as illustrated in FIG. 2.

An electric motor **56** drives the gear **48** through a worm **58**. An electric clutch **60**, again controllable from within capsule **10** by any suitable means (not shown) is interposed between worm **58** and motor **56**. The latter may be energized from a conventional power supply (not illustrated) carried within capsule **10**.

Operation

Initially, the capsule **10** is floating on the surface of the ocean, with the cable **12** extending to the weight or anchor **14** on the ocean floor. The unwinding reels **20** and **22** are fully wound, with the bags **34** and **36** uninflated and adjacent to their respective reels as shown in broken lines in FIG. 1. The capsule **10** is now winched to a predetermined depth by action of motor **56**, this selected depth corresponding to approximately two-thirds of the total depth desired. The hydrostatic valves **32** and **40** then concurrently operate to permit inflation of bags **34** and **36** with gas from cylinders **30** and **38**, the amount of emitted gas being chosen such that the total effective buoyancy of bags **34** and **36**, taken together, approximately matches the buoyancy of the capsule.

During this phase of capsule descent, the shaft **24** is at rest by virtue of the action of the overrunning clutch **52**, which permits the outer race member **50** to rotate with drum **16** while the inner race member **54** is stationary. Also, the electric clutch **60** (FIG. 2) is engaged so that motor **56** drives the worm **58**, while the electric brake **44** is released to permit hollow shaft **46** to rotate. Consequently, motor **56** turns drum **16** to wind the cable **12** thereon and draw the capsule **10** downwardly against its natural buoyancy. It should be noted that the worm **58** is so designed as not to be "self-locking."

At the selected depth, the bags **34** and **36** are inflated and become buoyant. In rising toward the surface, they unwind cable from their respective drums **20** and **22** and hence turn the shaft **24** on which the drums are carried. Due to the nature of the overrunning clutch **52**, a positive engagement between the race elements **50** and **54** occurs, and the drum **16** is rotated by the buoyant force acting on the inflated bags. Such rotation of drum **16** results in continued descent of the capsule. During this phase the motor **56** can be deenergized through a manual control (not shown) or it can be power augmented automatically as a function of the rotation of shaft **24**.

Reference is made to FIG. 4 of the drawings for the electrical and mechanical interrelationship of the components of FIGS. 1 through 3.

It is intended that the capsule **10** reach its desired depth at approximately the time the inflated bags **34** and **36** reach the surface, the cables **26** and **28** being of a length such as to permit such operation to occur. To retain the capsule at such location, the brake **44** is engaged and clutch **60** released. Of course, the capsule may be stopped by energization of the brake **44** at any desired depth until the bags **34** and **36** reach the surface. The inflated bags **34** and **36**, on the ocean surface, may be retrieved if desired by a vessel, the cables **26** and **28** being provisioned to be automatically released from their respective drums **20** and **22** when fully extended inasmuch as they are no longer needed.

At the conclusion of the project or research activity, it is only necessary, in order to permit the capsule **10** to rise to the surface, to release the brake **44**. The capsule **10** will now ascend due to its own inherent positive buoyancy, allowing the cable **12** to unwind from drum **16**.

It is contemplated that certain safety arrangements will be incorporated into the disclosed assembly, but these have not been illustrated or described since suitable expedients will be readily apparent to those skilled in the art to which the invention pertains. For example, if the capsule's electric power should fail or the various switch controls malfunction, the clutch **60** and brake **44** are so designed as to automatically become disengaged to permit cable **12** to unwind from drum **16** as the capsule **10** ascends to the surface by virtue of its own buoyancy.

It has been mentioned that capsule **10** may be brought by its own internal power supply to a point approximately two-thirds of the total downward distance to be traveled in the water column. This can be accomplished if the radius of each of the reels or drums **20** and **22** is three times the radius of the reel or drum **16**. Under such conditions, a three-to-two torque advantage results at the take-up reel **16** in terms of available versus required torque when the bags **34** and **36** exert a buoyant force on their respective unwinding reels **20** and **22**. Thus, the take-up reel **16** is now being driven by the unwinding reels, and since (because of the ratio of their diameters) the unwinding reels spool out cable three times faster than the take-up reel winds cable, the capsule **10** will be winched the remaining one-third of the total desired depth and reach bottom just as the inflated bags reach the surface. For example, if the weight or anchor **14** is at a depth of 300 feet, inflation of bags **34** and **36** at a 200-foot depth will result in the reels **20** and **22** releasing 300 feet of cable while winding reel **16** takes up 100 feet of cable as the capsule descends to the 300-foot depth. At this point the bags **34** and **36** have reached the surface, as previously described.

In FIG. 5 of the drawings is illustrated a diagram of forces which may be present on the various components of the assembly of FIG. 1 when the device is submerged. Purely as an example, if B_1 is the buoyancy of capsule **10** and B_2 the total buoyancy of the two inflated bags **34** and **36** taken together, then with equal buoyancies $B_2/2$ for the two buoys it is possible to set

$$B_1=B_2$$

It has been stated that the respective radii of the winding and unwinding reels is such that

$$3r_1=r_2$$

Then the total tension t_2 on cables **26** and **28** due to the inflated bags **34** and **36** is

$$t_2=B_2$$

The tension on the anchor cable **12** is

$$t_1=2t_2$$

The available torque T_2 becomes

$$T_2=t_2r_2$$

This is 1.5 times greater than the required torque T_1, since

$$T_2=t_1r_1=\tfrac{2}{3}t_2r_2$$

For a vehicle having an assumed capsule diameter of 5.5′ its operational buoyancy can be trimmed or ballasted to be in the neighborhood of 750 lbs. A 750-pound buoyant force in sea water requires a buoy or balloon volume (total) of 11.7 cubic feet. As this buoy or balloon ascends from the depth of say 200 feet to the surface, the gas must expand by a factor of seven, so the final volume becomes 81.9 cubic feet at the surface. The 750-pound buoyancy at 200 feet then becomes 5,250 pounds just before breaking the surface. Consequently, each of the bags **34** and **36** incorporates means (not shown) for spilling or discharging excess gas as it rises to the surface. The 11.7 cubic foot total volume of the bags **34** and **36** can be represented by one 2.82 ft. diameter sphere or two 2.25 ft. diameter spheres, but a natural-shape balloon should be designed with minimum circumferential stress in the fabric for maximum freedom from splitting or rupture. As far as the cylinders **30** and **38** are concerned, they need not be of excessive size or weight, as one cubic foot of compressed air at 2,000 p.s.i. can provide 19.7 cubic feet at the 200 ft. arbitrary depth where inflation takes place.

In FIG. 6 of the drawings is shown a modification of the device of FIG. 1 in which a single inflatable bag or balloon **62** is utilized in place of the two members **34** and **36** of FIG. 1 and with the unwinding cable **64** passing through a tubular passage **66** formed in the hull of capsule **10**. In certain cases such a design may be desirable in order to help balance and align the upward buoyant forces with the downward pull from the weight or anchor **14**.

With only one inflatable element being present, only one unwinding drum **68** is required, this member being coupled by a gear assembly **70** to the winding drum **16**, the latter being identical to the corresponding component in FIG. 1. The shaft of drum **16** is controlled by a motor and brake assembly **72** in the same basic manner as in FIG. 1, while a clutch **74** permits the shaft of drum **68** to be disengaged from gear assembly **70** in a conventional manner. It is important to note that the drums or reels **16** and **68** in FIG. 6 are of the same diameter, and that the necessary winding-to-unwinding ratio is achieved by the choice of a 1-to-3 gear ratio for the elements of assembly **70**.

FIG. 7 is similar to FIG. 5 but illustrates the forces acting on the apparatus of FIG. 6. The buoyancy B_1 of the capsule **10** is here equal to the buoyancy B_2 of the single inflatable bag **62** of FIG. 6. The radius r_1 of drum **16** is equal to the radius r_2 of drum **68**. However, the radius of the gears of assembly **70** is such that

$$R_1=3R_2$$

The tension t_2 in the cable **64** is

$$t_2=B_2$$

and the tension t_1 in the anchor cable is

$$t_1=2t_2$$

If F represents the force on the gear teeth in assembly **70**, then

$$T_2=t_2r_2=FR_2=FR_1/3=T_1/3$$

which is the torque at drum **68**.

Therefore,

$$T_1=3T_2$$

which is the torque available at drum **16**.

Now,

$$T_1=t_1r_1=2t_2r_2=2T_2$$

which is the torque required at drum **16**.

Then the torque available to bring about descent of the capsule **10** is greater than that required by a factor of 3 to 2 or a ratio of 1.5.

FIG. 8 is a graph bringing out the winch gear ratio (for FIG. 6) versus depth in feet at the point of inflation of the buoyant members for a winch drum with 300 feet of cable. However, the usable gear ratio for a given buoyancy ratio is shown in FIG. 9, and must correspond to a torque ratio greater than one to be meaningful. In this figure, B_1 is the trimmed buoyancy associated with the vehicle and its winding drum, and B_2 the buoyancy on the unwinding drum of FIG. 5. By ascertaining the usable gear ratio from FIG. 9 it is possible to predetermine the minimum permissible starting depth for inflation of the member **62** of FIG. 6. This is given by FIG. 10 for a torque ratio of 1.5 (available/required at winding drum **16**).

It should be borne in mind that the breaking strength of the cable **64** limits the choice of buoyancy ratio, and as a practical matter the selection of a buoyancy ratio of one and a gear ratio of three dictates a level of 200 feet for inflation of the buoyancy member **62** of FIG. 6, or the corresponding members **34** and **36** of FIG. 1 for a contemplated research activity depth of 300 feet, and this yields a one-third saving in power over that required to drive a standard winch the full distance of 300 feet.

It will be recognized that many modifications and variations of the present invention are possible in the light of the above teachings. For example, the number of inflatable members is obviously not limited to two, and if additional devices are utilized their operation can be selectively sequenced if desired to more effectively extend the time during which a buoyant force is applied to the vehicle. Furthermore, electrical switches in the form of solenoids can be substituted for the hydrostatic valves **32** and **40**, these controls being preferably interconnected so that release of pressurized gas from the cylinders **30** and **38** occurs simultaneously and chemical gas generators can be substituted for pressurized gas. Still further, friction clutches may be utilized in place of the electric clutches **60** and **74**, and a friction-type brake substituted for its electric counterpart **44**. It is understood that various other ratios between sizes of corresponding components are possible such as buoyancy ratios, gear ratios, reel ratios, etc. by adjusting various parameters involved in the torque ratios and depth of initiation of the self-winding feature. All of these expedients as well as others which will be apparent to those skilled in the art to which the invention relates are intended to be embraced within the scope of the appended claims.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Apparatus for bringing about the descent of a vehicle capable of moving in an essentially vertical direction through a column of water, said apparatus being carried by said vehicle as it moves downwardly from the surface to a predetermined depth, said apparatus comprising:

means tethering said vehicle to the bottom of said water column;

an inflatable member;

means for inflating said member following a movement of said vehicle from the surface to a predetermined depth in said water column, as a result of which inflation said member is rendered buoyant; and

means for applying the upward force developed when said member is rendered buoyant to draw said vehicle downwardly against the action of said tethering means.

2. Apparatus in accordance with claim 1 in which said vehicle is in the form of a manned observatory.

3. Apparatus in accordance with claim 1 in which said means for applying the upward force developed when said member is rendered buoyant to draw said vehicle downwardly against the action of said tethering means includes a winch mounted on said vehicle, and in which said tethering means includes a first cable designed to be selectively wound on a first drum of said winch.

4. Apparatus in accordance with claim 3 in which said means for applying the upward force developed when said member is rendered buoyant to draw said vehicle downwardly against the action of said tethering means includes a further drum on said winch and a second cable connecting said buoyant member to said winch, said second cable being initially wound on the said further drum of said winch and being designed to be selectively unwound therefrom following inflation of said member.

5. Apparatus in accordance with claim 4 further including electrically-energized means forming part of said winch for bringing about a movement of said vehicle from the surface to a predetermined depth in said water column while said member remains uninflated.

6. Apparatus in accordance with claim 5 in which said means for inflating said member following a movement of said vehicle from the surface to a predetermined depth in said water column includes a source of pressurized fluid and a hydrostatic valve connecting said source of pressurized fluid to said member, said valve being preset to open when said vehicle has descended to said predetermined depth.

7. Apparatus in accordance with claim 6 in which movement of said vehicle from the surface to a predetermined depth in said water column while said member remains uninflated is brought about by said electrically-energized means acting to rotate said first drum of said winch and thereby winding thereon said first cable which forms part of said tethering means.

8. Apparatus in accordance with claim 7 in which inflation of said member by operation of said hydrostatic valve at said predetermined depth acts to bring about a rotation of the said further drum of said winch as said second cable unwinds therefrom while said buoyant member ascends in said water column.

9. Apparatus in accordance with claim 8 further including an overrunning clutch disposed intermediate the two mentioned drums of said winch, rotation of said further drum following inflation of said buoyant member acting to bring about continued rotation of said first drum due to the operation of said clutch irrespective of the status of said electrically-energized means, whereby said vehicle continues to be drawn downwardly in said water column beyond the predetermined depth at which inflation of said member occurs.

10. Apparatus in accordance with claim 9 in which said vehicle is of generally spherical configuration with a vertically-oriented opening extending diametrically therethrough, said second cable being disposed in part within said opening.

11. Apparatus for bringing about the descent of a vehicle capable of moving in an essentially vertical direction through a column of water, said apparatus being carried by said vehicle as it moves downwardly from the surface to a predetermined depth, said apparatus comprising:

means tethering said vehicle to the bottom of said water column;

a plurality of inflatable members;

means for inflating said members in an essentially simultaneous fashion following a movement of said vehicle from the surface to a predetermined depth in said water column, as a result of which inflation said members are each rendered buoyant; and

means for applying the upward force developed when each of said members is rendered buoyant to draw said vehicle downwardly against the action of said tethering means.

12. Apparatus in accordance with claim 11 in which said last-mentioned means includes a winch having a plurality of drums one greater in number than the number of said inflatable members and all but one of which are arranged for concurrent rotation, a plurality of cables respectively connected to said plurality of inflatable members and initially respectively wound on all but said one of said plurality of drums, and in which said tethering means includes a further cable designed to be wound on said one of said plurality of drums as a function of the unwinding from their respective drums of the plurality of cables connected to the said inflatable members.

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