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AMPLIFYING DEMAND VALVE

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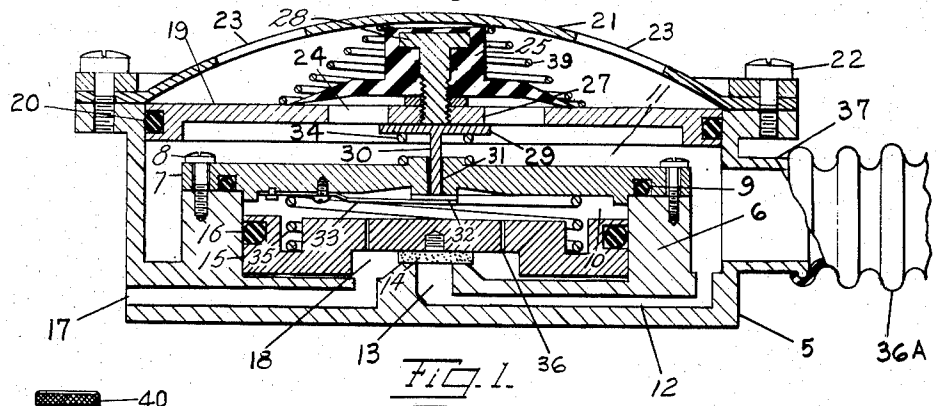


FIG. 1.

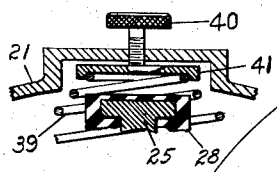
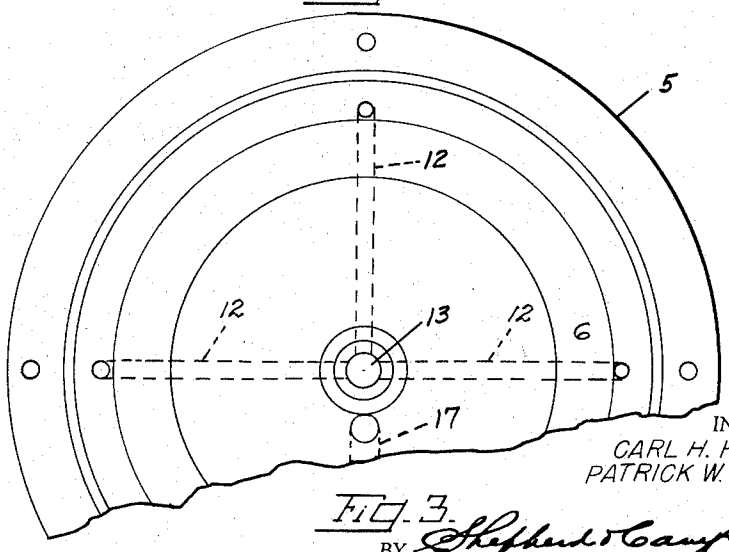


FIG. 1A

FIG. 2.



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FIG. 3.

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AMPLIFYING DEMAND VALVE

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This invention relates to an amplifying demand valve. The primary object of the invention is to provide a demand valve for use in connection with breathing apparatus which will enable a person to secure a full supply of breathing medium, air for example, without undue effort upon the part of the breather.

The sport of skin diving has achieved widespread popularity. In this sport air from a pressure tank, carried on the back of the diver, is supplied through a pressure regulating valve at any desired pressure, usually about 200 pounds per square inch, to a demand valve. A breathing tube leads from the demand valve to a mouthpiece and serves as both an inhalation and an exhalation tube.

The present invention contemplates the provision of a demand valve in which an initial pressure reduction or suction induced in the valve by the effort of inhalation, is utilized to set into action mechanical elements to supply additional air in just the right amount.

An outstanding characteristic of the demand valve of this invention is its extreme sensitivity. It operates very easily under a minimum of inhalation effort but is just as effective in preventing an oversupply of air to the breathing tube. This valve is very small, of light weight, rugged in construction and very reliable in operation.

In the accompanying drawing:

Fig. 1 is an enlarged central, transverse sectional view of the improved demand valve;

Fig. 2 is a plan view with parts broken away; and

Fig. 3 is a plan view of the casing alone.

Fig. 1A is a detail section of the dome showing a spring adjusting means hereinafter described.

Like numerals designate corresponding parts in all of the views. The particular embodiment of the invention which we have chosen for purposes of illustration comprises a cup-like casing **5**. A ring-like body **6** which upstands from the bottom of casing **5** supports a cap plate **7**, which is secured to ring **6** by screws **8**. Packing **9** may be provided to prevent leakage between the chamber **10** which underlies plate **7** and the chamber **11** which lies above and extends around said cap-plate **7** and body **6**. A plurality of ports **12** leading through the body **5**, extend from chamber **11** to an upwardly facing main port **13**. Port **13** constitutes a seat for a valve disc **14** that is secured to the lower face of a plate-like piston **15**. This piston **15** carries a suitable packing ring **16** which ring engages the inner wall of body **6**. Air or other suitable breathing gas is delivered from any suitable source of supply, such as one of the conventional air supply tanks (not shown) employed by divers, to a main supply conduit **17**, the capacity of which is equal to or exceeds the combined capacity of all of the ports **12**. Breathing air is delivered from **17** to a cavity **18** formed in the underside of piston **15**.

A second plate-like piston **19** is mounted for vertical movement in the upper part of casing **5** and makes fluid tight engagement with the inner face of the vertical wall of casing **5** by packing ring **20**. Piston **19** underlies and is protected in a dome-like housing **21**, that is held in

place by screws **22**, and is provided with openings **23**, through which sea water or other outside fluid may enter the space beneath the dome and bear upon the upper face of piston **19**. Openings **24** formed through piston **19**, open at their tops beneath a flexible rubber exhalation valve **25**. The parts of the piston which lie between the several openings **24** constitute spider legs **26** by which a central hub **27** is supported. An adjusting screw **28** is embedded in a central part of the rubber valve and is threaded in the hub **27**. Turning of this screw and valve adjusts the tension of the outer flexible edges of the exhalation valve upon the top of piston **19** and consequently determines the exhalation pressure necessary to unseat said valve.

Secured to the under face of piston **19** is a plate **29**. A depending stem **30** of this plate projects through a port **31**, formed through the cap plate **7** and is adapted, when said piston moves downwardly, to unseat a valve disc **32**, which until then closes port **31**. The valve disc is carried by a leaf spring **33** that is secured to the under face of the cap plate. A spring **34** bears between cap plate **7** and piston **19** and tends to move the piston outwardly and a spring **35** bears between cap plate **7** and piston **15** and tends to move the valve disc **14** to closing position over port **13**.

A plurality of fine resistor openings **36** are formed through piston **15**. These are called resistor openings because their combined capacity is less than the capacity of port **31**. Consequently the necessary suction above piston **15** can be created by inhalation by the user, despite the fact that some pressure fluid can pass from **17** upwardly through these resistor openings. The passage of this pressure fluid to chamber **10** permits and insures the return of piston **15** and main valve **14** to valve closing position when inhalation ceases and exhalation begins. A combined inhalation-exhalation tube **36A** is connected to nipple **37** which leads from the side of the casing **5** and tube **36A** is thereby brought into communication with the chamber **11** which underlies piston **19**. The pressure reduction or suction induced in chamber **11** causes piston **19** to move inwardly against the tension of spring **34** and this takes place very early in the act of inhalation due to the large area of piston **19**. This inward movement of piston **19** acts through stem **30** to unseat valve **32** and thereby establish in chamber **11** a pressure reduction or suction which causes piston **15** to rise and thereby unseat valve disc **14**. The resultant uncovering of port **13** establishes communication between the full pressure supply in conduit **17** and chamber **11**, through the several ports **12**. Thus it will be seen that a full pressure supply is delivered to the breathing or inhalation tube **36A** as the result of a very slight breathing effort upon the part of the diver. When the call for more air is satisfied and the suction in chamber **11** is thereby reduced, piston **19** rises, valve **32** is closed by spring **33** and piston **15** is moved by spring **35** to cause valve disc **14** to close port **13**. This cuts off all communication of chamber **11** with supply conduit **17**.

In the act of exhalation the parts are all in the position last described and the fluid of exhalation passes from the inhalation-exhalation tube, through chamber **11**, openings **24** and out of the rubber exhalation valve. The tube **36A** is of quite large capacity and the nipple **37** is so located that this large capacity inhalation-exhalation tube is in close and direct communication with the breathing chamber **11**. Consequently upon exhalation, some exhalation pressure would, up to the time of completion of the closing of valve **32**, be available through port **31**, to assist spring **35** in bringing about a prompt return of piston **35** to a closing position of main valve **14**. This effects a prompt shutting off of the pressure from supply conduit **17**. An important characteristic of this invention

lies in the relative areas of the pistons 19 and 15 and in the fact that both of these pistons are of very considerable area. Also the small diameter of port 31 in comparison with the large area of piston 19 is of importance, as will be presently explained. The relative areas of the pistons and the small size of port 31 contribute to the easy breathing characteristics of this demand valve in the following way. Upon initial inhalation upon the part of the diver a very low degree of suction imposed upon the underside of large area piston 19 will suffice to move said piston inwardly to unseat valve 32. This low degree of suction, when imposed, in turn, upon the relatively large piston 15 (which is more than half as large in area as piston 19) in conjunction with the pressure from conduit 17, acting upon the underside of piston 15, suffices to quickly lift said piston and unseat the main supply valve 14. These large and relative areas of the pistons serve, in turn, upon the exhalation cycle to quickly return the pistons to the position of Figure 1, with the exhalation pressure acting, up to the degree of resistance to opening of the exhalation valve 25, to assist in the quick return of valve 14 to closed position.

It is to be noted that each of the pistons, being bodily movable as a whole, inwardly and outwardly, is effected by its actuating pressure over its whole area and this, in conjunction with the large areas of these pistons, renders the device very sensitive and readily responsive to the breathing action of the diver. This in turn relieves the diver of fatigue in the use of the device. The ease of breathing is largely dependent upon the ease of response of the pistons to the pressures imposed thereon. Piston 19 responds readily because of its large area in comparison with the size of port 31, while piston 15 responds readily because the work done in elevating such piston is done by the pressure from port 17 and not by the breathing action of the diver.

While the use of diaphragms, in place of the pistons, is within the scope of the invention, such diaphragms, if employed, should be of a nature to be freely movable, inwardly and outwardly in the same manner as the pistons. Diaphragms of the character frequently employed in devices of this nature, wherein the diaphragms are clamped around their peripheries, are responsive to pressures at their centers but become increasingly resistant to pressures toward their peripheral areas. This is especially pronounced where the diaphragms are of thick rubber or like elastic or flexible material. Therefore the term "freely movable" as employed herein is intended to define a pressure operated element which is as responsive to pressure at its peripheral portion as at its central portion.

It should further be noted that the connection of port 12 directly to the breathing chamber insures that when the pressure flow changes from inhalation to exhalation there will be no existing attenuation of the fluid in the breathing chamber 11. Upon the contrary the chamber will be so filled that upon the beginning of the exhalation cycle, piston 19 will move outwardly, promptly and valve 14 will seat quickly.

The figures shown in the drawing are enlarged beyond the actual size of a valve which we have constructed and used. This valve was only 3 inches in diameter yet through its use we were able to deliver 720 litres of air per minute under a one inch water column suction head. The valve may be made as small as one inch in diameter and still yield highly satisfactory results. It requires but a minimum number of parts and practically no maintenance.

Since the chamber 11 is the chamber to which the inhalation-exhalation tube 36A is connected this chamber may be termed a breathing chamber, and it will be so designated in the claims.

While the invention, for purposes of clarity, has been described as of particular utility in the field of diving it is to be understood that its utility is not limited to that particular field. Its small size, light weight and great sensensitivity render it useful as a means for supplying individual passengers on airplanes, at high altitudes with just the right amount of breathing medium. Such medium may be air, oxygen supply, or otherwise.

While we have illustrated a single exhalation valve, we may employ two or more of these valves, on top of piston 19 if desired. It will be observed that the relative distances between the exhalation valve and the center of the piston 19, is immaterial. It will also be observed that in contrast to most demand valves, which warn the diver by increased inhalation resistance, as the pressure in the supply tank decreases, our valve decreases the inhalation resistance as the pressure in the supply tank decreases. It will be noted that our structure is "fail-safe" in the respect that if spring 33 should break, valve 32 would open gravitationally, and thus insure such movement of piston 15, as would open main valve 14 under inhalation.

In Fig. 1A is shown a means for adjusting the tension of the cone spring 39, which bears upon the top of the piston 19. This consists of a screw 40 that is threaded through an extension of the dome and which carries a plate 41 against which the top of the spring bears.

The diver can, when he experiences increased inhalation resistance screw down on screw 40 to assist movement of piston 19 and this decreases the discomfort of such increased inhalation resistance.

It is to be understood that the invention is not limited to the particular construction shown but that it includes within its purview whatever changes fairly fall within either the terms or the spirit of the appended claims.

We claim:

1. An amplifying demand valve comprising a casing divided into a first breathing chamber and a second chamber, a first pressure operated element in the first of said chambers, one face of which is exposed to outside pressure and the other face of which is exposed to the pressure in said first chamber, a second freely movable pressure operated element in the second of said chambers, a main fluid pressure supply conduit, a port to which said main conduit leads, a secondary conduit leading from the said port to the first breathing chamber, a first valve actuated by the second pressure operated element for closing said port to interrupt communication between the main conduit and the second conduit, a port between the first and second chambers, a second valve controlling said port, means carried by the first named pressure operated element for engaging and opening said second valve upon movement of the first named pressure operated element under suction in the first chamber and an inhalation tube connected to said first chamber, the opening of said second valve establishing such reduced pressure conditions in the second chamber as to move the pressure operated element therein to actuate the first valve to establish communication between the main and secondary conduits and means for conducting pressure from the main supply conduit to the underside of the second pressure operated element.

2. A structure as recited in claim 1 comprising an exhalation valve on the outer face of the first named pressure operated element, and means establishing communication between the exhalation valve and said first chamber.

3. A structure as recited in claim 1 in combination with a flexible rubber-like exhalation valve mounted upon the first pressure operated element, there being escape ports formed through said element which open beneath said valve.

4. A structure as recited in claim 1 wherein the pressure operated elements are pistons.

5. A structure as recited in claim 1 wherein there are a plurality of the secondary conduits all leading to said port and all controlled by said first valve.

6. An amplifying demand valve comprising a cup like casing, an annular wall upstanding from the bottom of

said casing, a fixed cap plate supported upon the annular wall to establish a chamber inside the annular wall, an inner piston lying substantially parallel with the cap plate and movable in said chamber toward and from the cap plate, an outer piston lying outside of and in spaced relation to the cap plate and having its outer side exposed to external pressure, the space between the cap plate, and the outer piston constituting a breathing chamber, means tending to move the inner piston away from the cap plate, a valve upon the lower side of the inner piston, a port controlled by said valve, a main supply conduit leading to said port and to the underside of the inner piston, a conduit establishing communication between said port and the breathing chamber beneath the outer piston, a port through the cap plate, a valve controlling said port, means tending to move said valve to closed position, means upon the outer piston acting to unseat said valve upon movement of the outer piston toward the cap plate, means tending to move the outer piston away from the cap plate and an inhalation tube connected to the breathing space, the area of the inner piston being at least half as great as the area of the outer piston and the size of the port through the cap plate being very small in comparison with the diameter of the outer piston.

7. A structure as recited in claim 6 in combination with a perforated dome secured to the casing and overlying and housing the first pressure operated element.

8. A structure as recited in claim 6 comprising an exhalation valve mounted upon the outer face of the outer piston, said piston having openings therethrough which open beneath said valve.

9. A structure as recited in claim 6 wherein the outer piston has a plurality of exhalation openings therethrough, a rubber-like exhalation valve of cup formation having a thin and flexible periphery which bears upon the outer face of the said piston outwardly of said openings, and an adjusting screw threaded into the piston and engaged with the rubber like valve whereby the latter valve can be turned and its tension adjusted.

10. A structure as recited in claim 6 wherein the outer piston has a plurality of exhalation openings therethrough, a rubber-like exhalation valve of cup formation having a thin and flexible periphery which bears upon the outer face of the said piston outwardly of said openings, and an adjusting screw threaded into the piston and engaged with the rubber like valve whereby the latter valve can be turned and its tension adjusted and a protecting perforate dome secured to the casing and overlying and protecting the exhalation valve.

11. A structure as recited in claim 6 wherein the inner piston has openings therethrough the capacities of which

are less than the capacity of the port through the cap plate.

12. An amplifying demand valve comprising a cup like casing having an annular wall upstanding from its inner bottom face, a cap plate spanning and secured to said wall to form a first piston receiving chamber, a freely movable inner piston mounted to move in and making fluid tight engagement with the wall of said chamber, a valve actuated by movement of said piston and a main supply port upon which said valve seats, a plate-like piston disposed in spaced relation to the cap plate and defining a breathing chamber between itself and the cap plate, said piston closing the otherwise open top of the breathing chamber and making fluid tight connection with the wall of the casing and being of greater area than said inner piston, said plate-like piston having its outer face subjected to external pressures, a port between the breathing chamber and the first piston chamber, a valve normally closing said port, means for opening said valve when the plate-like piston is drawn inwardly by suction, a main supply conduit leading to the first named main supply port and to the underside of the inner portion, secondary air conducting means leading from the first named port to the breathing chamber, said main supply conduit and said secondary air conducting means being brought into communication with each other when said valve is unseated under movement of the inner piston and air conducting restrictor means of less capacity than the port of the cap plate which restrictor means lead from the upper to the lower sides of the inner piston and are of less capacity than the port through the cap plate, said inner piston being at least half as large in area as the plate like piston.

13. A structure as recited in claim 1 in combination with spring means bearing upon the pressure operated element in the first chamber and assisting its movement under external pressure.

14. A structure as recited in claim 1 in combination with spring means bearing upon the pressure operated element of the first chamber and assisting the movement of the said pressure operated element when exhalation takes place, and means for adjusting the tension of said spring from the exterior of the casing.

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