Sept. 24, 1968 J. H. EMERSON 3,402,711

BREATHING APPARATUS

Filed Jan. 6, 1964 5 Sheets-Sheet 1

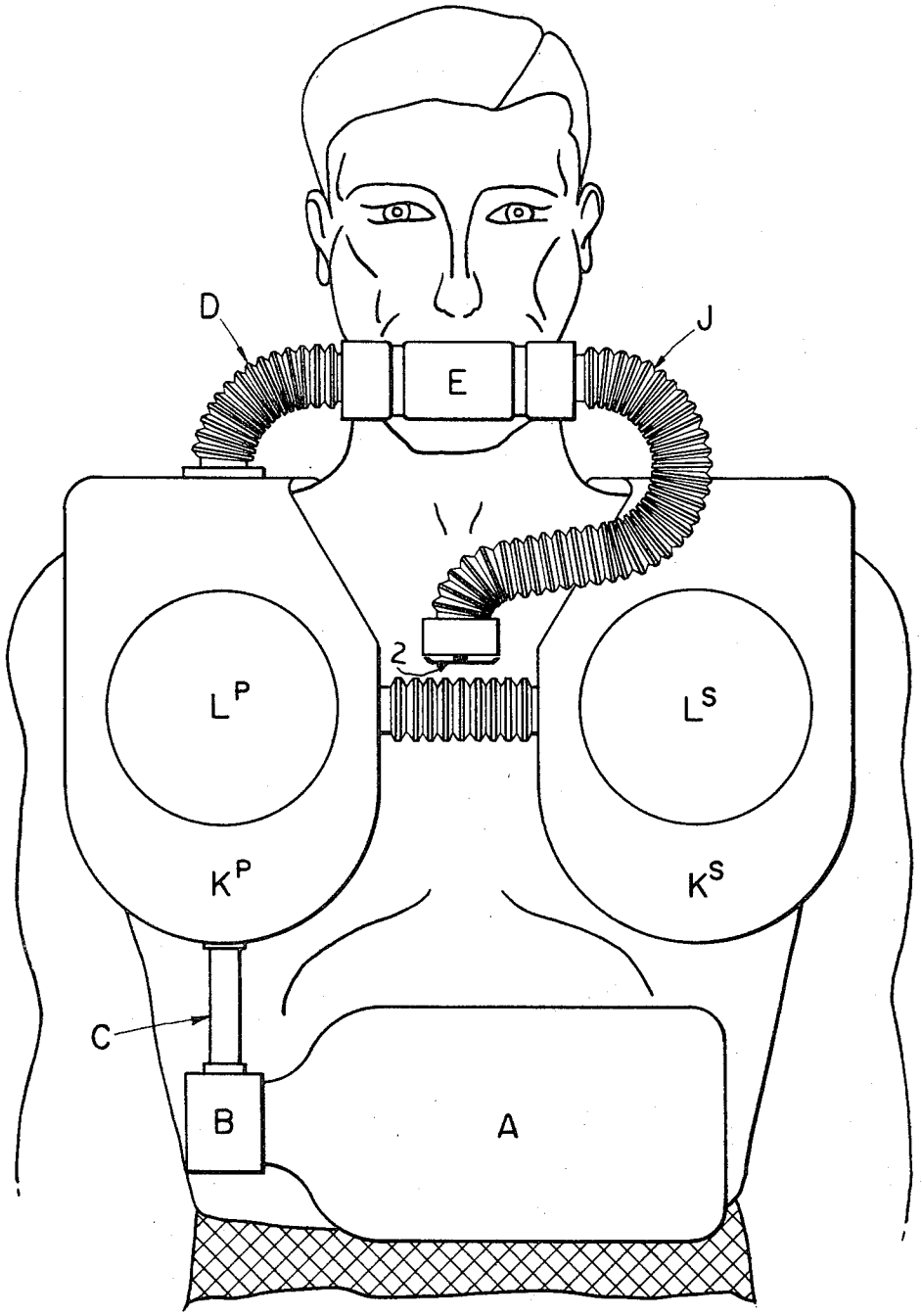


FIG. 1

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BREATHING APPARATUS

Filed Jan. 6, 1964 5 Sheets-Sheet 2

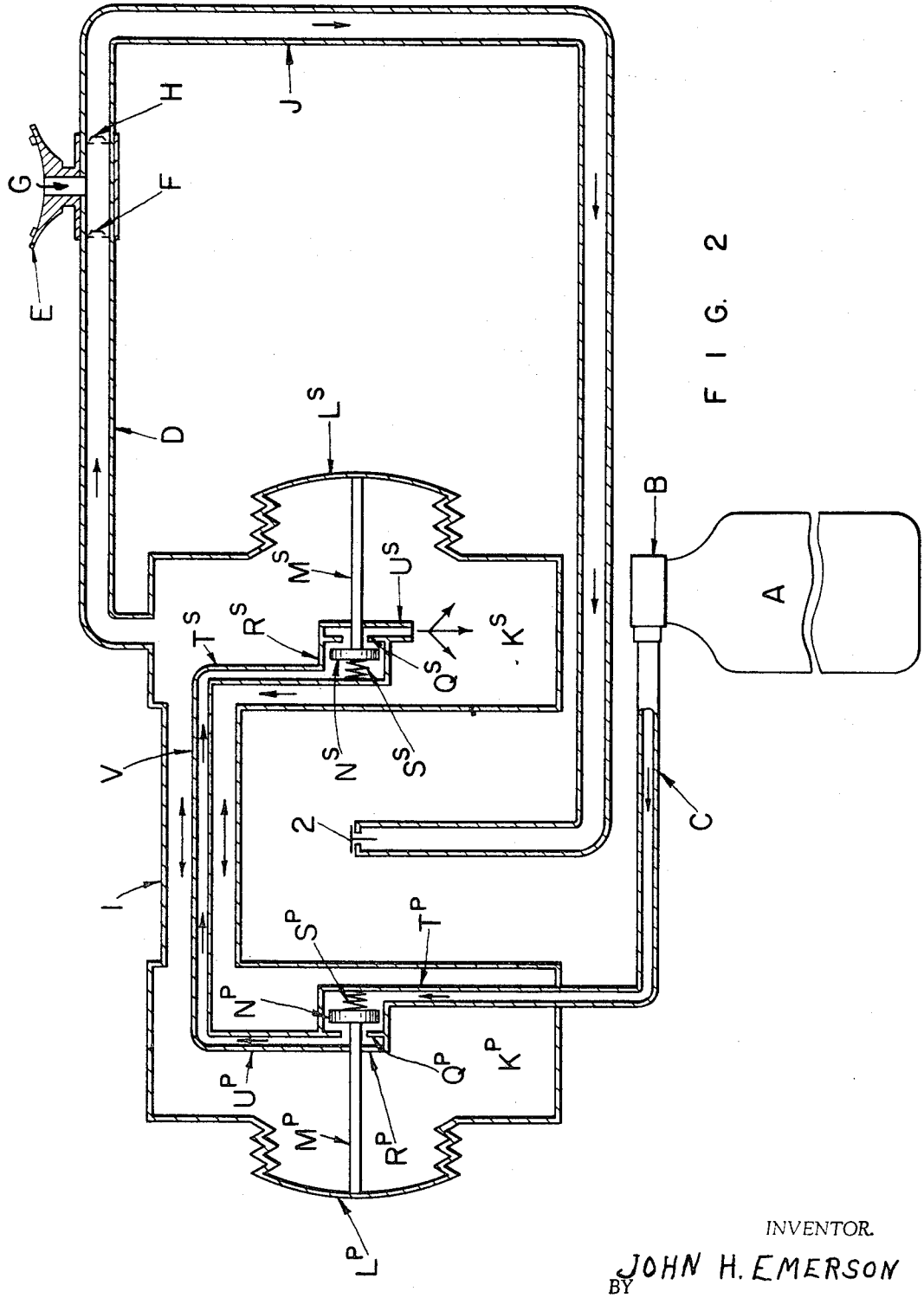


FIG. 2

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BREATHING APPARATUS

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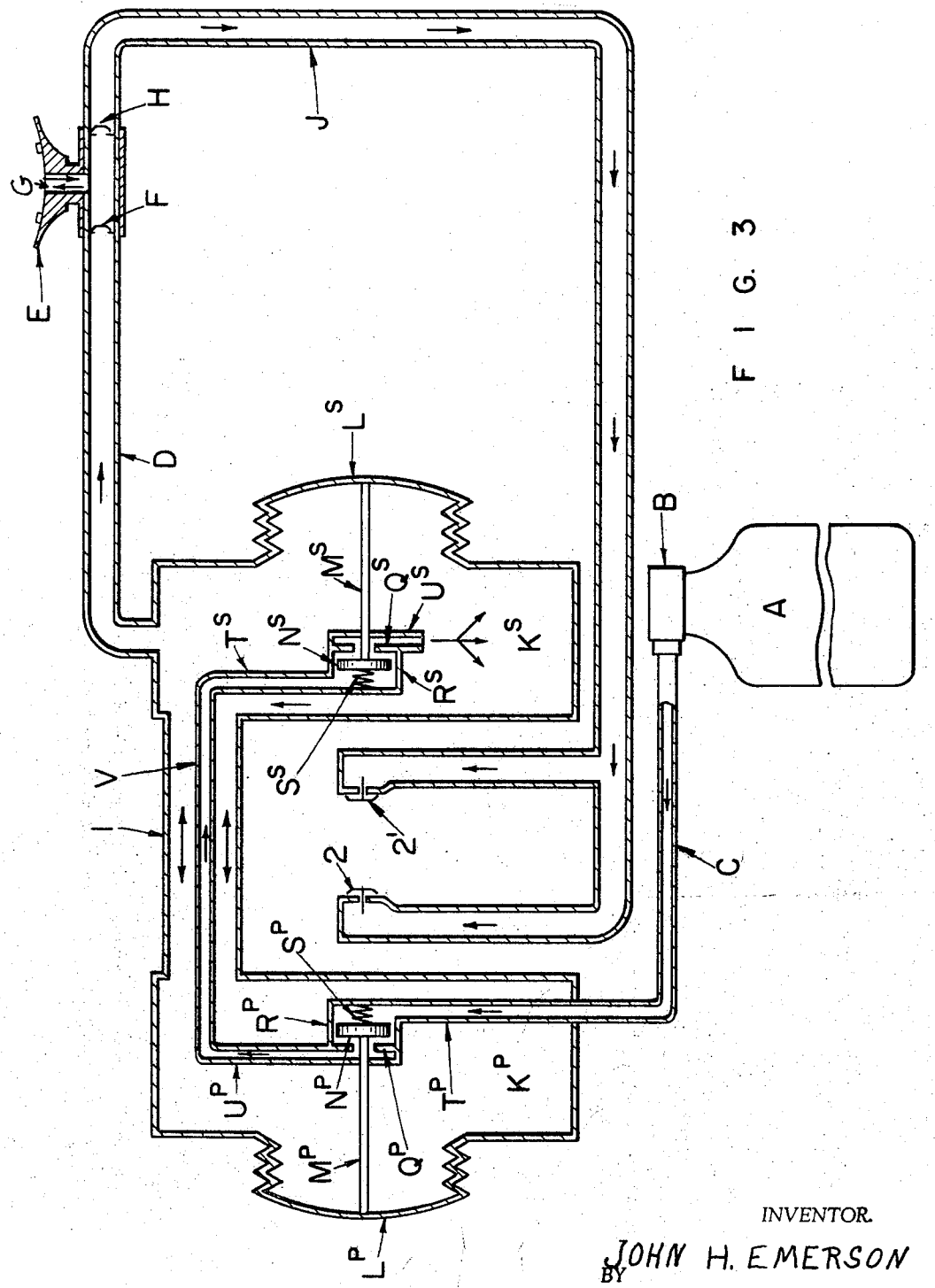


FIG. 3

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BREATHING APPARATUS

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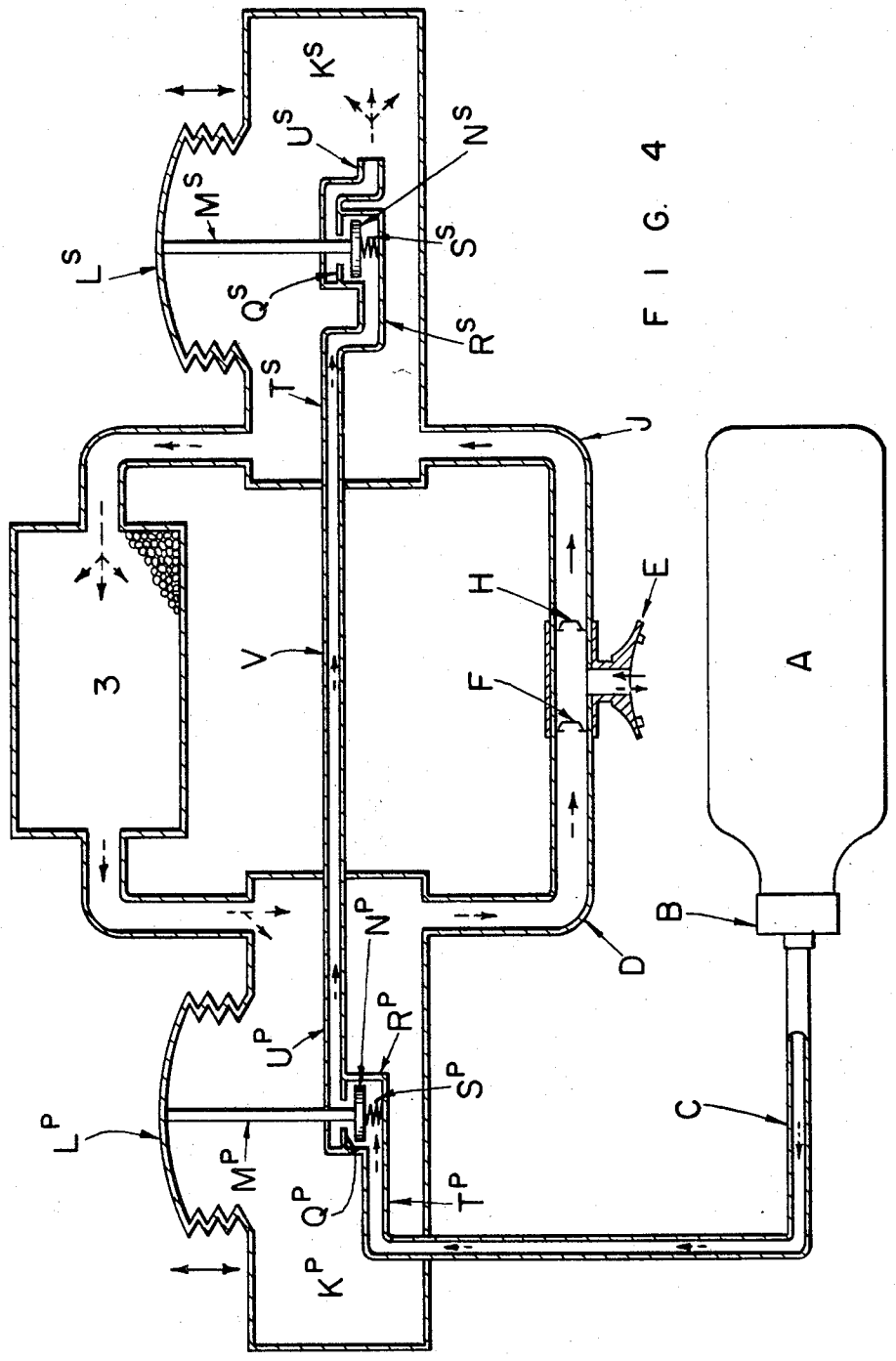


FIG. 4

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BREATHING APPARATUS

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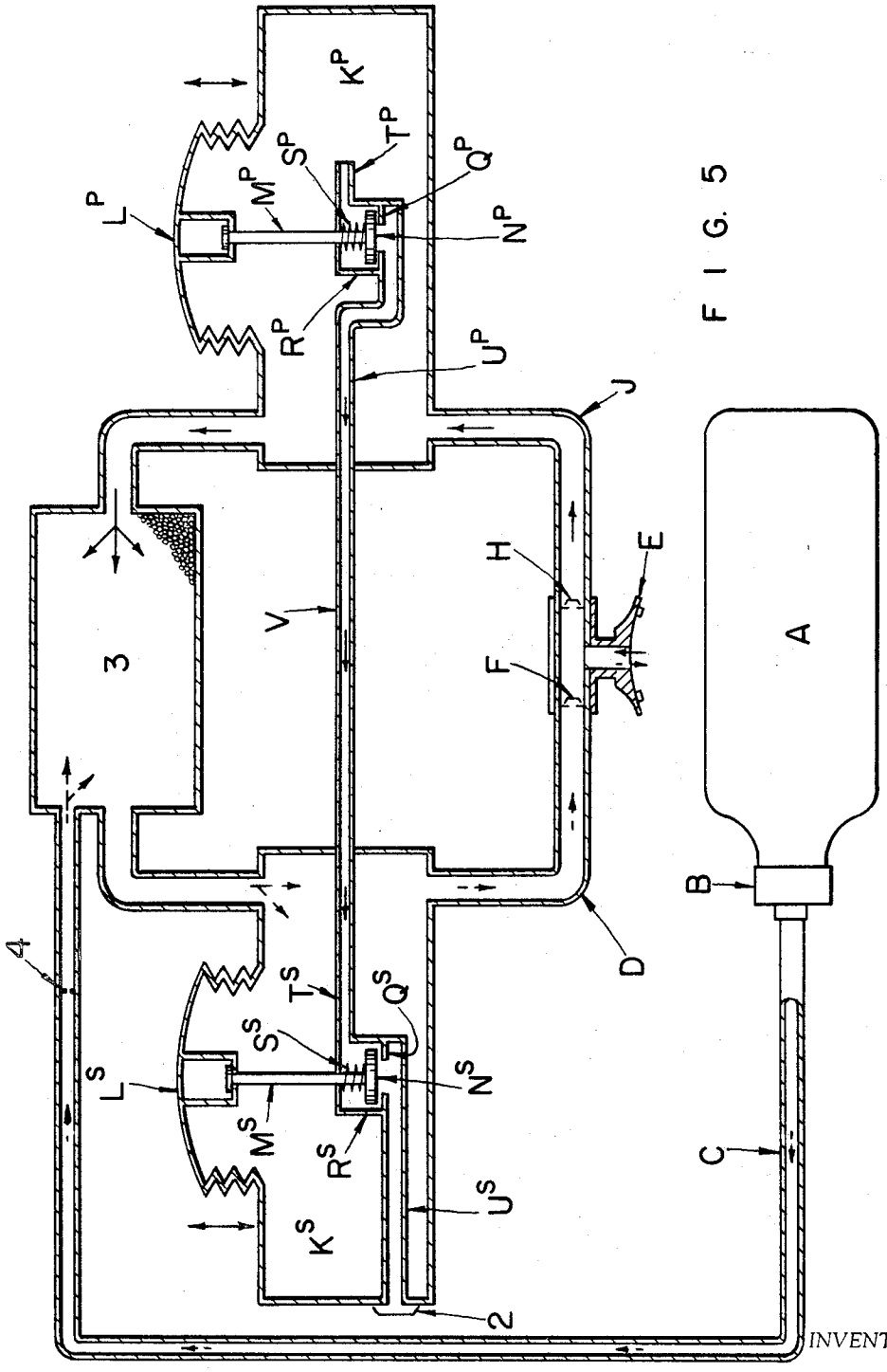


FIG. 5

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United States Patent Office 3,402,711 Patented Sept. 24, 1968

3,402,711

BREATHING APPARATUS

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6 Claims. (Cl. 128—142.2)

The present invention relates to free swimming breathing apparatus for use under water, and has as its object to provide means for compensating the breathing system to obtain a more uniform breathing pressure and buoyancy of the system when the wearer changes position under water.

The breathing systems involved in this invention are those in which a portion of the system includes movable wall areas, one side of each of these areas being in communication with the swimmer's airway and the other side of each of these movable wall areas being in communication with the surrounding water.

The compensating means of the present invention can be applied to the breathing system to control the inflow of gas to the system or the outflow of gas from the system or both.

The most commonly used breathing system for under water use is known as the "open circuit." This system includes a mouthpiece in communication with a conventional pressure regulating valve either attached directly to the mouthpiece or carried on the back and in communication with the mouthpiece through a breathing tube. This pressure regulating valve has a movable wall, one side of which is in communication with the ambient pressure of the water surrounding the swimmer and the other side of which is in communication with the swimmer's lungs through the mouthpiece. Compressed breathing gas, e.g. air or oxygen, carried in a container by the swimmer or led to the swimmer by a hose supplies the pressure regulating valve so that a flow of such gas is introduced through the valve into the breathing system when, due to an inhalation effort by the swimmer, the movable wall of the regulating valve moves in a direction toward the breathing system and away from the ambient water pressure. Exhalation from the swimmer causes the valve to close and is discharged through a check valve from the breathing system into the surrounding water.

A second type of breathing system is known as "closed circuit" and, in this type, the mouthpiece communicates with a closed circuit type of breathing system having a portion of the circuit containing a chemical for absorbing the CO_2 given off by the swimmer. A portion of such breathing system includes one or two flexible breathing chambers and a manual or automatic valve in the system to replace the oxygen used up by the swimmer.

A third type of breathing system known as "semi closed" provides a mouthpiece in communication with a breathing system (sometimes provided with a chemical for absorbing CO_2 given off by the swimmer), a portion of which system includes one or two flexible breathing chambers and means to supply a constant flow into the system that is greater in volume than the volume of oxygen being used by the swimmer so that at every exhalation by the swimmer a controlled amount of gas is discharged into the surrounding water to maintain a relatively constant volume in the breathing system.

One of the most troublesome problems in all three of these breathing systems is that varying positions of the swimmer substantially affect either the resistance to breathing in the open circuit or the buoyancy in the closed circuit.

The present invention provides a way to minimize these problems by providing two or more demand valves placed

in the breathing system on opposite sides of the user's lungs, i.e. on opposite sides of the user, or on opposite sides of a single breathing bag or in each of two breathing bags, these valves being connected in series with each other so that flow of gas will not occur until both valves are opened.

The advantageous features of the invention will be set forth in the following description of certain embodiments with reference to the accompanying drawings in which:

FIGURE 1 is a front elevation of one form of the apparatus as positioned on a user or wearer;

FIGURE 2 is a cross sectional diagrammatic view of the embodiment shown in FIGURE 1, applied to an open circuit breathing system having a single exhalation valve;

FIGURE 3 is a cross sectional diagrammatic view of the apparatus (open circuit) of FIGURE 2 but with two exhalation valves;

FIGURE 4 is a cross sectional diagrammatic view of another embodiment of the invention applied to a closed circuit breathing system;

FIGURE 5 is a cross sectional diagrammatic view of still another embodiment of the invention applied to a semi closed circuit system.

Referring now to the drawings, A represents a vessel containing gas, e.g. oxygen, under pressure with a conventional pressure reducing regulator B, i.e. a pressure regulating valve, at its outlet and a conduit C leading from said pressure reducing regulator to the breathing system.

Inhalation conduit D conducts gas from the breathing system to mouthpiece and valve assembly E which includes an inlet check valve F, conduit G for leading to and from the user through the mouthpiece and outlet check valve H through which exhalation gas is discharged to exhalation conduit J.

A primary gas control system includes chamber K^P with a movable wall L^P, which, when it moves toward the opposite wall of chamber K^P, engages stem M^P and forces valve N^P at the opposite end of stem M^P open by compressing spring S^P which normally holds valve N^P in a closed position against its seat Q^P in chamber R^P which chamber R^P includes an inlet conduit T^P and an outlet conduit U^P with seat Q^P located between inlet conduit T^P and outlet conduit U^P.

Outlet conduit U^P leads through conduit V to a secondary gas control system which includes chamber K^S with movable wall L^S, which, when it moves toward the opposite wall of chamber K^S, engages stem M^S to move valve N^S away from its seat Q^S against the force of spring S^S which normally holds valve N^S in a closed position against its seat Q^S in chamber R^S, which chamber includes an inlet conduit T^S and an outlet conduit U^S with seat Q^S located between inlet conduit T^S and outlet conduit U^S.

Referring to the open circuit system shown in FIGURES 1 and 2, conduit 1 provides a constantly open passageway between chambers K^P and K^S, and conduit J leads to an exhalation check valve 2 which is located midway between chambers K^P and K^S and discharges into the surrounding water.

In use, if the user is in a position under water with his right shoulder and the primary chamber K^P farther from the surface than the secondary chamber K^S the breathing system will operate as follows: gas from tank A will pass through pressure regulator. B to conduit C to valve chamber R^P. Upon start of an inhalation by the swimmer, movable wall L^P in primary chamber K^P will move inwardly to a position to force valve N^P open against spring S^P and the pressure in conduit T^P allowing gas to pass by valve N^P to conduit V which leads to secondary valve chamber R^S. Further inhalation effort by the swimmer will move wall L^S of chamber K^S inwardly

against stem M^S to open valve N^S, allowing the gas to flow into chamber K^S and to the user through conduit D, valve F, and conduit G. Valve N^P will open with less inhalation effort than valve N^S because the inward water pressure on movable wall L^P is greater than that on movable wall L^S because it is further away from the surface. If the user is in a position with his left shoulder and secondary chamber K^S farther from the surface than the primary K^P, the breathing system will operate as follows: gas pressure from tank A and regulator B will be delivered through conduits C and T^P to valve chamber R^P. As the swimmer starts an inhalation, movable wall L^S in the lower secondary chamber K^S, will move to a position to force valve N^S open against spring S^S but no gas will flow into the system because valve N^P will stay closed until greater inspiratory effect subsequently moves movable wall L^P inwardly to open valve N^P and then a flow of gas will be established by valve N^P through conduit V and valve N^S to chamber K^S and to the mouthpiece through conduit D, valve F, and conduit G.

Upon termination of inhalation, gas will flow into the breathing system until the movable wall of the chamber located nearest to the surface is forced away from stem M^P or M^S allowing its valve to close and block further flow. The swimmer can now exhale through valve H, conduit J and valve **2** located in a position midway between the primary chamber K^P and the secondary chamber K^S.

FIGURE 3 shows a construction identical to FIGURES 1 and 2 except that it shows two exhalation valves **2** and 2^1 which can now be located in closer proximity to the primary chamber K^P and the secondary chamber K^S. This double exhalation valve arrangement serves to better balance the exhalation cycle in different positions.

FIGURE 4 shows, in a closed breathing circuit, the same combination of two valves N^P and N^S (controlled by movable walls L^P and L^S) which must both be open before gas (oxygen) from tank A can flow into the system. This arrangement maintains the expansible breathing chambers with a more constant volume of gas than is possible when a single valve is used. The closed circuit system preferably should have larger expansible chambers K^P and K^S so that an entire exhalation of the user can be retained in the system and available for the subsequent inhalation since the exhaled gases are not outletted from the system but intstead are retained in the system and inhaled again, oxygen from tank A being added through valves N^P and N^S during inhalation to replenish the oxygen removed by the lungs. The closed circuit also requires a canister **3** (FIGURES 4 and 5) in the gas circuit which is charged with a chemical (for instance granular soda lime) to absorb the CO_2 given off in the exhalation of the user, and, as a rule, pure oxygen is used in supply vessel A. The valves N^P and N^S, and hence the flow of oxygen therethrough from tank A to unit K^S, are operated in the same manner as in the embodiments of FIGS. 2 and 3, the flow of gas during inhalation being shown by the broken arrows whereas the flow during exhalation is shown by the full-line arrows. During exhalation the valves N^P and N^S are closed by springs S^N and S^S and the exhaled gases flow from the mouthpiece E via conduit J and valve H into, and are retained by, chamber K^S, canister **3** and chamber K^P. Such exhalation gases flow to canister **3** via chamber K^S and to chamber K^P via K^S and canister **3**. During inhalation such exhalation gases in K^S, K^P and canister **3**, together with the oxygen introduced by opening of valves N^P and N^S, flow from such chambers and canister via conduit D and valve F to the mouthpiece E. All exhaled gases must pass through canister **3** before they are inhaled again.

Still another form of my invention is shown in FIGURE 5 applied to a semi closed breathing system. A constant flow of gas is supplied from tank A through regulator B and fixed orifice **4** located in supply conduit C. This fixed flow must be set at a higher level than the rate at which the swimmer is using up oxygen, so that on each exhalation by the swimmer the chambers K^P and K^S are expanded sufficiently to open both valves N^P and N^S and allow a portion of each exhalation to be discharged to the surrounding water through exhalating valve **2**. The remainder of each exhalation left in the breathing system passes through CO_2 absorbing canister **3** and with the steady flow of gas into the system through orifice **4** provides gas for the subsequent inhalation by the swimmer. The two valve chambers K^P and K^S located in separate positions this time control the level of gas by controlling the flow of gas from the system into the surrounding water, to thereby maintain more constant gas contents of these chambers than is possible using a single valve system.

In this case, springs S^P and S^S hold the valves N^P and N^S closed during inhalation. Movement of the movable walls L^S and L^P inwardly during inhalation is relative to stems M^S and M^P so that the valves N^P and N^S are not affected. However, movement of such movable walls outwardly during exhalation moves valves N^P and N^S away from their seats, the valve closest to the surface being opened first since the water pressure on the movable wall of that valve is less. This permits flow of exhalation gases through conduit T^P, valve N^P, conduit U^P, V and T^S, valve N^S, conduit V^S and valve **2** into the water.

Thus, the two control valves N^S and N^P are in the exhalation circuit rather than in the inhalation circuit as in FIGS. 2 to 4.

Flow of oxygen during inhalation is shown by the broken arrows and flow of gas during exhalation by the full-line arrows. Some exhaled gas flows to and is retained in chambers K^P and K^S and canister **3** for subsequent inhalation whereas some flows out of the system via valves N^S and N^P. Gas from tank A replaces that lost through valve **2** as well as the oxygen removed by the lungs. The chemical in canister **3** removes CO_2 from the exhaled gases retained in the system.

I claim:

1. An underwater breathing system for connection to a user's airway including a source of breathable gas under pressure, a conduit system communicating between said source and the user's airway, said conduit system having a first valve and a second valve separated from each other and connected in series in a manner that the gas pressure at the outlet of said first valve is substantially equal to the gas pressure at the outlet of said second valve, said valves being controlled by movable wall areas of said conduit system which are separated from each other and which are exposed on one side to the interior of said conduit system and on the other side to the water and arranged to open when the pressure in the conduit system is changed in one direction and to close when the changed pressure is changed in the opposite direction, whereby when the system is positioned with one valve and movable wall thereof at a different distance from the surface of the water than the other, the valve which is located farthest from the surface of the water will open first upon a change in pressure in said system and as the pressure in said conduit system is subsequently changed further the second valve will open, allowing a flow of gas through said two valves.

2. An underwater breathing system for connection to a user's airway including a source of breathable gas under pressure, a first conduit leading from said source to a first valve, a second conduit leading from said first valve to a second valve located in a position separated from said first valve, and means to lead the discharge from only said second valve into said breathing system, said valves both being controlled by movable wall areas of said breathing system which are separated from each other and which are exposed on one side to the interior of said breathing system and on the other side to the water and arranged to open when the pressure in said breathing system is reduced by inhalation and to close

when the reduced pressure in said breathing system is increased during exhalation, whereby whichever valve is located farthest from the surface of the water in which the breathing system is used will open first and as the pressure in said breathing system is subsequently further reduced by a further inhalation effort the second valve will open, allowing a flow of gas from said source of gas under pressure through said first conduit through said first valve, through said second conduit, through said second valve into said breathing system.

3. An underwater breathing system for connection to a user's airway, including a source of breathable gas under pressure with suitable control means to provide said gas to said breathing system, a first conduit leading from the interior of said breathing system to a first valve, a second conduit leading from said first valve to a second valve and means to connect the discharge from said second valve to the water surrounding said breathing system, said valves being connected in series arrangement and both being controlled by movable wall areas of said breathing system which are separated from each other and which are exposed on one side to the interior of said system and on the other side to the water and arranged to open as the pressure in said breathing system is increased during exhalation and to close when the increased pressure of said breathing system is decreased during inhalation, whereby whichever valve is located nearest to the surface of the water in which that breathing system is used will open first and as the pressure of the breathing system is subsequently further increased by a further exhalation effort the second valve will open allowing a flow of gas from the breathing system through said first conduit through said first valve through said second conduit and said second valve into the water surrounding said breathing system.

4. A breathing system comprising:

(A) means forming a single breathing chamber and including

(1) first and second movable wall portions;

(B) a source of breathable gas;

(C) conduit means connecting said source with said breathing chamber;

(D) first and second valve means serially located within said conduit means and each operable by a respective one of said movable wall portions; and

(E) means communicating said breathing chamber with a user.

5. A system according to claim 4 wherein the volume of the breathing chamber is at least equal to the volume of a user's normal inspiration.

6. A system according to claim 4 wherein the means forming the single breathing comprises first and second interconnected flexible breathing bags.

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