United States Patent

Lok

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[54] **BATHYAL UNIT**

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[51] **Int. Cl.**..**B63c 11/36**

[58] **Field of Search**......114/16 R, 16 E; 61/69; 9/8 R

[56] **References Cited**

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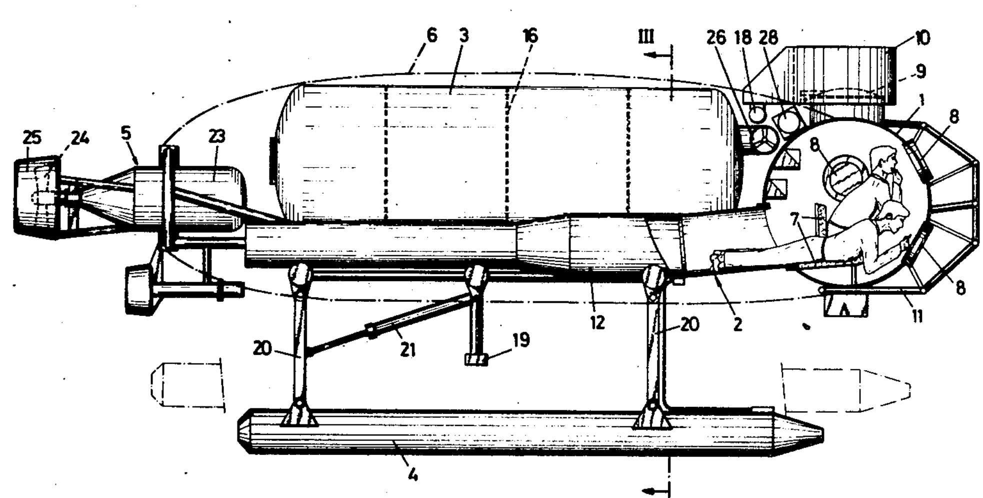
[57] **ABSTRACT**

A deep-sea unit having a float and ballast chamber distinct from the crew accommodation, the float and ballast chamber being adapted to be pressurized so as to subject the wall thereof to an internal pressure slightly in excess of the external pressure from the ambient water at the operating depth. This construction permits the use of relatively light material.

5 Claims, 3 Drawing Figures



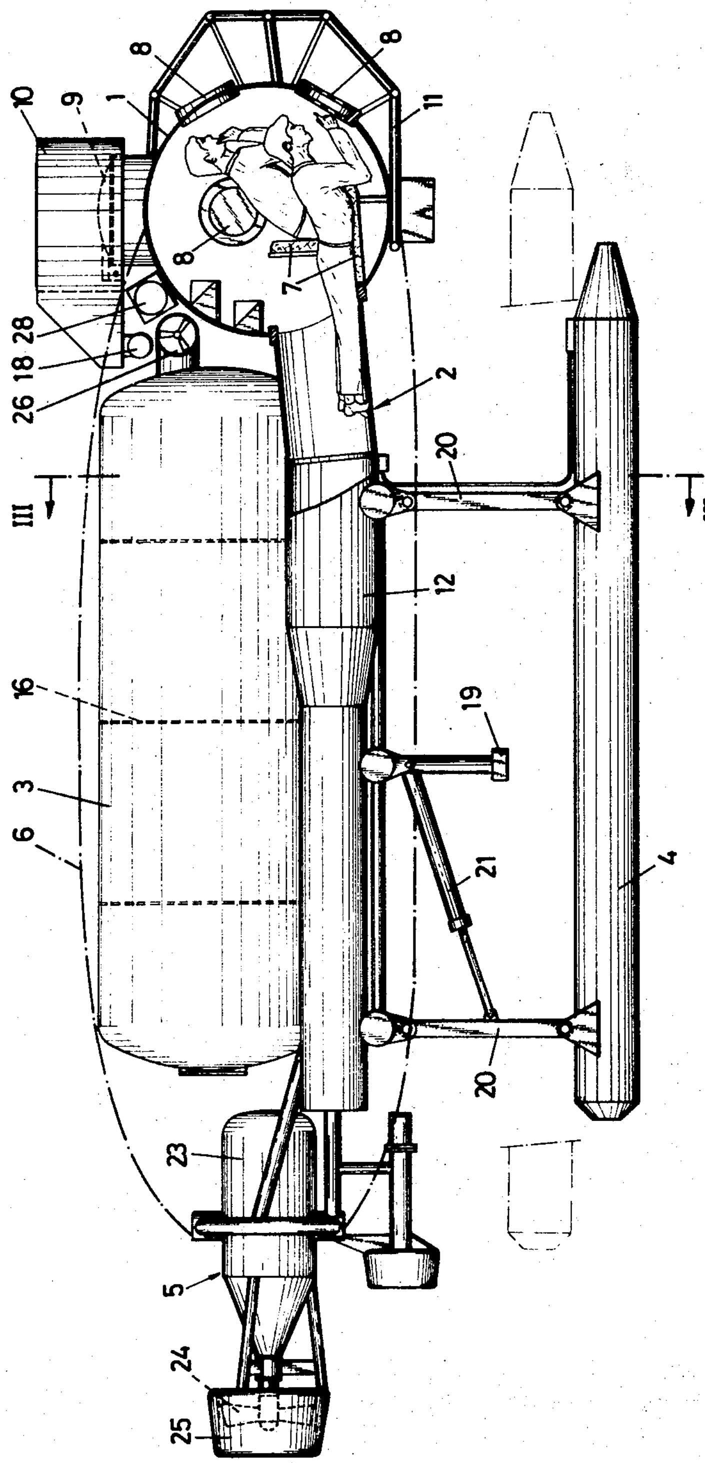


FIG. 1

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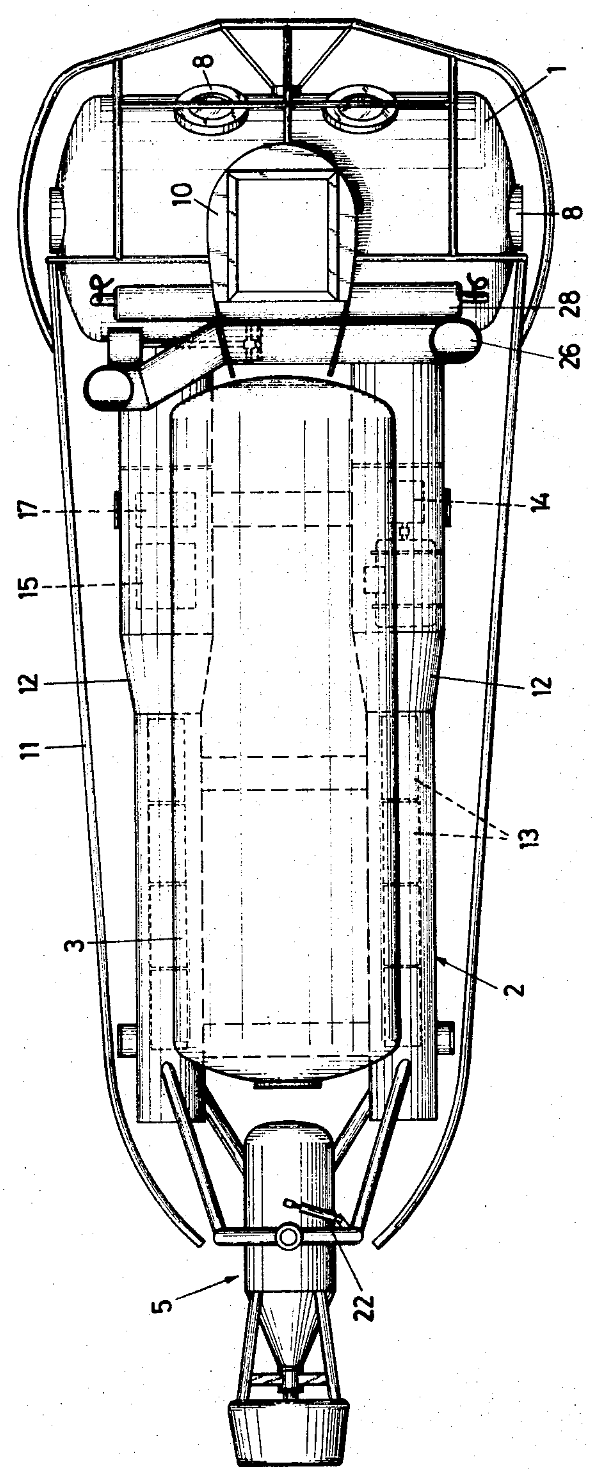

FIG. 2

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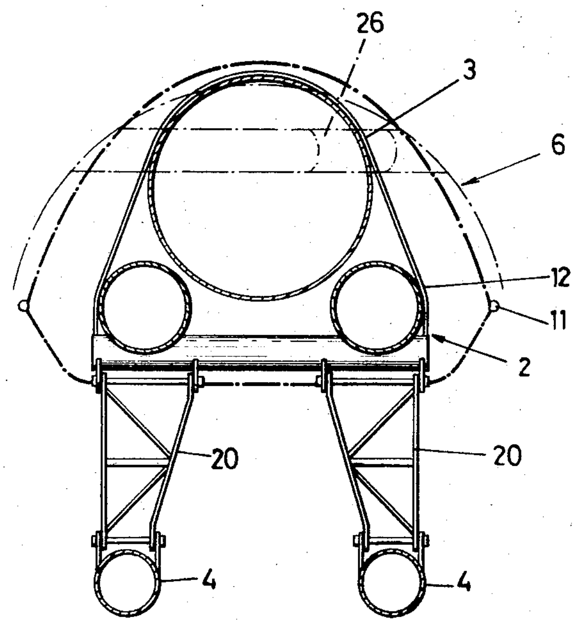
FIG. 3



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BATHYAL UNIT

This invention relates to a bathyal unit.

Such submarine devices for use at great depths are known in various embodiments, to be divided into two types:

TYPE A

Deep-sea units in which the crew are accommodated in a pressure-resistant cabin, the cabin having no buoyancy per se. The required buoyancy is in this instance provided by a container (balloon) of thin metal, filled with a liquid which is lighter than the ambient water, for example, Prof. Piccard's Bathyscaph, or by floats consisting of syntactic foam (hollow glass spheres) embedded in a plastics material.

TYPE B

Deep-sea units in which the pressurized cabin itself provides the buoyancy or a predominant part thereof. In this case, the crew is likewise accommodated in the pressurized cabin. Examples of this type are the diving saucer of Cousteau in France, and the Aluminaut of the Reynolds Metals Co. and General Dynamics in America.

A-type vessels have the disadvantage that the float is highly voluminous on account of the small difference in specific gravity between the available liquids which are lighter than water and the water itself, as a result of which they are highly vulnerable and unwieldy. The liquid used is preferably gasoline. The use of syntactic foam is rather expensive, its specific gravity is still rather high (about 0.7), and nothing is as yet known of its long-term behavior.

Heavy rough work cannot be carried out with the former type of vessel. When, for example, the thin-walled float strikes a leak against a rock or a ship under water, the gasoline escapes and the vessel sinks. When, in addition, heavy equipment must be taken along, the float would become so large that, practically speaking, it can no longer be manufactured.

B-type vessels have the disadvantage that the pressure-resistant cabin accommodating the crew must be of as light a construction as possible in order to provide the highest possible buoyancy. This is only possible by tolerating very high stresses in the material. In particular for depths of several thousands of meters, very special and expensive materials must be used in constructing this vessel on the verge of the impossible. For example, for a diving depth of 4,000 meters a sphere diameter of 2 meters and a wall thickness of 30 mm, the compressive stress in the wall is 6,600 kg/cm^2. In testing according to proper engineering practice, at a depth 50 percent deeper, this stress is as high as 10,000 kg/cm^2.

The front of the pressurized cabin with the window is always unprotected to ensure proper view. For an apparatus designed for heavy and rough work in unknown waters with often very powerful currents at great depths, in which the vessel may be thrown onto rocks and shipwrecks with great force, it is insufficiently reliable.

In order to keep the weight as light as possible, the Reynolds Metals Co. in cooperation with General Dynamics, in the U.S.A., are building a submarine vessel built up from plates of an aluminum alloy riveted and glued together. At an indicated safe diving depth of 5,000 meters, the compressive stress in the wall of the cabin is 3,800 kg/cm^2, which is a high stress for an aluminum alloy. Moreover, the reserve buoyancy of this vessel is extremely low, and it is impossible to take along heavy tools.

It is an object of the present invention to provide a simple and reliable device of this kind, which is adapted to rise from great depths in the sea at all times and in all conditions, and which combines a minimum weight of its own with a high carrying capacity.

According to the invention, there is provided a bathyal unit comprising a working compartment, and at least one separate float chamber secured to said working compartment, said float chamber being adapted to receive gas under such a high pressure that, at the operating depths, the most favorable stress occurs in the wall of the float chamber, there being provided means for letting ballast water into, and out of, the float chamber while maintaining the gas content thereof.

By virtue of the use of gas under high pressure in the float chamber, it is possible to realize a very light construction, while, by using this chamber also as a ballast tank, a very simple and reliable construction is obtained with a maximum buoyancy.

The unit is preferably so designed that the means for letting out ballast water from the float room comprise a valve operable from the working compartment, it being possible to increase the gas pressure to such an extent that is becomes considerably higher than the pressure at the operating depths, the means for letting in ballast water being arranged to be connected to a pump on board an auxiliary surface vessel. The apparatus can then be lowered by pumping ballast water into the float chamber from the auxiliary vessel, or by means of a pump on board of the submerged unit, which may be operable by hand. To raise the unit only requires opening a valve of the float chamber, whereby the buoyancy will be increased owing to the ballast water being expelled by the gas under high pressure present therein.

Even if, for any reason whatsoever, the unit should occupy an extremely slanting position or should even be turned upside down, it is possible to cause the unit to resume a floating position owing to a suitable construction of the ballast water discharge openings, of which, for that purpose, at least one should always terminate below the water level. Furthermore, an extremely stable control of the buoyancy of the unit will be obtained owing to the fact that the pressure in the float and ballast chamber is independent of the ambient pressure, so that there will be no changes in buoyancy during rising or diving. This will be the case when a ballast chamber is used in which the pressure is equalized to the pressure of the surrounding water, so that when the ballast chamber is partly filled with gas, the gas will expand as the vessel is rising, as a result of which an additional amount of ballast water will be expelled and the buoyancy increases during rising.

By itself, a stable control for rising and diving is described in Dutch patent application 66,18451, laid open to public inspection. In the vessel described in that patent application, use is made of the variable buoyancy of expandable bags. This is a complicated, vulnerable, and expensive solution of the subject problem. The filling fluid in this case will be a light, non-compressible liquid having a specific gravity lower than water. Such a fluid is considerably heavier than gas under a high pressure, such as, for example, gaseous hydrogen, so that the buoyancy of the prior vessel will be rather low, which is of considerable importance when heavier freight is to be accommodated on board the unit.

One embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings. In said drawings,

FIG. 1 is a diagrammatic part-sectional elevation of a bathyal unit according to the invention;

FIG. 2 is a plan view; and

FIG. 3 a cross-sectional view, taken on the line III—III of FIG. 1.

The unit comprises at least one pressurized cabin **1** for the crew, a frame generally designated by **2** and built up from tubes and pipes, which frame accommodates auxiliary equipment; a combined float and ballast tank **3**; a pair of longitudinal runners **4** mounting batteries; a steering en driving unit **5**; and a streamlined hull **6** shown in dot-dash lines.

The pressurized cabin **1** is of approximately spherical, well-known construction and is provided with seats or lying places **7** for the crew, a plurality of windows **8** (in this example six), a manhole **9**, and a turret **10**. The whole unit, and in particular the front of the cabin is surrounded by a fender structure **11**. Secured to the cabin and/or the fender structure may be grabs, feelers and search lights. In the cabin, atmospheric pressure (sea level) is maintained as much as possible. The cabin will be relatively thick-walled in order that no high-alloy metals need be used. As a consequence, its own buoyancy is insufficient by itself.

The frame **2** comprises a pair of substantially cylindrical longitudinal tubes **12**, at the trailing ends of which auxiliary batteries **13**, and in the middle of which a hydraulic pump unit **14** and protective and auxiliary equipment **15** are accommodated. The leading ends of these longitudinal tubes connect with the cabin **1**, which provides space for the crew to occupy a horizontal position.

The float and ballast tank **3** is arranged between and above the longitudinal tubes **12**, and is divided into four compartments by means of three partitions **16**. The partitions are for the greater part water-tight, but communicate with each other at the top, so that the quantity of ballast water can be independently controlled in each compartment, but the same pressure prevails in each compartment. By means of a ballast tank **17**, ballast water can be pumped into the tank **3**. There is also provided a connection **18**, by means of which ballast water and/or gas can be pumped into the float and ballast tank **3** from an auxiliary surface vessel. Provided at the bottom of the ballast tank **3** is a ballast water outlet **19**. Not only does the float tank provide sufficient buoyancy for the entire unit with the cabin and apparatus, but owing to the use of a gas filling there is obtained a very high carrying capacity, for example, for transporting heavy loads from or to the sea bed.

The two runners **4** are each secured to the frame **2** by means of a pair of legs **20** hinged at both ends. The position of the runners relative to the unit can be changed by means of hydraulic trimming jacks **21**.

At the stern of the frame **2**, the steering and driving unit **5** is mounted for pivoting movement about a vertical axis. The position of the steering and driving unit can be controlled from an hydraulic steering cylinder **22**. The driving unit comprises an electric DC motor **23** which drives a variable-pitch propellor **24**, mounted in a jet tube **25**, through reduction gearing.

The hull **6** surrounds the frame **2** and the float and ballast tank **3** in order that the unit may encounter less resistance in the water, but is not water or air tight. Provided at the front behind the cabin **1** is a bow jet tube **26** housing a hydraulically driven propellor for making the unit still better steerable. Furthermore, disposed under the hull is an oxygen tank **28** storing a reserve supply of oxygen for the crew.

In operation, the deep-sea unit is lowered into water by an auxiliary vessel, and the ballast tank is pressurized to the desired pressure through connection **18**. The pressure is so selected that, at the operating depth, there will still be an over-pressure of at least 2 kg/cm^2 relative to the ambient water. It is thus achieved that the vessel is under an omnilateral internal overpressure in all circumstances. As a result, a lighter construction may be used as compared with a float tank without an overpressure. For operations at a great depth the float tank will be filled with a light gas, such as hydrogen or helium at a high pressure. For operations to be carried out on a continental shelf, that is to say, up to a depth of maximum 300 m, it will be sufficient to use air at a pressure of rather more than 30 kg/cm^2. Owing to the use of internal overpressure, it is possible to employ a relatively thin-walled structure of normal commercial steel.

In order te save weight, the pressurized cabin is made of alloyed steel having a tensile strength of, for example, 50 kg/mm^2 or more. The windows are provided with plexiglass of a suitable thickness. Also to save weight, components not subjected to loads are made of a light material, such as glass fiber reinforced polyester. These are components for the hull, the stern jet tube, the bow jet tube, and the turret. The batteries, for example, lead-acid batteries provide the energy for the DC drive motor **23** of the propellor **24** as well as for driving a hydraulic pump **14** for operating the hydraulic equipment. The controls are mounted in the working cabin, which in addition accommodates the navigation and communication equipment. The various hydraulic valves and conduits are known per se and can be electrically controlled from the pressurized cabin by means of a **24** V electrical circuit and various solenoids. In order that the unit may still be operable in the case of breakdown of the energy system, a manually operable hydraulic pump is provided for operating the auxiliary equipment. The oil reservoir is of the closed type and is provided with a pressure cushion of innert gas for taking up the changes in volume of the hydraulic cylinders. For the remote control of the cocks and valves, such as of the ballast tank, there is provided a separate manually operated hydraulic system, the hand pump and controls for which are accommodated in the working cabin. In addition, the ballast tank comprises a plurality of small hydraulic jacks for opening and closing the valves.

The vertical displacement of the unit is controlled by the crew, employing the ballast system. The ballast tank will commonly be half filled with water, with the pressure being adapted to the operating depth. By means of piping, the water can be pumped into each of the four compartments of the ballast tank from outside against the pressure prevailing in the tank. When a valve is opened, ballast water will be forced out of the ballast tank by the gas present therein even at the operating depth. The outlet valves are positioned so that the ballast water can be expelled in all positions of the unit without the escape of gas. The arrangement is such that, upon breakdown of the hydraulic system, a normally closed, throttled passage opening is opened, through which the ballast water will be slowly and automatically expelled, so that the unit will rise to the surface. In order that a heavy load may be picked up from the seabed, there is moreover provided a large outlet valve, which is opened when the carrying capacity of the unit must be considerably increased. The adjustment of the units position relative to the horizontal (trimming) can be effected by distributing the ballast water over any or all of the four compartments of the ballast tank in a suitable manner, or by changing the position of the runners. The unit will normally rise or dive at an angle of 15°, the position of the unit being adapted by moving the runners forwardly or backwardly, it being possible to increase the angle of inclination to about 20°. The extreme position of the runners is indicated by dot-death lines in FIG. 1.

Diving will normally be effected with a slightly positive buoyancy, the unit being driven downwardly by the driving unit by being trimmed at an angle of possibly 15°.

I claim

1. An apparatus for deep-sea operations comprising a working compartment, and at least one separate float chamber secured to said working compartment, said float chamber being sealed against the normal ingress of water and having gas therein under a high pressure that is greater than the external pressure at the selected operating depths and wherein tensile stress occurs in the entire wall of the float chamber under all operating conditions, and means for forcing ballast water into the float chamber directly with said gas and means for letting ballast water out of the float chamber under controlled conditions while maintaining the gas content thereof.

2. An apparatus according to claim 1, characterized in that the means for letting out ballast water from the float chamber comprise a valve operable from said working compartment with the gas pressure of a value considerably higher than that of the external pressure at the operating depth functioning as means for expelling ballast water.

3. An apparatus according to claim 1, characterized in that the means for forcing in ballast water includes means for receiving ballast water being supplied under pressure from an external source.

4. Apparatus according to claim 1, characterized in that the means for forcing ballast water into the float chamber comprise a pump operable from the working compartment.

5. The apparatus of claim 1 wherein the pressure within said float chamber is entirely independent of the pressure within said working compartment.

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