March 2, 1965 H. L. M. SELLNER ETAL 3,171,376

DIVING MACHINE WITH GAS BALLAST TANK

Filed Nov. 27, 1962 4 Sheets-Sheet 1

Fig. 1.

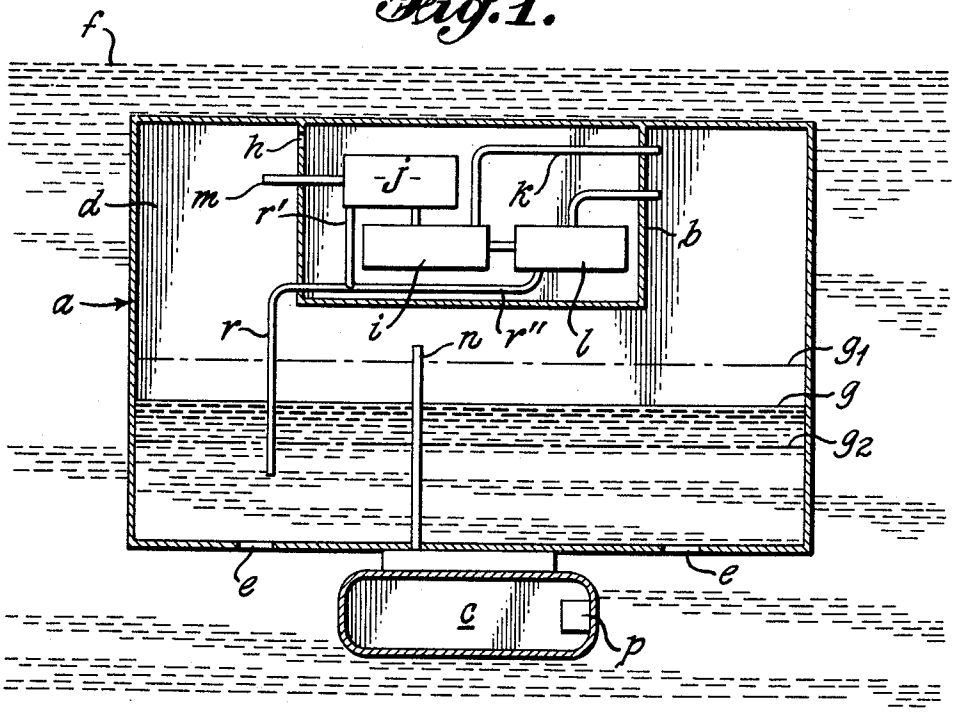
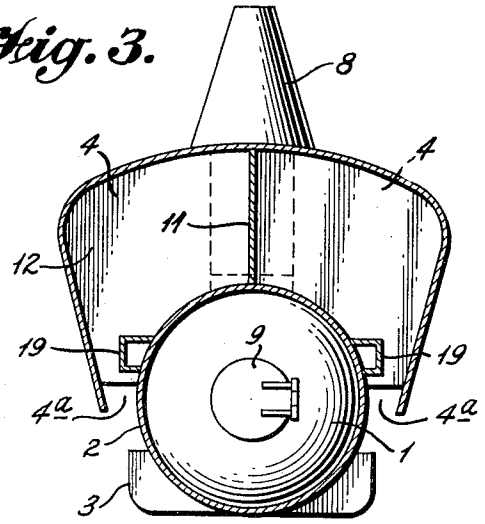


Fig. 3.



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DIVING MACHINE WITH GAS BALLAST TANK

Filed Nov. 27, 1962 4 Sheets-Sheet 2

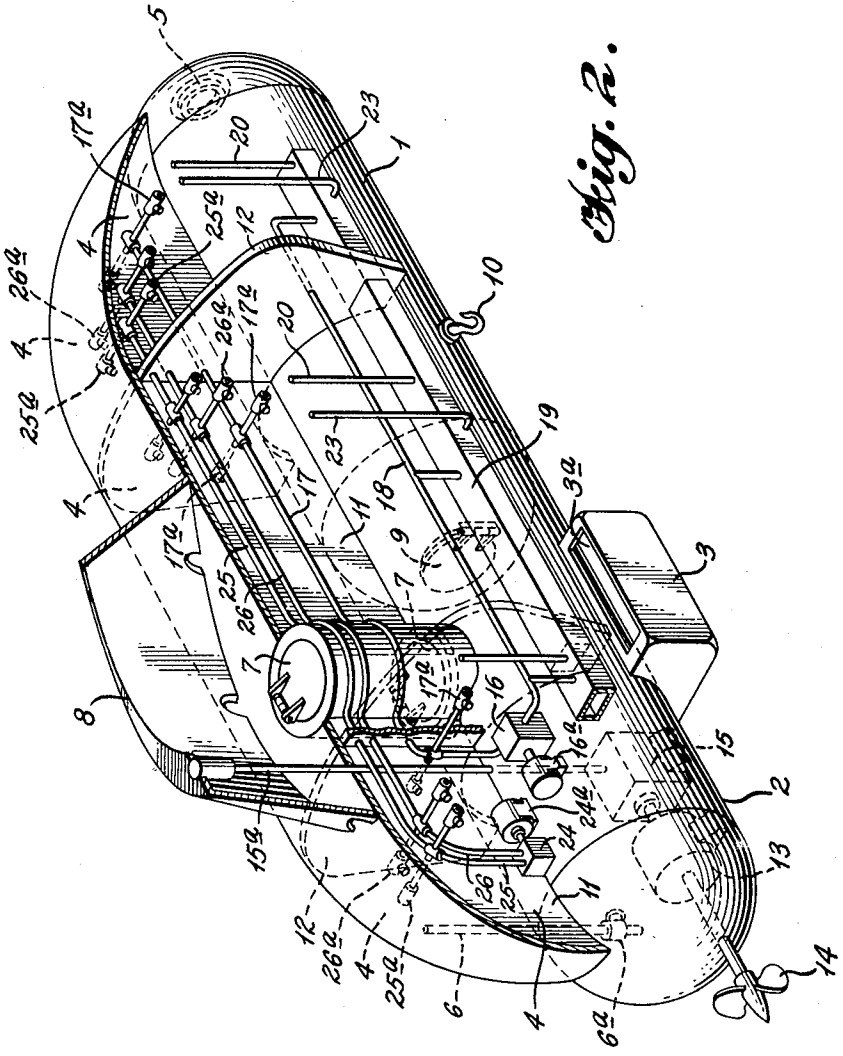

Fig. 2.

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DIVING MACHINE WITH GAS BALLAST TANK

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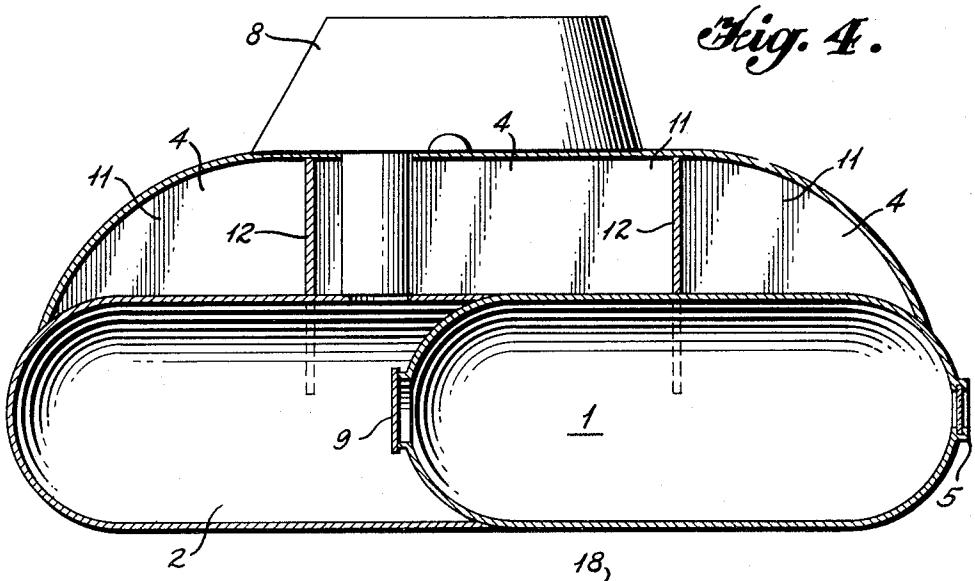
Fig. 4.



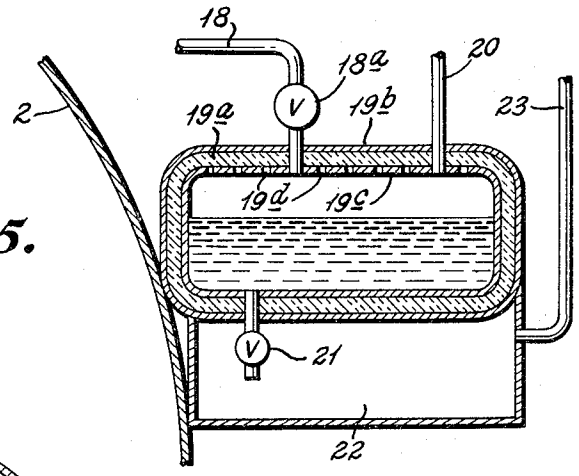


Fig. 5.

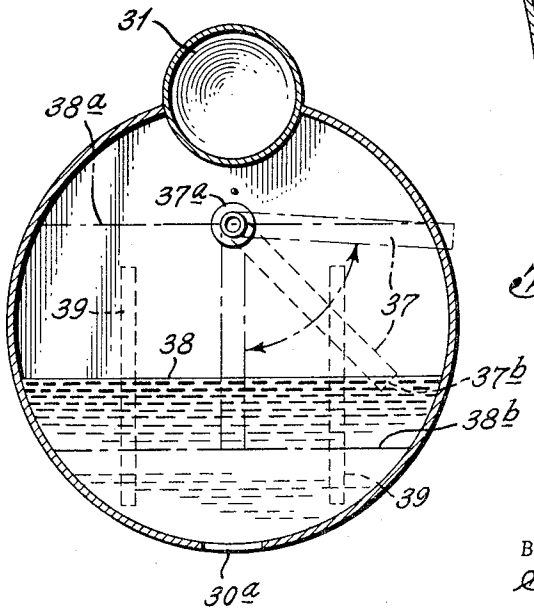


Fig. 8.

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DIVING MACHINE WITH GAS BALLAST TANK

Filed Nov. 27, 1962 4 Sheets-Sheet 4

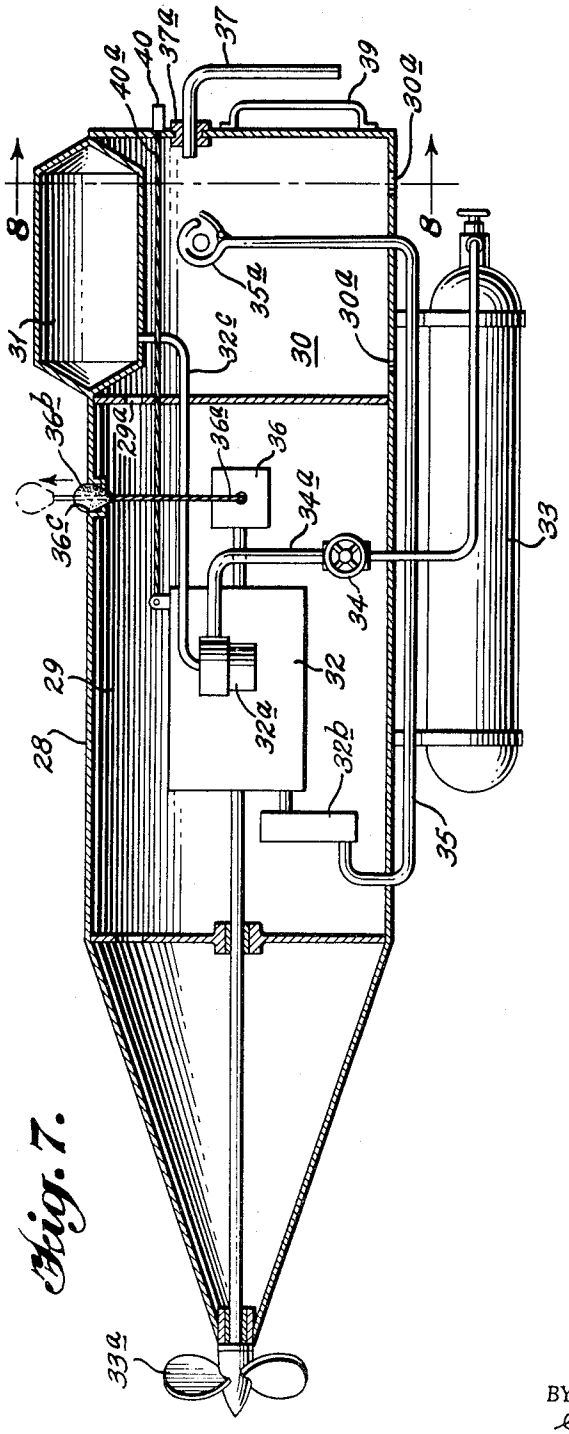

Fig. 7.

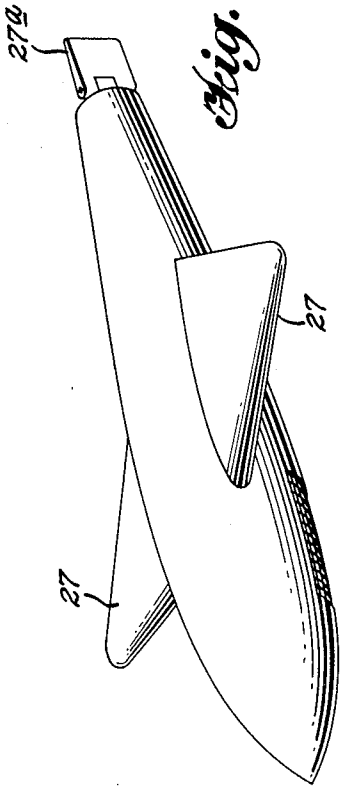

Fig. 6.

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United States Patent Office

3,171,376

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3,171,376

DIVING MACHINE WITH GAS BALLAST TANK

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13 Claims. (Cl. 114—16)

The invention relates to immersed machines the buoyancy of which is controlled by means of a chamber containing gas in pressure equilibrium with the surrounding water and in particular to submarine diving machines having ballast tanks containing simultaneously and in variable proportions water and gas.

In present submarine vehicles, such as submarines, submersibles and bathyscaphes, the problems of hydrostatic equilibrium and of control of vertical movements during the various operations of immersion are solved in a rough and imperfect manner. None of these vehicles is able to develop and control an upward force permitting the positioning, the putting down and the manipulation of weights on the bottom and the lifting of weights and the regulation of speeds on descent and ascent.

Conventional diving or submersible machines comprise a thick hull withstanding the pressure in which the crew, the motive equipment and the various installations necessary for the operation of the machine are maintained at atmospheric pressure, and have ballast tanks in constant pressure equilibrium with the water and which can consequently be constructed with thin walls. These ballast tanks contain water and air alternately. In order to dive, cocks are opened and the ballast tanks are filled with water; in order to rise to the surface again, the air blast which empties the ballast tanks is turned on. The variations in weight during submersion are compensated by exchange of water between the outside and regulating tanks contained in the thick hull.

Diving machines for great depths known heretofore, of the bathyscaphe type, can be used only for submarine exploration work and comprise a thick hull holding the crew and ballast tank containing petrol. As the petrol is more compressible than water, the bathyscaphe becomes heavier and heavier as it descends and can resume a positive buoyancy on the bottom only as a result of releasing ballast, becomes lighter and lighter on ascent and cannot redescend without taking on ballast again.

The use of ballast tanks containing in the submerged state, by way of lift or support means, volumes of gas in pressure equilibrium with the water at the same level has hitherto been proscribed in submarine vehicles by reason of their great variations of volume as a function of the submersion, which accentuates the defects of vertical stability inherent in any submerged vehicle.

An object of the invention is to provide a diving machine in which the lift means are constituted by volumes of gas in pressure equilibrium with the surrounding water at the same level and which are stable under submersion.

Another object of the invention is to provide a diving machine capable of diving, controlling its submersion, reaching the bottom of the sea, picking up a load and rising to the surface with the load.

A further object of the invention is to provide a diving machine which is capable, when submerged, of re-establishing its longitudinal and transverse equilibrium which are possibly upset, for example, as a result of picking up a load.

Yet another object of the invention is to provide a diving machine which rises automatically to the surface in the event of damage to the devices controlling its submersion.

Other objects and advantages of the invention will become apparent from the following description given with reference to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic representation of a diving machine according to the invention showing the various elements of the machine,

FIGURE 2 is a perspective view of a submarine vehicle incorporating a number of characteristics of the invention,

FIGURES 3 and 4 are respectively a diagrammatic cross-section and a diagrammatic longitudinal section of the submarine vehicle shown in FIGURE 2,

FIGURE 5 is a view in transverse section of a liquefied gas reservoir,

FIGURE 6 is a perspective view of another submarine vehicle according to the invention,

FIGURE 7 shows diagrammatically another constructional form of submarine vehicle, seen in longitudinal section, and

FIGURE 8 is a sectional view on the line 8—8 of FIGURE 7.

The diving machine shown diagrammatically in FIGURE 1 comprises essentially at least one ballast tank *a*, an engine compartment *b* and a cabin *c*, which are assembled with one another by the structure of the machine. The ballast tank *a* contains in the upper portion a lifting or supporting gas *d* and contains in the lower portion orifices *e* allowing the surrounding water *f* to penetrate freely into the ballast tank. When the machine is in equilibrium in the immersed or submerged state, the water enters the ballast tank as far as the level *g*. The pressure of the gas *d* is obviously the same as that of the water *f* at the depth of the machine, so that the outer walls of the ballast tank *a* do not need to resist the pressure and can be constructed as a thin hull or shell like the walls of the ballast tanks of a conventional submarine.

The cabin *c* is designed to accommodate the crew and the pressure prevailing inside the cabin must be substantially equal to atmospheric pressure. The walls of the cabin must therefore withstand the external pressure and are constructed as a thick hull or shell, for example like the hull of a conventional submarine or like the cabin of a bathyscaphe, according to the maximum depth provided for the machine.

The engine compartment *b* can be maintained at atmospheric pressure and must, therefore, be in the form of a thick shell like the cabin. The engine compartment may also be in the form of a thin shell and be maintained at the pressure of the surrounding water or at a pressure close thereto, for example by means of apertures such as *h* enabling the compartment *b* to communicate with the upper portion of the ballast tank *a*, or else by means (not shown) including a compressed air cylinder, a compressor for making air pass from the compartment into the cylinder and a valve for making air pass from the cylinder into the compartment.

It is obvious that the cabin *c* may be eliminated if the machine is not to receive crew, but only apparatus capable of operating in the engine compartment, the machine being for example remote controlled.

The engine compartment encloses a reservoir *i* containing a substantial quantity of the gas *d* under reduced volume, in a physical state such that it expands if it is subjected to the temperature of the water *f* and to the pressure corresponding to the maximum submersion which can be attained by the machine. This gas under reduced volume may, for example, be in the liquid state, or at very low temperature, or in solution in a suitable liquid or solid solvent, or even simply compressed, although this latter method of storage does not enable the volume of the gas to be reduced to a considerable extent and is consequently relatively cumber-

some. An apparatus *j* in the compartment *b* enables gas to be drawn in from the ballast tank *a* via intake *m* and to be reduced to the physical state in which it is contained in the reservoir *i*, and then to cause it to pass into this reservoir. The apparatus *j* will be, for example, a liquefaction apparatus if the reservoir *i* contains liquid gas, or else a compressor.

The reservoir *i* may be completely closed and be, for instance, similar to a cylinder of butane supplied in the liquid state. The reservoir *i* may also be maintained in pressure equilibrium with the surrounding water, for example by means of a vent *k* ending in the ballast tank. It is obvious that in this latter case the gas under reduced volume will have to be maintained at very low temperature, for example by insulating the reservoir *i* against heat.

An apparatus *l* in the compartment *b* enables gas under reduced volume to be withdrawn from the reservoir *i*, increased in volume and delivered into the ballast tank *a*. If the reservoir *i* contains gas in the liquid state the apparatus *i* will comprise a vaporising device. If the reservoir *i* is completely closed the apparatus *l* will comprise an expansion valve. The calories necessary for the vaporisation or expansion may be supplied, for example, by a source of electric energy, but the calories will preferably be supplied, wholly or in part, by placing the gas in heat-exchange relationship with the surrounding water *f*, so that the gas enters the ballast tank *a* at a temperature close to the temperature of the ballast tank. It is, in fact, essential that variations in temperature do not cause the volume of the gas in the ballast tank *a* to vary in uncontrolled manner. It will be understood that the arrangement described enables the submersion of the machine to be controlled. In fact, the transfer of the gas from the ballast tank *a* to the reservoir *i* and vice versa does not change the weight of the machine, but enables the volume of the gas *d* in the ballast tank *a* to be varied at will. By virtue of Archimedes Principle the buoyancy of the machine depends only on the level of the water in the ballast tank. For a level *g* substantially independent of the submersion, the buoyancy is nil and the machine is maintained in vertical equilibrium. If the level rises for example to g_1, the buoyancy becomes negative and the machine descends; if the level descends to g_2, the machine rises.

The arrangements *j* and *l* can be controlled from the cabin *c* by schematically shown control console *p* in such manner as to maintain the level in the ballast tank at the desired height, this level being detected, shown schematically by a measuring device *n* and readable from the cabin by means of a transmitting device (not shown). It is also possible to provide a control device shown schematically at *r* for controlling directly as indicated schematically by *r'* and *r''* the submersion control arrangements *j* and *l* at the level of the water in the ballast tank, the control device being arranged in known manner so that the said level may be maintained automatically at a desired value displayed in the cabin.

In the case where the reservoir *i* is maintained in pressure equilibrium with the ballast tank *a* by means of a vent *k*, the latter constitutes a safety device ensuring automatically the ascent of the machine to the surface if the arrangements *j* and *l* are damaged, because the gas contained under reduced volume in the reservoir *i* has a tendency to become heated and assume the temperature of the water *f* and expand to enter the ballast tank *a* through the vent *k*. In the case where the reservoir *i* is completely closed it is necessary to provide an equivalent safety device, which may be a conduit of small section (not shown) ensuring a permanent leakage from the reservoir *i* towards the ballast tank, or else a cock which can be operated directly from the cabin *c* and placing the reservoir in communication with the ballast tank.

The ballast tank *a* could be replaced in some types of machine by one or more flexible balloons containing the lift gas *d* internally and subjected externally to the pressure of the water *f*.

The submarine vehicle shown in FIGURE 2 is capable of diving to a great depth. It is constructed to dive to a given depth, shift while diving, control its submersion and bring up to the suface loads picked up at the bottom of the sea.

The vehicle has a structure similar to that of a conventional submarine, incorporating in particular a cabin **1**, an engine compartment **2**, a bilge **3** and ballast tanks **4** forming the outer shell or hull on the top and at the sides.

The cabin **1** is similar to the cabin *c* of FIGURE 1 and is constructed to withstand the pressure of the water at the maximum submersion. It is designed to house a crew and the apparatus and installations necessary for their existence and the controls (not shown) enabling the devices located outside the cabin to be remote controlled in known manner. The cabin **1** may also contain port holes such as **5** similar to the port holes of bathyscaphes.

The engine compartment **2**, located at the rear of the cabin **1**, is constructed as a thin shell and communicates with the upper portion of a ballast tank **4** through a vent **6** equipped with a valve **6***a*. The valve **6***a* is closed when the compartment **2** communicates with the atmosphere by means of hatches **7**, the vehicle floating on the surface. When the vehicle is diving, the valve **6***a* is opened so as to maintain the compartment **2** in pressure equilibrium with the ballast tanks **4**, which are themselves in pressure equilibrium with the water outside.

The submarine vehicle comprises a conning tower **8** similar to the conning tower of a conventional submarine and into which the hatches **7** open, thus making it possible to pass from the conning tower **8** into the compartment **2** when the vehicle is floating on the surface. A pressure-tight door **9** then makes it possible to pass from the compartment **2** into the cabin **1**.

The bilge **3** communicates with the outside of the vehicle through openings **3***a* in the upper part of the bilge, as a result of which the bilge **3** is always full of water at the submersion pressure. Means (not shown) are provided for introducing into the bilge material picked up at the bottom of the sea. These means may be, for example, a pump drawing in water with material up to a size of a few centimetres and discharging this material into the bilge.

The vehicle may moreover be provided with means (not shown) enabling a load of substantial size to be seized or picked up at the bottom of the sea or the same to be attached to hooks **10** carried by the machine. Pick-up or collecting means are advantageously constituted by nets forming traps controlled by cables wound on winches supported outside the cabin **1** and/or the compartment **2**, the winches being controlled from inside the cabin.

The ballast tanks **4** communicate with the outside through bottom openings **4***a*, like the ballast tanks of a conventional submarine. The ballast tanks **4** are divided by a tight longitudinal bulkhead **11** and two tight transverse bulkheads **12** into a group of two midships ballast tanks, a group of two forward ballast tanks and a group of two aft ballast tanks.

The engine compartment **2** contains the propulsive equipment, which, for example, is similar to that of a conventional submarine, but is designed to operate at the pressure of maximum submersion. The propulsive equipment comprises in known manner an electric motor **13** connected to a set of storage batteries (not shown) and driving a screw **14**, it being possible for the electric motor to be coupled with a heat engine **15** operating only when the vehicle is floating on the surface and provided with an exhaust pipe **15***a* which is adapted to be closed. The set

of storage batteries supplies the electric energy for the propulsion of the submerged vehicle and for the operation of the various pieces of apparatus consuming energy which are located on board the vehicle. The engine **15** is supplied with fuel from tanks (not shown) disposed in the compartment **2** or in the ballast tanks.

The compartment **2** also contains devices for controlling diving and submersion, comprising essentially a liquefaction apparatus **16** actuated by an electric motor **16***a* and drawing in the gas in the ballast tanks **4** through a header **17** terminating in each ballast tank at an intake controlled by a valve **17***a*. The liquefaction apparatus **16** discharges the cool and liquefied gas by gravity into a header **18** which conveys it into the liquid gas reservoir **19** which may extend longitudinally through the bulkheads **12** along each side of the vehicle. The liquefaction apparatus **16** may be for example, a Linde apparatus, the principle of which is well known, using for cooling the gas after each compression stage a circulation of water taken from and returned to the outside of the vehicle. The production of the circulation of water does not offer any difficulty, since the compartment **2** is in pressure equilibrium with the outside.

As will be seen from FIGURE 5, a reservoir **19** is provided which is immersed in the water and fixed to the lower part of each ballast tank **4** and the entry into each reservoir **19** of the liquefied gas arriving through the header **18** is controlled by a valve **18***a*. The reservoir **19** is constituted by a heat insulator **19***a* between two tight walls **19***b*, **19***c*, but the inner wall **19***c* has in its upper section orifices **19***d* for balancing the pressures between the inside of the reservoir and the space between the two walls. A vent **20** provides free communication between the atmosphere of the reservoir **19** and that of the ballast tank containing the said reservoir **19**. A valve **21** enables the liquid gas in the reservoir **19** to flow off by gravity, in controlled quantity, into a vaporiser **22** which communicates freely through the vent **23** with the atmosphere of the said ballast tank. The vaporiser **22** takes the calories required for vaporisation, at least partly from the outside water by means of a water-circulation type heat exchanger (not shown). A part of the calories required for the vaporisation may be supplied by electric heating.

The header **17** and the vents **20** and **23** contain dehumidifying filters of known type for preventing the introduction of moisture into the liquefied gas and into the reservoirs **19**.

The liquefaction apparatus **16** makes it possible, by remote operation from the cabin **1** of the valves such as **17***a* and **18***a*, to draw in gas from all the ballast tanks **4** at the same time or from some of the ballast tanks only and to deliver the liquefied gas to one or more reservoirs **19**. By remote operation of one or more valves **21** the vaporisers **22** enable liquefied gas to be drawn from one or more reservoirs **19**, to be vaporised and to be delivered to the corresponding ballast tank or tanks. The above-described devices accordingly enable the volume of gas in each ballast tank to be controlled and consequently an action to be exerted on the buoyancy of the submarine vehicle as explained above with reference to FIGURE 1.

These devices also make it possible to a certain extent to cause gas to pass from one ballast tank to the other in order to control the longitudinal and transverse equilibrium of the vehicle. However, a device is provided which enables an action to be exerted on this equilibrium and which comprises a compressor **24** having a large delivery rate and a low rate of compression and driven by an electric motor **24***a*, provided with an intake header **25** and a delivery header **26** opening into each ballast tank **4** through valves **25***a* and **26***a* respectively, remote controlled from the cabin **1**.

It will be appreciated that the latter device, comprising a compressor **24** having a large delivery rate and a low rate of compression, intake means including intake valves **25***a* for sucking gas from each ballast tank, and delivery means including delivery valves **26***a* for delivering gas into each ballast tank, and further comprising means for controlling the valves **25***a* and **26***a* from the cabin makes it possible to suck a desired amount of gas from any ballast tank to deliver the same to any other ballast tank in order to control the longitudinal and transverse equilibrium of the vehicle. It will be apparent that the object of the said device is merely to cause gas to pass from one ballast tank to another without it being necessary to compress the gas into a liquid state in liquefaction apparatus **17**, thus permitting of a lesser consumption of energy. Actually, the compressor **24** does not compress the gas into a liquid state, and has a delivery rate which is large enough to perform a quick conveyance of the gas from one ballast tank to another, and a low rate of compression, which is just high enough to perform said conveyance.

The possibility of varying the submersion and the trim at will provides a new method of propulsion which can assist the motive equipment and even replace it completely in some machines. FIGURE 6 illustrates a method of propulsion of this kind. The machine shown digrammatically is provided with a rudder **27***a* and with horizontal fins **27**. If the machine is pointed downwardly, in the position shown, and a movement of gas is carried out between ballast tanks in the manner already described and if lift gas is liquefied in order to make the machine heavy, this starts a downward movement and the action of the water on the fins causes it to move forward at the same time. Conversely, by placing the machine so that it is pointing upwardly and by lightening it, it will be caused to move forward at the same time as it ascends; thus, it can be made to perform very considerable movements by successive dives and ascents accompanied by changes of trim. The rudder **27***a* enables the horizontal direction of the movement to be modified.

The gas contained under reduced volume in the reservoir *i* of FIGURE 1 may be a gas supporting combustion, that is to say generally speaking a gas containing oxygen in a more or less high proportion, serving as supporter of combustion for a heat engine supplying energy to the machine and exhaust gases which are delivered to some at least of the ballast tanks to serve as lift gas.

Such an arrangement is used in the submarine scooter which is shown diagrammatically in FIGURES 7 and 8. The submarine scooter comprises a shell or hull **28** defining an engine compartment **29** communicating at **29***a* with a ballast tank **30** open at **30***a* and surmounted by a fuel tank **31**. The compartment **29** contains an internal combustion engine **32** driving a screw **33***a*. The carburetor **32***a* is supplied with fuel from the tank **31** through fuel line **32***c* and with air from a cylinder of compressed air **33** fixed below the hull through the intermediary of an expansion valve **34** in air line **34***a*. The expansion valve **34** is a diaphragm-type expansion valve of known type used on independent diving suits and expanding the air from the cylinder **33** to the pressure of the compartment **29**, that is to say to the submersion pressure. The exhaust gases of the engine **32** pass into an oil-removing filter **32***b*, are cooled in the pipe **35** extending to the outside of the hull and end up in the ballast tank **30** through a schnorkel tube **35***a* which prevents any danger of the water which may possibly be present in the ballast tank penetrating into the engine **32**. The engine **32** is equipped with a starting device comprising a drum **36** coupled to the crankshaft of the engine by a ratchet system and a return spring for winding up a starting cord **36***a* provided with a rubber ball **36***b* which closes an orifice **36***c*.

The level of the water in the ballast tank **30** is regulated by means of a bent pipe **37** entering the ballast tank through a rotating packing **37***a*. It will be seen from FIGURE 7 that the pipe **37** permits regulation of the level of the water in the ballast tank **30**, which is supplied in excess with exhaust gas through the pipe **35**. When the pipe **37** is inclined at about 45° with respect to the vertical, the level is established at **38**, the surplus gas escaping

through the end 37*b* of the pipe 37; the buoyancy of the scooter is then nil and the scooter remains submerged. There are shown in dot-dash lines in FIGURE 8 two other positions of the pipe 37 corresponding respectively to a level 38*a* of negative buoyancy and to a level 38*b* of positive buoyancy.

The pilot remains outside the machine and holds on to handles 39. He controls the scooter by manoeuvring the submersion control pipe 37 and a lever 40 which controls the engine 32 through the medium of a cable 40*a*.

The invention is capable of constructional embodiment in a variety of ways and the arrangements described may be combined in various manners. For example, one or more ballast tanks of the vehicle shown in FIGURE 2 may be provided with an articulated bent pipe such as 37 or with an equivalent device for discharging the excess lift gas to the outside and obtaining in the ballast tanks an adjustable separation level between the water and the lift gas. In certain circumstances such a device enables part of the energy necessary for the liquefaction of the lift gas to be saved, provided, of course, that sufficient liquefied gas is left in the reservoirs 19 for rising to the surface.

What is claimed is:

1. A diving machine for penetrating to a given depth in water having a natural temperature, comprising in combination:

(*a*) as lift device, at least one chamber containing a gas in variable volume, said chamber being adapted to maintain the gas in pressure equilibrium with the water;

(*b*) storage means containing a substantial quantity of gas under reduced volume and in a physical state such that it has a natural tendency to increase its volume when the gas under reduced volume is subjected to the natural temperature of the water and to a pressure which may reach the pressure of the water at the given depth;

(*c*) a device for controlling the submersion by controlling the volume of gas in the chamber, comprising means for drawing gas from the chamber, reducing its volume and delivering it to the storage means and means for withdrawing gas under reduced volume from the storage means, increasing its volume and delivering it to the chamber, and

(*d*) a safety device for placing the storage means in communication with the chamber at least when said submersion control device is damaged.

2. A diving machine according to claim 1, comprising means for placing the storage means in communication in permanent manner with said chamber, as a result of which the gas under reduced volume is at the same pressure as the gas in the chamber, the storage means being provided with means for maintaining the gas under reduced volume at a low temperature.

3. A diving machine according to claim 1, wherein the chamber is a ballast chamber in free communication with the water in the bottom part, as a result of which the ballast chamber contains lift gas and water up to a variable level.

4. A diving machine for penetrating to a given depth in water having a natural temperature, comprising at least one ballast chamber containing a lift gas, in free communication with the water at the bottom part, at least one storage reservoir containing a substanttial quantity of gas in the liquid state when the reservoir is subjected internally to atmospheric pressure, said reservoir being provided with a vent device placing it in free communication with the ballast chamber and with heat-insulating means for maintaining the reservoir at a very low temperature; and submersion control means comprising a liquefaction apparatus for drawing gas from the ballast chamber, cooling it to the reservoir temperature and delivering it to the reservoir, and a vaporising device for removing gas contained in the reservoir, heating it and delivering it to the ballast chamber.

5. A diving machine according to claim 1, wherein the submersion control device moreover comprises means for discharging out of the machine the gas in the ballast chambers which is below an adjustable given height.

6. A diving machine according to claim 5, wherein at least a part of the gas contained in the storage means under reduced volume is a gas supporting combustion, comprising a heat engine for supplying energy to the machine, means for withdrawing gas supporting combustion, expanding it and delivering it to the engine, means for supplying the engine with fuel, as a result of which the engine produces energy and exhaust gases, and means for delivering the exhaust gases to some at least of the ballast chambers.

7. A diving machine according to claim 1, wherein the submersion control device comprises means for heating the gas drawn from the storage means to a temperature close to the temperature of the chamber, including means for placing said gas in heat-exchange relation with the water.

8. A diving machine as claimed in claim 3, comprising means for detecting said level of water in the ballast chamber, whereby the submersion control device can be actuated in response to said level.

9. A diving machine according to claim 4, further comprising a cabin having an internal atmosphere at atmospheric pressure and walls arranged to withstand externally a pressure equal to the pressure of the water at the given depth, an engine compartment containing propulsive means for the diving machine and the said liquefaction apparatus, and means in the cabin for controlling the said liquefaction apparatus and the said vaporizing device to vary the amount of gas present in the ballast chamber, whereby the water is present in the said ballast chamber up to a level which is varied to control the buoyancy of the machine.

10. A diving machine according to claim 9, having a number of the said ballast chambers spaced longitudinally along the said machine on both sides thereof, and further comprising a compressor, in take means for sucking gas selectively from each ballast chamber to the compressor, and means for delivering gas selectively from the compressor to each ballast chamber.

11. A submarine vehicle for penetrating to a given depth in water, controlling its submersion and bringing up to the surface loads from the bottom of the sea, comprising:

(*a*) a body comprising a cabin having pressure proof walls, a number of ballast tanks freely open at the bottom part thereof, which are spaced along the length of the body on both sides thereof, and an engine compartment which communicates with one of said ballast tanks in an upper portion thereof, through vent means;

(*b*) means for entering the engine compartment and cabin when the vehicle is floating on the surface, including hatchway means in the upper part of said compartment, means for obturating said vent means, and hatchway means leading from said compartment to the cabin;

(*c*) tying means for supporting loads exteriorly of the body;

(*d*) in the engine compartment, a propulsive equipment, a liquefaction apparatus, and power storage means;

(*e*) heat insulated reservoir means containing a gas in a liquid state in a bottom portion of each ballast tank, vent means for the reservoir means, which freely open in the upper part of said ballast tank, delivery valve means for delivering said gas to vaporizing means, and vent means for the vaporizing means, which open freely in the upper part of said ballast tank;

(*f*) duct means for feeding the liquefaction apparatus with gas from the said ballast tanks, including intake valve means for opening said duct means in each ballast tank selectively, and discharge means for the

liquefaction apparatus, including discharge valve means leading to each reservoir means;

(*g*) control means in the cabin for controlling said delivery, intake and discharge valve means.

12. A submarine vehicle according to claim 11, further comprising a bilge which is freely open at the upper part thereof and pump means for sucking water and solid material into the bilge.

13. A diving vehicle comprising at least one ballast tank freely open at the bottom part thereof, an engine compartment in free communication with the ballast tank at the upper part thereof, a propulsion heat engine in said compartment, a fuel tank and fuel feed means for the engine, storage means containing an oxidizer gas under pressure, suction means leading from the storage means to the engine and incorporating a diaphragm-type expansion valve in said compartment for expanding the gas to the pressure of said compartment, an exhaust pipe for the engine, which extends to the exterior of the vehicle and opens in the

upper part of the ballast tank, a discharge pipe having a substantially horizontal portion which enters the ballast tank through rotating sealing means and a bent outer portion which extends externally of the vehicle, and control means for the engine externally to the vehicle.

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