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2,363,488

MEANS FOR RAISING OR LIFTING SUNKEN OR PARTIALLY SUNKEN VESSELS

Filed March 26, 1942

3 Sheets-Sheet 1

FIG. 1.

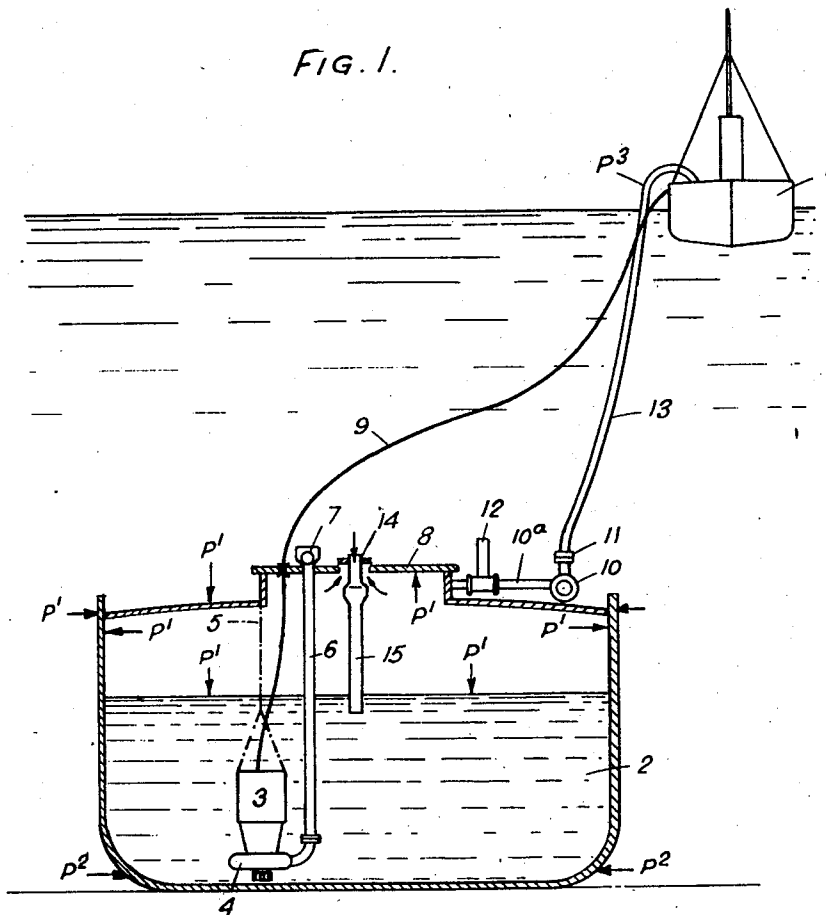
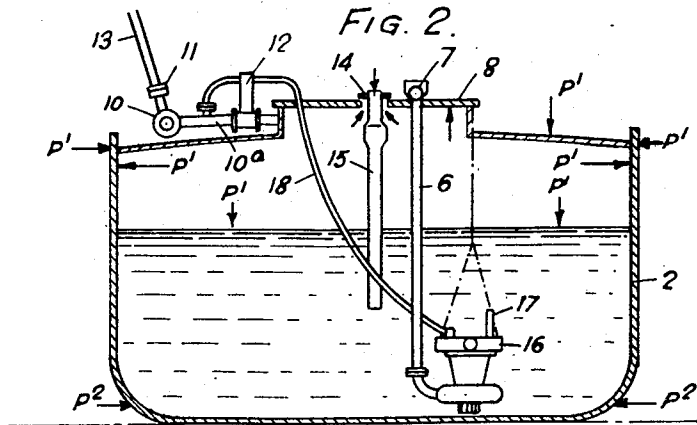


FIG. 2



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3 Sheets-Sheet 2

FIG 3.

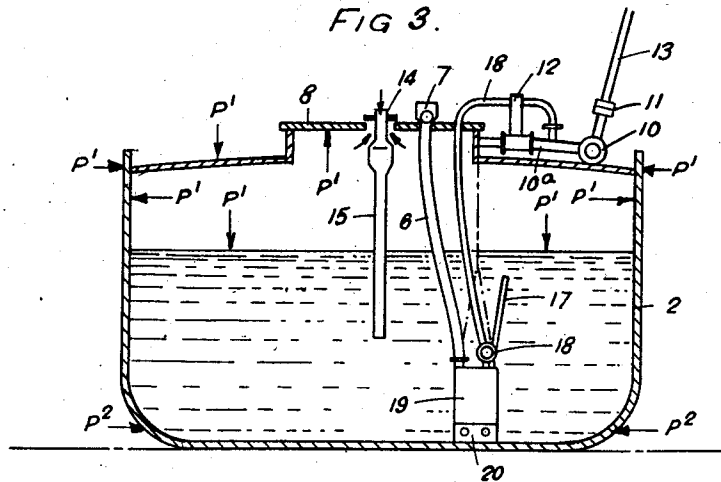
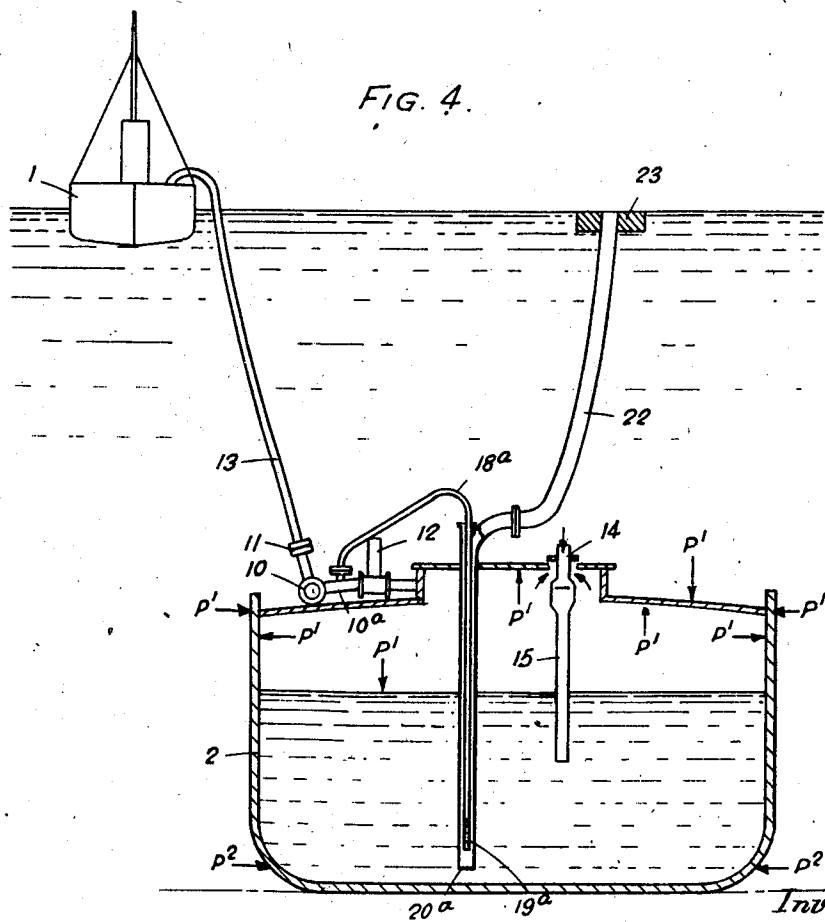


FIG. 4.



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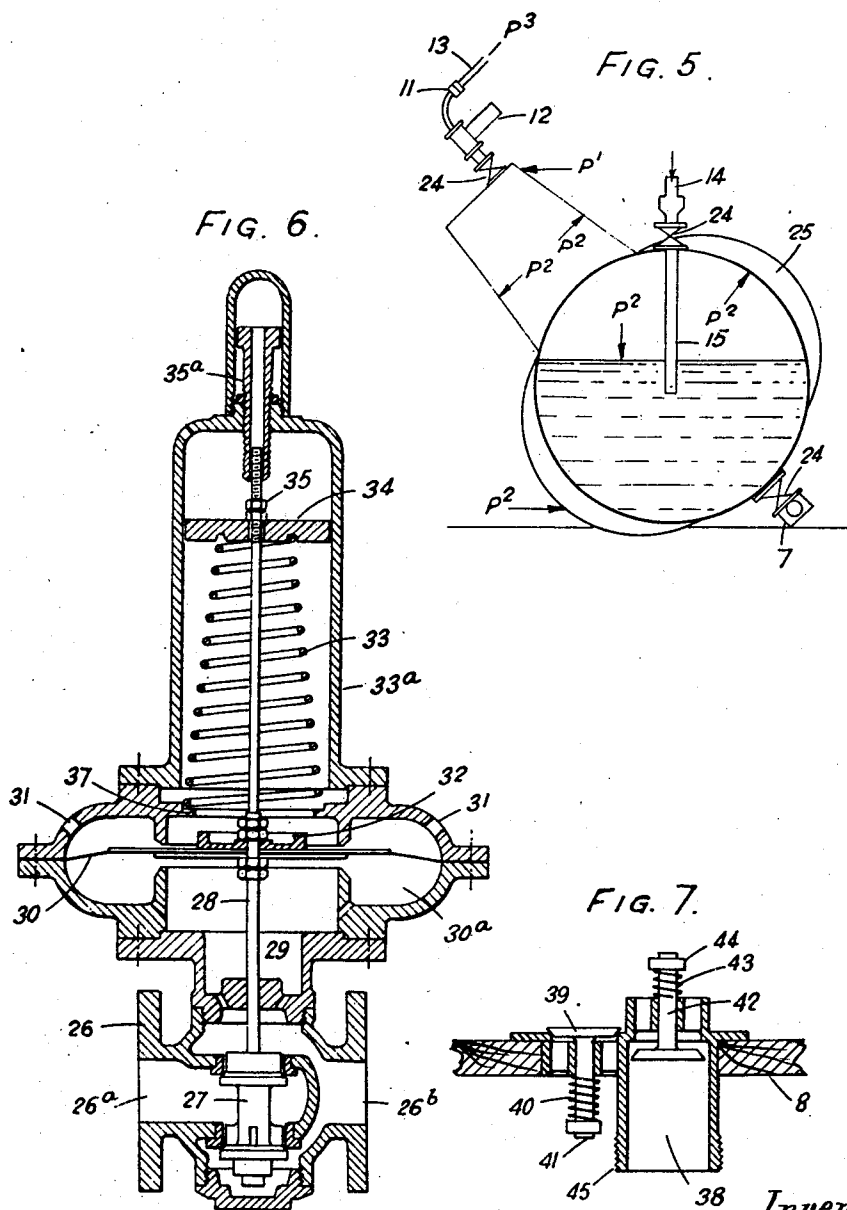
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,363,488

MEANS FOR RAISING OR LIFTING SUNKEN
OR PARTIALLY SUNKEN VESSELS

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7 Claims. (Cl. 114—50)

This invention relates to an improved method of and means for lifting submerged or partially submerged vessels by means of compressed air or gases in such manner that the maximum use is made of the flotation power of the vessel itself without damage thereto. By such use of the flotation power a great simplification in the work and equipment is effected together with a saving in the under-water labour required and lifting operations hitherto considered impracticable are rendered possible.

It has previously been proposed to employ compressed air for this purpose in the case of cap-sized sunken vessels and compressed air has been applied to war vessels and the like that normally assume this position when unstable.

The object of the invention is to provide a method of and means for lifting by compressed air for use in the case of more lightly built craft which may sink in the normal or nearly normal position. Hitherto this has been impracticable owing to the deck structure being too weak structurally to withstand the unbalanced pressure arising during the lifting operation unless very heavy stiffening is resorted to.

According to the present invention the method comprises forming a substantially air and water tight compartment or compartments in the submerged or partially submerged vessel which when empty or partially empty is of sufficient size to provide the necessary flotation power to raise the vessel, removing the water contained in such compartment or compartments by a pump or other mechanical means and at the same time admitting compressed air or gas to the space voided by the water through one or more valves each of which is arranged to supply the air or gas automatically in such a manner that throughout the operation the internal pressure balances the external hydrostatic pressure on the weakest part of the compartment or balances it to such an extent that the resultant external or internal pressure is always maintained below the limit at which said weakest part of the compartment might be damaged by the pressure, the compartment also being fitted with a two-way safety valve or two separate valves arranged to maintain a balance of pressure between the admitted air or gas and the water by releasing excess of air pressure arising from any cause or likewise to enable flooding to take place in the event of the internal pressure falling out of balance.

In carrying out the invention it is necessary as a preliminary step to remove the cargo, or a

sufficient proportion thereof, to provide sufficient voids in order that when the water is displaced by air, enough flotation power may be obtained. When this is done a submersible pump, which may be electrically driven, air motor driven, of the air displacement type, of the air lift, or any convenient type, is preferably, but not necessarily, placed in the hold or holds with its suction inlet located at the lowest point. The outlet therefrom is taken to the deck or hatch level or point at which it is determined that the structure will be weakest, and fixed there, it being unnecessary and undesirable to carry the outlet to the surface. At this point, namely, where it passes through the hull or hatch or deck, a non-return valve is fitted.

It is desirable, but not necessary, to fix in the hold during the operations an indicator whereby the actual water level existing in the hold at any stage of the operations may be recorded at the surface.

Next all openings in the hold or holds are covered with a wooden or steel hatch cover or patch or mattress of well-known form, and secured in the usual manner. It is unnecessary for this to be of heavy construction, and the customary wooden hatch covers are quite suitable for the purpose provided that whatever method is used it should be as watertight and airtight as possible under the circumstances, and provided always that it is fixed in such manner that it will withstand either upward or downward pressure. At no time is it necessary for this hatch cover to sustain a load in either direction of any magnitude and by experiment it has been found that a load of plus or minus up to 4 lbs. per square inch is desirable but this may be controlled within finer or coarser limits as may be deemed advisable. It is not necessary in every case to repair a damaged hull below the surface before lifting, as sufficient lifting power may be obtained from adjacent holds.

At a suitable point in the deck or wherever may be determined as the structurally weakest point, one or more valves constructed according to the invention are fitted. The function of these valves is to admit compressed air or gas at a pressure corresponding to the hydrostatic pressure existing at the predetermined point referred to above. In addition a two-way safety valve or two separate valves are provided and arranged to maintain a balance of pressure in the hold between the admitted air or gas and the water by releasing excess of air pressure or

to enable flooding to take place in the event of the internal pressure falling out of balance.

The operation of lifting is carried out by pumping water from within the hold or vessel and at the same time admitting air or gas into the void so caused at such a pressure and volume that the external and internal pressure is maintained in substantial balance within the predetermined limits and at the weakest point of the vessel's structure. In the case of a vessel being lifted from a considerable depth it will be realised that the number of automatically operating balance valves fitted must be suitably increased to permit of the release, in the allowable interval of time, of the expanding air as the vessel rises to the surface and under a gradually decreasing external pressure.

Where vessels are designed to sustain pressure in all directions such as a submarine, the method may be used with advantage. In this case the various valves may be fitted by the use of trepanning tools without loss of contained air or admission of further water. The valves would be adjusted to an out of balance pressure sufficient to eject all water and internal water ejected through the non-return valve by air pressure only. The automatic valves will preserve the structure of the vessel at all and any trim that the vessel may assume in the course of the operations.

For a like reason with the normal type of vessel, this method eliminates the danger of loose internal water uncontrolled by baffles, swash-plates or other means for controlling surging when lifting as no matter what trim the vessel may assume the operation of lifting is not interfered with and trim can be adjusted at the surface.

The invention can conveniently use compressed air, compressed air and steam mixture, or very advantageously a mixture of steam and combustion gases as produced under pressure in the internal combustion boiler, or any other gas or mixture of gases under pressure.

To enable the invention to be fully understood it will now be described by reference to the accompanying drawings, in which:

Figs. 1-4 inclusive are sectional elevations showing diagrammatically sunken vessels having various forms of the invention applied thereto, the section in each case representing a selected hold or compartment in the vessel,

Fig. 5 shows the application to a sunken vessel of a modified form of the invention,

Fig. 6 is a sectional elevation of one of the automatic valves constructed according to the invention, and

Fig. 7 is a similar view of another type of valve used.

Referring to Fig. 1. A salvage vessel 1 is shown on the surface of the water above the submerged hull 2. The hatch opening of the selected hold or compartment of the hull is patched and made water and air tight by a suitable cover 3 so that the compartment is sealed and a submersible electric motor 3 is suitably suspended therefrom by a sling 5 and is in driving connection with a pump 4 having a flexible discharge pipe 6 connected to a non-return valve 7 in the hatch cover 8. The motor is supplied with power through the cable 9 from the salvage vessel, the cable passing through a gland in the hatch cover as shown. A compressed air high pressure main 10 is laid along the deck of the hull 2 and is connected by a slip coupling 11 to the main compressed air supply pipe 13 carried by the salvage

vessel and which is supplied with air from the vessel's compressors in the usual manner. A branch pipe 10a from the main 10 opens into the hold and an automatic high pressure air inlet and reducing valve 12 is fitted thereto as shown. This valve is shown in section in Fig. 6 and is automatically controlled by the hydrostatic pressure. A two-way balance valve 14 is also fitted to the hatch cover 8 and connected to a flexible dip pipe 15 the lower end of which is below the surface of the water in the hold. This valve is shown in Fig. 7 and operates to release excess of air pressure or to enable flooding to take place through the pipe 15 in the event of the internal pressure falling out of balance. This valve is also automatically controlled by the hydrostatic pressure at its point of fixture similarly to the valve 12.

The valve 12 is set at the weakest point of the deck structure of the vessel and, in conjunction with valve 14, automatically maintains the internal pressure at the equivalent external hydrostatic pressure at the point of fixture and thus balances the pressure taking the strain off the structure. Thus if the receiver pressure is P3 and the hydrostatic pressure at the valve 12 is P1 then the pressure on both sides of the deck and within the hold will be P1. It will also be seen that if the pressure at the bottom of the vessel externally is P2 and if the internal water is pumped out the stress on the hull at that point will be P2—P1, but this resultant pressure will not exceed that for which this part of the structure was normally designed.

Fig. 2 shows a similar case but in this example the submersible electric motor is replaced by an air or gas motor 16 coupled to the high pressure supply by the pipe 18 through the hatch cover 8 and exhausting through 17 into the hold at a back pressure equal to P1 i. e. the external pressure on the hatch or deck.

Fig. 3 shows a further case wherein an air or gas displacement pump 19 is used in place of a mechanically driven pump. 20 indicates the inlet water valves and 20a the reserving air pressure valve and 17 the exhaust pipe of the pump. In this case as in Fig. 2 the pump exhausts under a back pressure equal to P1. High pressure air or gas is supplied to the pump through the hatch cover 8 by means of pipe 18 in both cases but the back pressure of the pumps reduces the amount to be supplied from the salvage vessel direct.

Fig. 4 shows a further case wherein an air or gas lift pump is used. In this case the mechanical pump is replaced by a high pressure air or gas lift pipe 18a having a perforated end 19a inserted concentrically within the discharge pipe 20b. This discharge pipe may preferably be continued by the flexible pipe 22 held at the surface by the float 23 and by which the "submergence" effect is enhanced. Instead of the pipe 22 a non-return valve may be fitted in the pipe 20b at the hatch cover as in the other examples illustrated.

Fig. 5 shows the application of a modified form of the invention in the case of a vessel with damaged compartments wherein the structure of the vessel permits of a plus internal pressure either for the purpose of holding back water from leakage holes low down in the structure or of ejecting internal water by raising the internal pressure to P2. In this case a mechanical pump is not used, the water being expelled by air pressure in the usual way. The chief function of the invention is to control the pressure by auto-

matic means at all stages of the salvage work with the maximum economy of air and the maximum safety to the structure of the vessel. As shown a sunken submarine 25 is provided with isolating valves 24 and to these valves the air reducing valve 12 and the balance and non-return valves 14 and 7 respectively are fitted as hereinbefore referred to in the other examples. The air reducing valve 12 is set with an out of balance internal load of P2-P1 lbs. per square inch. In the event of a damaged hull the valve 7 would not be fitted but the out of balance load would be set to correspond to the depth of the fracture. By these means and by the use of valves 12 and 14 violent surges of excess air through the fractures are avoided with the consequent freedom from violent changes of trim.

Fig. 6 shows one of the valves 12 in section and arranged for automatic control by the external hydrostatic pressure. The valve comprises a body 26 having a high pressure inlet at 26a and a reduced pressure outlet 26b. The valve 27 itself is of the balanced type and is mounted on a stem 28. The stem carries a diaphragm 30 mounted in a chamber 30a a pressure plate 34 being attached to the upper end of the stem and adjustably held by the nuts 35 or the adjustable stud 35a as shown. The pressure plate serves as an abutment for a loading spring 33 mounted in a chamber 33a attached to the diaphragm chamber the other end of the spring bearing against shoulders 37 as shown. The external water is admitted to the upper surface of the diaphragm through the ports 31 for automatic working.

As shown, the spring 33 is arranged to place an upward out of balance pressure on the diaphragm 30 to any desired limit and can readily be adjusted. The out of balance load acts upwardly and since the underside of the diaphragm is in communication through the ports 29 with the low pressure side which communicates with the vessel's hold it follows that the resultant pressure in the hold equals the surrounding pressure P1 plus that given by the spring.

The spring is conical and by reversing it so that the narrow end of the frustum bears on a second pressure plate 32 attached to the stem 28 adjacent to the diaphragm while the other end bears on the plate 34 together with removal of nuts 35 and adjustment of stud 35a the action is reversed and the resultant pressure within the hold will equal P1 minus the spring pressure.

Fig. 7 shows diagrammatically one form of two way balance or overpressure valve fitted into a hatch cover. This valve may be constructed in two separate portions, in one piece as shown, or arranged with the two valves concentrically.

38 is the valve body and 39 the air release valve from the hold with an interchangeable loading spring 40 and keeper nut 41 arranged on the valve stem.

In a like manner 42 represents the inlet flooding valve with loading spring 43 and keeper nut 44.

The inlet valve is fitted with a screwed or flanged or other suitable connection 45 to which the dip pipe can be fitted.

It will be seen that if the springs 40 and 43 are light springs then the internal and external pressures are maintained balanced within a few ounces. If on the other hand spring 40 is replaced by one to give a load on the valve equivalent to X lbs. per square inch, then the internal pressure will be maintained at P1 plus X lbs. per

square inch over that pertaining without. In a like manner by changing spring 43 the reverse effect may be obtained, and similarly by adjusting the relative strength of springs 40 and 43 any desired degree of sensitiveness or out of balance load may be obtained.

In the operation of the invention as water is pumped out of the hold 2 by any of the various means hereinbefore described high pressure air or gas is fed through valve 12 until the predetermined internal pressure is reached. It will be realised that in the case where the back pressure of air or gas driven pumps is utilised very little air or gas will be supplied through valve 12 and any excess will be released by valve 14. Both valves 12 and 14 may be set to any desired out of balance load, plus or minus, by changing or adjusting the appropriate springs, alternatively they may be set to equalise the pressure within a few ounces of absolute balance.

At the point of neutral and positive buoyancy valve 12 ceases to function and valve 14 blows off the excess air pressure and volume as the vessel rises. One or more of these valves are fitted depending upon the depth and the volume of air to be released in a given time interval.

Should the salvage work be left in an uncompleted stage by stress of weather or other cause, no harm can arise to the sunken vessel as valve 12 prevents loss of air by breakage of the pipe line 13 and should air leak from other points valve 14 adjusts the loss by flooding through the valve and pipe 15.

In a like manner any tank, vessel or vessel fitted with airtight hatches may be protected during submergence arising from any cause by the fitting of valve 14 as part of its original design. Under no circumstances could such a vessel suffer damage to the deck or hull from unbalanced air or water pressure.

It will be seen that it is unnecessary to cofferdam vessels that are but slightly submerged, it being more economical to fit the hatch covers 8. By the use of this invention the essential part of the salvage equipment will be within the hold of the vessel and receive the maximum protection therefrom against sea action.

While it is preferable in most cases to mount the pumping gear within the hold of the submerged vessel it is not essential as such gear may be carried on the deck of the sunken vessel if desired.

I claim:

1. A method of lifting a submerged vessel which comprises forming a substantially air and water-tight compartment therein, removing the water contained in such compartment by pumping, admitting compressed gas to the space voided by the water controlling the supply of gas automatically in such a manner that throughout the operation the internal pressure balances the external hydrostatic pressure on the weakest part of the compartment, maintaining a balance of pressure between the admitted gas and the water by releasing excess of air pressure arising from any cause, and flooding in the event of the internal pressure falling out of balance.

2. The method of claim 1 characterized by the fact that the removal of the water is accomplished by suction.

3. Apparatus for lifting a submerged or partially submerged vessel having at least one compartment adapted to be made water and airtight, comprising in combination means for removing water from said compartment, means for ad-

mitting a gaseous medium under pressure to the space voided by the water and means for automatically maintaining a balance between the internal pressure and external hydrostatic pressure on the weakest part of said compartment such that the resultant external or internal pressure is always maintained below the limit at which said weakest part of the compartment may be damaged by the pressure, said means comprising at least one valve adapted automatically to control the admission of said gaseous medium and valve means fitted to said compartment adapted to release excess of internal pressure in said compartment arising from any cause or to enable flooding to take place in the event of the internal pressure falling out of balance.

4. Apparatus as defined in claim 3 in which said valve for controlling the admission of said gaseous medium to the space voided by the water is a reduction valve automatically controlled by the external hydrostatic pressure, said valve adapted to be set to predetermined out of balance limits in relation to the external hydrostatic pressure.

5. Apparatus as defined in claim 3 in which said valve means fitted to said compartment comprises a two-way balance valve fitted to the weakest part of the top of said compartment and connected to a dip pipe the lower end of which is below the surface of the water in said compartment.

6. Apparatus for lifting a submerged or partially submerged vessel having at least one compartment adapted to be made water or airtight, comprising in combination means for removing water from said compartment and at the same time admitting a gaseous medium under pressure to the space voided by the water consisting of a submersible pump displacing a gaseous medium fed thereto under pressure, the said pump operating under back pressure conditions and exhausting into the voids created by pumping,

and means for automatically maintaining a balance between the internal pressure and external hydrostatic pressure on the weakest part of said compartment such that the resultant external or internal pressure is always maintained below the limit at which said weakest part of the compartment may be damaged by the pressure, said means comprising at least one valve adapted automatically to control the admission of said gaseous medium and valve means fitted to said compartment adapted to release excess of internal pressure in said compartment arising from any cause or to enable flooding to take place in the event of the internal pressure falling out of balance.

7. Apparatus for lifting a submerged or partially submerged vessel having at least one compartment adapted to be made water or airtight, comprising in combination means for removing water from said compartment and at the same time admitting a gaseous medium under pressure to the space voided by the water consisting of a gas lift pipe fitted internally in the compartment to be evacuated and adapted to discharge externally from said compartment and means for supplying a gaseous medium thereto under pressure, and means for automatically maintaining a balance between the internal pressure and external hydrostatic pressure on the weakest part of said compartment such that the resultant external or internal pressure is always maintained below the limit at which said weakest part of the compartment may be damaged by the pressure, said means comprising at least one valve adapted automatically to control the admission of said gaseous medium and valve means fitted to said compartment adapted to release excess of internal pressure in said compartment arising from any cause or to enable flooding to take place in the event of the internal pressure falling out of balance.

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