April 1, 1958 R. KIMES 2,828,739

UNDERWATER BREATHING APPARATUS

Filed May 3, 1954 2 Sheets-Sheet 1

Fig. 1.

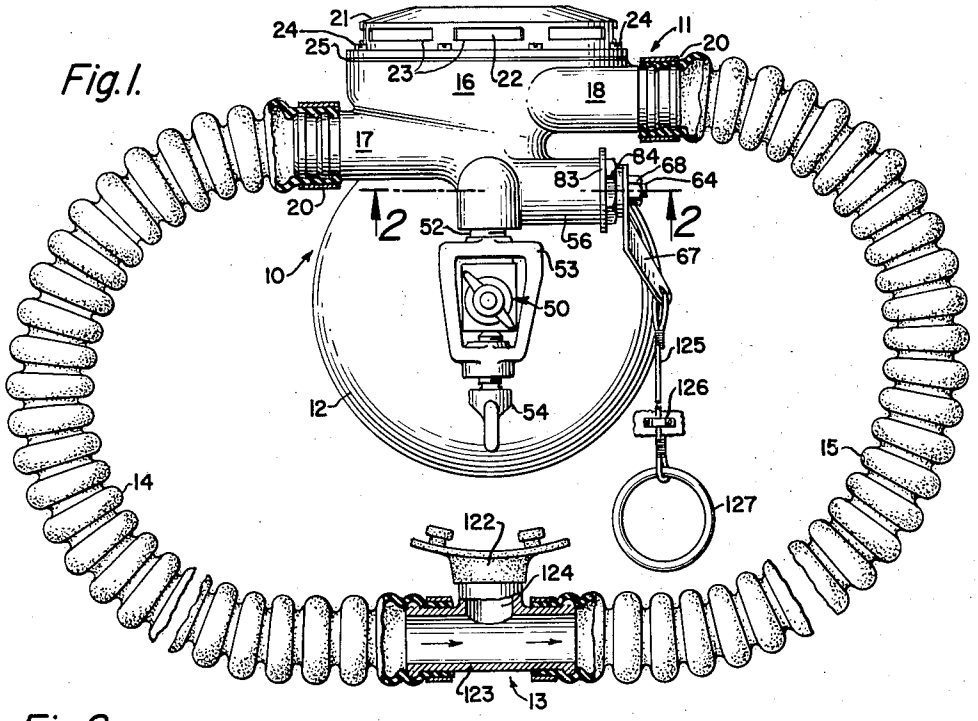
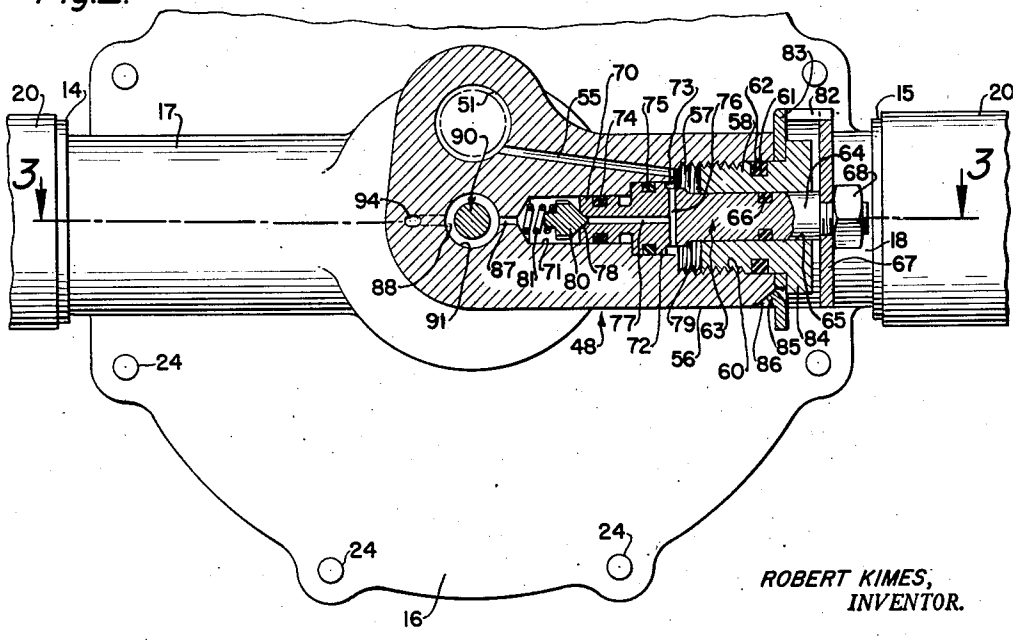


Fig. 2.



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Fig.3.

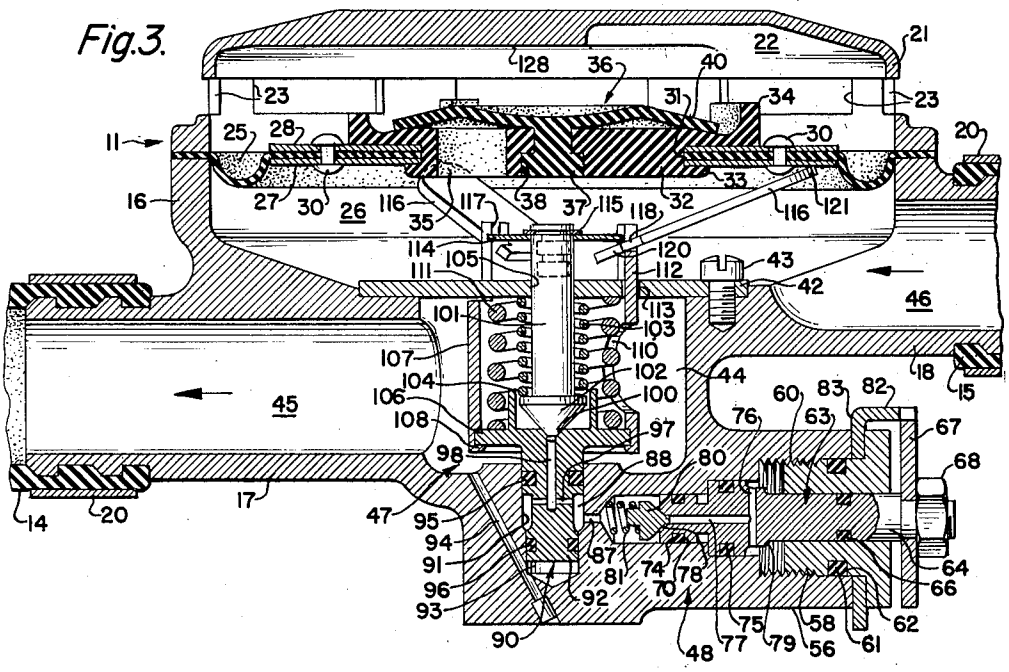


Fig.4.

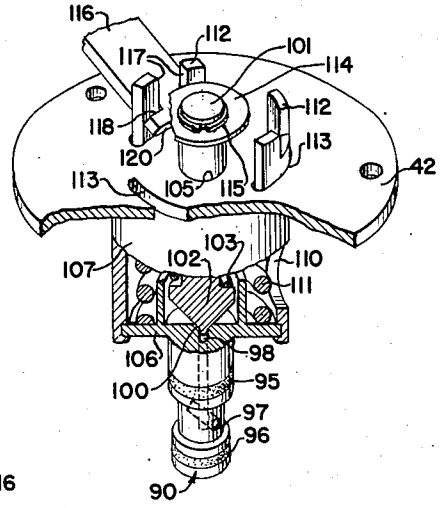
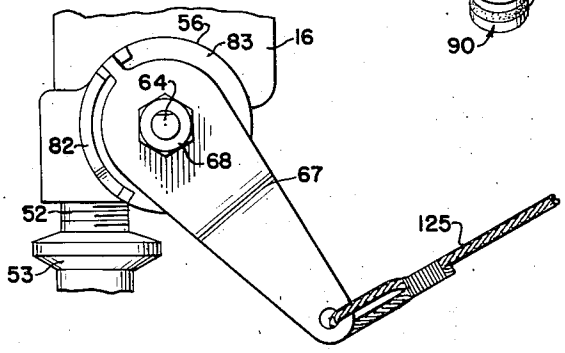


Fig.5.



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United States Patent Office 2,828,739 Patented Apr. 1, 1958

2,828,739

UNDERWATER BREATHING APPARATUS

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Application May 3, 1954, Serial No. 427,195

20 Claims. (Cl. 128—142)

The present invention relates generally to respiration devices, and relates more specifically to an improved device providing a low breathing resistance, whereby such device may be more easily and more comfortably used by a person.

The improvements according to this invention are intended for use with respiration devices of the type disclosed herein or may be used in connection with devices of the type disclosed in the co-pending application of Kimes et al., Serial No. 378,856, filed September 8, 1953.

Heretofore, breathing devices adapted primarily for use under water have incorporated various means for delivering a controlled quantity of a breathable gas in response to respiration induced changes in the pressure within the device, the gas being delivered at a pressure suitable for use in the lungs of an individual. Due to varying conditions, such as steadily dropping pressure of the usual bottled supply of breathable gas and variation in the depth at which the device is being utilized, constant changes in operating characteristics of the breathing devices were experienced. These changing characteristics resulted in undesirably increased breathing resistance. More specifically, in prior devices, a respiration pressure-responsive diaphragm, exposed on one side to the pressure of the surrounding fluid medium and on the other side to the pressure of a breathable gas, has been used to operate a valve for admiting breathable gas from a source to the point of use. Such devices have incorporated floating valve seat arrangements, operable in association with the valve, and with the arms of valve operating levers variable in attitude or presentation to the floating valve seat and relative to a normal position of the diaphragm. Means utilized in such devices for transmitting the movement of the diaphrgam, and for opening the valve member, necessarily changed the operating characteristcis thereof as the valve member was moved in accordance with movement of the floating valve seat relative to the diaphragm. This condition necessarily increased breathing resistance, because in certain attitude of the levers it required considerable movement of the diaphragm before the valve member became adequately open.

It is accordingly an important object of the present invention to provide a novel breathing device having means adapted to overcome disadvantages in prior devices, as set out hereinabove.

It is another object of the present invention to provide a novel under-water breathing device wherein efficient use is made of respiration induced movement of a movable wall for effecting opening of a breathable gas-control valve member.

A further object of the invention is to provide a novel actuating means for a valve member wherein the force required to open the valve member is directly proportional to the pressure of a breathable gas obtained from a source.

It is a still further object of the present invention to provide a breathing device wherein the necessary tolerances may be satisfactorily held without the necessity for

precision manufacturing of components or calibration of the finished device.

Other and further important objects of the present invention will become apparent from the disclosures in the following detailed specification, appended claims and accompanying drawings, wherein:

Fig. 1 is an elevational view of the breathing device of the present invention, shown with the normally associate flexible conduits and mouthpiece;

Fig. 2 is an enlarged, fragmentary, sectional view showing the reserve air valve of the present invention, taken substantially as indicated by the line 2—2, Fig. 1;

Fig. 3 is an enlarged sectional view through the regulator portion of the breathing device of the present invention, taken substantially as indicated by the line 3—3, Fig. 2;

Fig. 4 is a fragmentary perspective view, partially in section, showing details of the floating valve seat, valve member and operating means therefor; and

Fig. 5 is a fragmentary end view of the reserve valve operating lever and associated cam structure.

Referring to the drawings, wherein like reference characters denote like parts, the berathing apparatus of the present invention is indicated generally at **10**. The apparatus includes a regulator **11** mounted in association with a bottle or tank **12** which contains a supply of breathable gas under pressure. The regulator **11** is operatively connected to a mouthpiece **13** by a flexible inhalation conduit **14** and a similar flexible exhalation conduit **15**.

The regulator is provided with a substantially annular body **16** having laterally extending bosses **17** and **18** to which the inhalation and exhalation conduits **14** and **15** are respectively connected by clamp rings **20**. A disc-like cap **21**, forming an outer chamber **22**, and a plurality of radially directed openings **23** communicate between the chamber **22** and the exterior of the regulator. The cap **21** is secured to the body **16** by screws **24** and serves to retain a flexible diaphragm **25**, the peripheral portion of the diphragm **25** being disposed between the body **16** and the cap **21**.

The diaphragm **25** provides a movable wall for one side of a chamber **26**, formed within the body **16** of the regulator, for a purpose to be hereinafter more fully described. The diaphragm **25** is clamped between a pair of annular stiffening plates **27** and **28** that are secured together by rivets **30**. The diaphragm and the plates **27** and **28**, are formed with a centrally disposed opening **31** in which an exhalation valve insert **32** is adapted to be disposed. The insert **32** has a radially extending flange portion **33** adjacent the chamber **26**, which overlies a portion of the plate **27** adjacent the opening **31** to retain the insert **32** in position. The insert **32** is also provided with an axially extending peripheral flange **34** which extends into the chamber **22**. A plurality of spaced openings **35** extend in an axial direction through the insert **32**.

A flexible exhalation valve **36** is positioned in association with the insert **32** and has a centrally disposed button **37** which is received in a similarly shaped opening **38** in the insert **32**. The valve member **36** has a flexible peripheral portion **40** that normally lies in contact with an annular valve seat **41** formed on the outer surface of the insert **32** and spaced radially inwardly from the peripheral flange **34**. The insert **32** and the valve member **36** may be made from rubber or other flexible material and cooperate to permit fluid flow only outwardly from the chamber **26** by way of the passages **35**, the peripheral flexible portion **40**, chamber **22** and openings **23** to the surrounding fluid medium. Additional operation and detailed use of the valve member **36** will be more fully described hereinafter. The side

of the chamber 26, opposite the diaphragm 25, is occluded by a fixed disc 42 that is secured to the body 16 by screws 43. The disc 42 also forms a fixed wall for a secondary chamber 44 formed in the lower portion of the body 16. The chamber 44 communicates with the conduit 14 by a bore 45, formed outwardly through the boss 17, and the chamber 26 communicates with the conduit 15 through a bore 46, extending outwardly through the boss 18.

A floating valve seat arrangement, indicated generally at 47, is partially disposed within the chamber 44 to which breathable gas from the tank 12 is delivered through a reserve air valve arrangement 48. Referring primarily to Figs. 1 and 2, breathable gas from the tank 12 is delivered through a shut-off valve 50, attached to one end of tank 12, and into a receiving opening 51 by a fitting 52. The fitting 52 is secured to the valve 50 by a yoke 53 which is in turn secured to the valve 50 by a set screw 54. From the opening 51, the gas is conducted through a passageway 55, extending outwardly through a boss 56, to a chamber 57 formed adjacent an inner end of a nut 58. The nut 58 threadably engages the boss 56 by threads 60 and is sealed with respect to the boss 56 by an annular sealing member 61 disposed in an annular groove 62 formed in the periphery of the nut 58.

The reserve air valve arrangement 48 comprises a multi-purpose elongated member 63 that has a shaft portion 64 slidably disposed in an axial bore 65 formed through the nut 58. An annular sealing member 66 disposed about the shaft 64 seals the shaft relative to the bore 65. For a purpose to be hereinafter more fully described, the outer end of the shaft 64 is secured to an external lever 67 by a nut 68. The inner end of the member 63 is provided with a reduced diameter piston portion 70 that is slidably received in a bore 71, there being an increased diameter piston 72 disposed between the piston 70 and the shaft 64, the piston 72 being slidable in a bore 73. The bores 71 and 73 are coaxial with each other and have a common axis with the nut 58. The pistons 70 and 72 are sealed by sealing rings 74 and 75 respectively, which are disposed about their peripheries.

The breathable gas from the chamber 57 is conducted through radially extending passageways 76 in the member 63, adjacent the piston 72, and through an axially extending passageway 77 disposed between the passageways 76 and the inner end of the piston 70. This inner end of the passageway 77 is formed with a conical valve seat 78, there being a reserve air valve member 80 positioned for cooperation with the seat 78. The valve member 80 is biased in a direction toward the seat 78 by a compression spring 81. The other end of the spring 81 bears against the body 16.

The member 63, including the pistons 70 and 72, is adapted to remain normally in the position shown in Fig. 2 by virtue of the pressure differential acting thereon and in accordance with the differential in the areas of the pistons 70 and 72. The member 63 is adapted for movement away or outwardly from the nut 58 by rotation of the lever 67 acting in cooperation with a cam portion 82 of a member 83, the cam member 83 being secured to the outer end of the boss 56 by a flanged portion 84 formed on the outer end of the nut 58. Outward movement of the member 63 is limited by a stop 79 formed on the shaft portion 64 adjacent the enlarged portion 72 and adapted to cooperate with the inner end of the nut 58. The cam member 83 is held against rotation relative to the boss by a detent 85 which cooperates with a notch 86 formed in the outer end of the boss 56. For a purpose to be later described, movement of the member 63, in a direction outwardly from the nut 58, will serve to relieve the force of the compression spring 81 acting normally to bias the valve member 80 toward the valve seat 78.

The breathable gas flowing about the valve member 80, and within the bore 71, passes through an opening 87, and into an annular passageway 88, Fig. 3. The passageway 88 is formed partially in the outer surface of a floating valve seat piston 90 and partially in a bore 91 in which the upper portion of the piston 90 is reciprocally positioned. The piston 90 has a reduced diameter end 92 that is positioned for movement in a reduced diameter counterbore 93 formed coextensively with the bore 91. It may be seen that the upper portion of the piston 90 has a larger effective area than the area of the reduced diameter portion 92, thereby permitting the pressure of the breathable gas existing in the annular passageway 88 to bias the piston 90 and the floating valve seat arrangement 47 in an upward direction, as shown primarily in Fig. 3. The lower end of the bore 93 is vented to the chamber 44 by a vent passageway 94, the piston 90 and reduced diameter end 92 being sealed with respect to the bores 91 and 93 by annular sealing members 95 and 96 respectively. By providing the vent passageway 94, air is prevented from being compressed in the lower end of the bore 93 and any leakage past the sealing member 96 may be readily detected.

A plurality of radially extending bores 97 conduct the breathable gas from the annular passage 88 to an axially disposed passageway 98 formed within the piston 90, the upper end of the passageway 98 being provided with a conical valve seat 100. An elongated valve member 101, having a valve portion 102, cooperates with and normally occludes the upper end of the passageway 98. A compression spring 103, surrounding the valve member 101 and bearing between one side of the disc 42 and the valve portion 102, serves to bias the valve member 101 toward contact with the seat 100. An annular guide member 104, extending axially upwardly from the piston 90, serves to guide the valve portion 102 of the valve member. The upper portion of the valve member 101 is reciprocally positioned in an axial opening 105 in the disc 42.

A radially extending flange 106 is formed on the upper end of the piston 90, the peripheral portion of the flange 106 being rotatably retained in one end of a cylindrical fulcrum supporting member 107 and positioned thereinby inwardly directed tabs 108. The fulcrum supporting member 107 has large side openings 110 which communicate between the interior of the member 107 and the chamber 44 thereby permitting the flow of breathable gas from the passageway 98, past the valve portion 102, into the interior of the member 107, outwardly through the openings 110 and into the chamber 44. A relatively heavy compression spring 111 is disposed within the fulcrum supporting member 107, between the disc 42 and the flange 106, in order to bias the floating valve seat against the force exerted by the breathable gas in the annular passageway 88 against the pressure differential areas of the piston 90.

The fulcrum supporting member 107 has a plurality of upwardly extending fulcrum members 112 which extend through spaced arcuate slots 113 through the disc 42 (see also Fig. 4). The upper end of the valve member 101, i. e., the portion extending within the chamber 26, is provided with a radially extending head portion in the form of a disc 114 which is secured to the upper end of the valve member by a snap ring 115. A plurality of actuating levers 116 are disposed in and extend through notches 117, formed in the upper ends of the fulcrum members 112, there being cooperating opposed notches 118 on each side of the levers 116 which serve to retain the levers within the notches 117. The inner ends 120 of the levers 116 extend beneath the disc 114. The levers 116 extend substantially radially outwardly with their outer ends 121 engaging the diaphragm stiff-

ening plate 27 adjacent the periphery thereof. It may therefore be seen that, as the diaphragm 25 moves inwardly toward the chamber 26, the outer ends 121 of the levers 116 will be moved downwardly, thus moving their inner ends 120 upwardly, thereby to move the valve member 101 upwardly against the compression of the spring 103. This action serves to remove the valve portion 102 from the valve seat 100 and permit flow of breathable gas outwardly from the axial passageway 98.

The mouthpiece 13 of the present breathing device has a flexible lip engaging portion or bit 122 that is adapted for insertion within the mouth of a user. The hollow body portion 123 of the mouthpiece has end portions which are attached respectively to the inhalation and exhalation conduits 14 and 15. There is unrestricted communication between the mouthpiece ends of the conduits 14 and 15 and a flow passage 124 which is formed in the lip engaging portion 122. It is the usual practice for the tank 12 (or a plurality of tanks arranged for parallel operation) to be fastened to the back of the user by means of a harness, not shown, with the regulator 11 being in the approximate position shown in Fig. 1. A lanyard 125 is attached to the reserve air valve lever 67 and extends through suitable guides 126 formed on the hardness to a ring 127 or the like, the ring being positioned for easy access thereto.

Prior to descending into water, the user opens the valve 50 on the tank 12 thereby admitting breathable gas through the various flow passages of the reserve air valve arrangement 48 and to the passageway 98 of the floating valve seat arrangement 47. At this time, the floating valve seat will be in its uppermost position compressing the spring 111 and metering valve spring 103, the fulcrum members 112 being in their uppermost position with respect to the disc 42. It will be seen that the valve member 101 together with the washer 114 is also in its uppermost range. The stiffening plate 27 of the diaphragm 25 will contact the outer ends 121 of the levers 116. The exhalation valve 36 will be closed.

When entry is made into the water, it is to be noted that the pressure of the surrounding water acts upon the outer surface of the diaphragm 25, by entry of the water through the openings 23 in the cover 21, and that the pressure within the chamber 26 acts upon the other side of the diaphragm 25. As the pressure of the surrounding medium increases, a pressure differential is manifested across the diaphragm 25 thereby causing the diaphragm to move inwardly toward the chamber 26 and, through the levers 116 causing opening of the valve member 101 and the admission of breathable gas to the chamber 44, passage 45, conduit 14, through the mouthpiece 13, the conduit 15 and into the chamber 26 by way of the passage 46. The flow of the breathable gas along the aforementioned path will continue until the pressure of the gas in the chamber 26 equals that of the surrounding fluid medium, whereupon the diaphragm 25 will move outwardly thus permitting the valve member 101 to be closed by action of the compression spring 103.

It is the usual practice to begin use of the present breathing apparatus with compressed air at a high pressure, 3,000 p. s. i., for example, in the tank 12. This pressure, minus a pressure drop across the reserve air valve 48, is also manifested in the annular passageway 88 thus to move the fulcrum supporting member 107 to its uppermost position by compression of the spring 111. It will be seen that, as the breathable gas from the tank 12 is consumed, the force exerted on the piston 90 will be decreased, thereby permitting the floating valve seat and the piston 90, together with the fulcrum supporting member 107, to be moved downwardly by action of the spring 111. As the piston 90 moves downwardly, the effective force of the spring 103 is reduced, thus reducing the force which retains the valve portion 102 of the valve member

101 on the valve seat 100. In the initial position, with breathable gas at a high pressure available from the tank 12, the force of the spring 103 need be only sufficiently higher than the force of the breathable gas acting upon the end of the valve portion 102 to maintain the valve portion 102 in contact with the valve seat 100. As hereinbefore stated, as the available pressure of the breathable gas is reduced due to consumption thereof, movement of the floating valve seat arrangement downwardly by action of the spring 111 will maintain the force of the spring 103 just slightly higher than the force of the breathable gas acting in a direction to open the valve member.

Concurrent with movement of the fulcrum supporting member 107 in a downward direction, due to reduced pressure of the breathable gas from the source, the fulcrum member 112 will also move downwardly, thus to maintain the fulcrums for the levers 116 within a constant range of distance from the radially extending disc 114 on the upper end of the valve member 101 and from the diaphragm stiffening plate 27. This maintenance of prescribed distance range serves to maintain constant the force, or in other words, the breathing effort, required to move the levers 116. This compensating action is in distinction to that in prior devices wherein the attitude assumed by the lever arms changes as the ranges of distance change between, respectively, the valve member and the fulcrums and the diaphragm and the fulcrums, thus increasing the force required to lift the valve as the supply pressure drops and thereby increasing the breathing resistance.

Upon inhalation by the user, a reduction in pressure will be created in the flexible conduits 14 and 15 and in the chambers 44 and 26 thereby to cause the diaphragm 25 to move inwardly toward the chamber 26, raise the valve portion 102 from the valve seat 100 and admit breathable gas to the chamber 44 and inhalation conduit 14. The pressure of the breathable gas admitted to the chamber 44 is determined by the extent of movement of the diaphragm 25 and the effective space between the valve portion 102 and the valve seat 100. It is to be noted that the reserve air valve member 80 normally is positioned to occlude the inner end of the passageway 77 and to open when a pressure differential exists across the valve member 80. Such a condition will exist upon inhalation or whenever the valve portion 102 is lifted from the valve seat 100.

Upon exhalation, exhalation gases will be transmitted to the mouthpiece 13 and through the exhalation conduit 15 to the chamber 26 thereby increasing the pressure within the chamber 26 and moving the diaphragm 25 outwardly until the central portion of the exhalation valve 36 contacts an inner surface 128 of the cover 21. When contact is made between the valve 36 and the cover 21, the peripheral portion 40 of the exhalation valve 36 will be flexed outwardly, thereby permitting flow of exhalation gases outwardly through the passages 35 to the surrounding fluid medium. In submarine usage the raised flange 34 on the insert 32 serves to prevent surging water from entering the chamber 26 beneath the edges 40 of the exhalation valve 36.

It is to be noted that, upon exhalation, a slight rise in pressure will also occur in the conduit 14; however, no flow will occur in this conduit inasmuch as the valve portion 102 is in a closed position. Additionally, upon inhalation, it is to be further noted that little or no reverse flow will be experienced in the exhalation conduit 15 thereby eliminating so-called "pendulum breathing" or re-breathing of exhalation products.

When the pressure of the breathable gas in the tank 12 reaches a predetermined low limit, approaching exhaustion, the force of the reserve air valve spring 81 will be such as to effect closure of the valve member 80. This closure occurs when the differential across the valve member 80 is insufficient to permit the valve member to open

with normal breathing. In most instances, the force of the spring 81 is set to accomplish such closure of the valve member 80 when the pressure of the breathable gas from the source drops to 300 p. s. i., for example. The closure of the valve member 80 at this point makes breathing very noticeably more difficult and serves as a warning to the user that the supply of breathable gas is approaching exhaustion, whereupon the ring 127 is grasped to pull the lanyard 125 and rotate the lever 67 in order to move the shaft portion 64 outwardly, thereby changing the position of the valve seat 78 and relieving or reducing the force of the compression spring 81. Following this action, the user then has a further predetermined quantity of breathable gas still remaining in the tank 12 and he may utilize this quantity during his return to the surface.

I claim:

1. A breathable gas regulating device comprising: first passage means for conducting breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; a valve for controlling gas flow outwardly from said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure of a surrounding fluid medium; valve means for controlling the flow of breathable gas through said first passage means; means tending to resist opening movement of said valve means; lever means operatively associated with said movable wall for opening said valve means upon a reduction in the pressure of said expired gas in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; and means responsive to changes in the pressure of the breathable gas at said source for varying the position at which said valve means is opened by said lever means.

2. A breathable gas regulating device comprising: first passage means for conducting breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; a valve for controlling gas flow outwardly from said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure of a surrounding fluid medium; valve means for controlling the flow of breathable gas through said first passage means; means tending to resist opening movement of said valve means; lever means adapted for engagement with one side of said movable wall for opening said valve means upon a reduction in the pressure of said expired gas in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; and means responsive to changes in the pressure of the breathable gas at said source for varying the position at which said valve means is opened by said lever means.

3. A breathable gas regulating device comprising: first passage means for conducting breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; an exhalation valve for controlling gas flow outwardly from said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure of a surrounding fluid medium; a flow control valve for controlling the flow of breathable gas through said first passage means; a floating valve seat for said flow control valve; lever means operatively associated with said movable wall for opening said flow control valve upon a reduction in the pressure of said expired gas in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; fulcrum means for said lever means, said fulcrum means being movable in accordance with movement of said floating valve seat; and means for positioning said fulcrum means and said valve seat relative to said movable wall in response to changes in the pressure of said breathable gas from said source.

4. A breathable gas regulating device comprising: first passage means for conducting breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; an exhalation valve for controlling gas flow outwardly from said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure of a surrounding fluid medium; a flow control valve for controlling the flow of breathable gas through said first passage means; a floating valve seat for said flow control valve; lever means adapted for engagement with one side of said movable wall for opening said flow control valve upon a reduction in the pressure of said expired gas in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; fulcrum means for said lever means, said fulcrum means being movable in accordance with movement of said floating valve seat; and means for positioning said fulcrum means and said valve seat relative to said movable wall in response to changes in the pressure of said breathable gas from said source.

5. A breathable gas regulating device comprising: first passage means for conducting breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; an exhalation valve for controlling gas flow outwardly from said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure of a surrounding fluid medium; a flow control valve for controlling the flow of breathable gas through said first passage means, said flow control valve having an enlarged head portion; resilient means tending to retain said flow control valve in a closed position; lever means having end portions adapted for engagement with one side of said movable wall and other end portions extending for operative association with said enlarged head for opening said flow control valve upon a reduction in the pressure of said expired gas in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; fulcrum means for said lever means, said fulcrum means being positioned intermediate said end portions of said lever means; and means responsive to changes in the pressure of the breathable gas at said source for varying the position at which said valve means is opened by said lever means.

6. A breathable gas regulating device comprising: first passage means for conducting a breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; a check valve for controlling fluid flow from said chamber to the surrounding fluid; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure in said chamber and on the other side to the pressure of the surrounding fluid; valve means for controlling the flow of breathable gas through said first passage means; means operably associated with said movable wall for opening said valve means upon a reduction of the pressure in said second passage means and in said chamber thereby to permit flow of said breathable gas through said first passage means; means operably associated with said valve means for decreasing the force required to open said valve means as the pressure of said breathable gas is reduced through use thereof; and means operably associated with said last mentioned means for maintaining substantially uniform the force required for movement of said valve opening means by said movable wall.

7. In a breathable gas regulating device: a regulator; a first chamber associated with said regulator for reception of a breathable gas from a source; valve means for controlling the flow of said gas into said first chamber;

inhalation conduit means for conducting breathable gas from said first chamber to a point of use; a second chamber in said regulator; exhalation conduit means for conducting exhalation products from said point of use to said second chamber; a movable wall having one side exposed to the pressure in said second chamber, the other side of said wall being exposed to the pressure of the surrounding fluid medium; a check valve for controlling fluid flow from said second chamber; lever means operably interconnecting said movable wall and said valve means, whereby, upon inhalation, a reduction in pressure is created in said exhalation conduit means and in said second chamber, thereby to move said movable wall and open said valve means to permit a flow of breathable gas into said first chamber and into said inhalation conduit means; and means having a movable fulcrum means for said lever means for maintaining substantially uniform the force required to move said lever means regardless of changes in the pressure of said breathable gas from said source.

8. A breathable gas regulating device comprising: first passage means for conducting a breathable gas from a source to a point of use; a chamber in said device; second passage means for conducting expired gas from said point of use to said chamber; a movable wall forming one side of said chamber, said movable wall being subjected on one side to the pressure in said chamber and on the other side to the pressure of the surrounding fluid medium; valve means for controlling the flow of breathable gas through said first passage means; lever means operably associated with said movable wall for opening said valve means upon a reduction of the pressure in said second passage means and in said chamber, thereby to permit flow of said breathable gas through said first passage means; means having a movable fulcrum means for said lever means for maintaining substantially uniform the force required to move said lever means regardless of changes in the pressure of said breathable gas from said source; and means positioned upstream from said valve means for interrupting the flow of said breathable gas when the source pressure thereof is reduced to a predetermined level.

9. In a breathable gas regulating device: a regulator; a first chamber in said regulator adapted for reception of a breathable gas from a source; valve means for controlling the flow of said gas into said first chamber; a movable valve seat associated with said valve means; spring means normally urging said seat away from said valve means; means to oppose the force of said spring means in response to the pressure of said breathable gas; inhalation conduit means for conducting breathable gas from said first chamber to a point of use; a second chamber in said regulator; exhalation conduit means for conducting exhalation products from said point of use to said second chamber; a movable wall having one side exposed to the pressure in said second chamber, the other side of said wall being exposed to the pressure of the surrounding fluid medium; a check valve for controlling fluid flow from said second chamber; lever means operably interconnecting said movable wall and said valve means, whereby, upon inhalation, a reduction in pressure is created in exhalation conduit means and in said second chamber, thereby to move said movable wall and open said valve means to permit a flow of breathable gas into said first chamber and into said inhalation conduit means; and fulcrum means for said lever means, said fulcrum means being operably connected to said movable valve seat and adapted for axial movement therewith, thereby to maintain substantially uniform the force required to move said lever means regardless of changes in the pressure of said breathable gas from said source.

10. A breathable gas regulating device comprising, in combination: a regulator body; a first chamber in said body; passage means for conducting a compressed breathable gas from a source to said first chamber; a valve member in said passage means; a movable element associated with said valve member, said element having a valve seat operably associated with said valve member; first spring means normally urging said valve member toward said valve seat; pressure differential area means provided on said element, said area means being subjected to the pressure of said breathable gas from said source, thereby to urge said element and said valve seat toward said valve member; second spring means acting on said element in a direction to oppose the force of said breathable gas on said pressure differential area means; an inhalation conduit for conducting said breathable gas from said first chamber to a point of use; a second chamber formed in said body; an exhalation conduit for conducting exhalation products from said point of use to said second chamber; a diaphragm forming one wall of said second chamber, said diaphragm having one side exposed to the pressure in said second chamber and the other side exposed to the pressure of the surrounding fluid medium; a check valve for controlling fluid flow from said second chamber; a plurality of levers engaging one side of said diaphragm and operable by movement of said diaphragm in response to an inhalation produced reduction in pressure in said exhalation conduit and in said second chamber to lift said valve member from said valve seat, thereby to permit flow of breathable gas into said first chamber and into said inhalation conduit; and fulcrum means for said levers, said fulcrum means being operably connected to said movable element and adapted for axial movement therewith, thereby to maintain substantially uniform the force required to move said levers regardless of changes in the pressure of said breathable gas from said source.

11. A breathable gas regulating device comprising, in combination: a regulator body; a first chamber in said body; a source of compressed breathable gas; passage means for conducting said breathable gas from said source to said first chamber; a valve member in said passage means; a movable element associated associated with said valve member, said element having a valve seat operably associated with said valve member; first spring means normally urging said valve member toward said valve seat; pressure differential area means provided on said element, said area means being subjected to the pressure of said breathable gas from said source, thereby to urge said element and said valve seat toward said valve member; second spring means acting on said element in a direction to oppose the force of said breathable gas on said pressure differential area means; an inhalation conduit for conducting said breathable gas from said first chamber to a point of use; a second chamber formed in said body, said valve member extending into said second chamber; an exhalation conduit for conducting exhalation products from said point of use to said second chamber; a diaphragm forming one wall of said second chamber, said diaphragm having one side exposed to the pressure in said second chamber and the other side exposed to the pressure of the surrounding fluid medium; a check valve for controlling fluid flow from said second chamber; a plurality of levers engageable with one side of said diaphragm and operable by movement of said diaphragm in response to an inhalation produced reduction in pressure in said exhalation conduit and in said second chamber to lift said valve member from said valve seat, thereby to permit a flow of breathable gas into said first chamber and into said inhalation conduit; fulcrum means for said levers, said fulcrum means being operably connected to said movable element and adapted for axial movement therewith, thereby to maintain substantially uniform the force required to move said levers regardless of changes in the pressure of said breathable gas from said source; and means positioned between said valve member and said source of breathable gas to interrupt the flow of said gas when the gas pressure of said source is reduced to a predetermined level.

12. In a breathable gas regulating apparatus having a

respiration responsive movable wall and a valve member for controlling flow of a breathable gas from a source to a point of use, means operable in response to movement of said movable wall for opening said valve member comprising: lever means operably engageable with said movable wall and extending to said valve member; fulcrum means for said lever means; and means for maintaining substantially uniform the force required to move said lever means regardless of changes in the pressure of said gas from said source, said means having means responsive to changes in pressure of the gas at the source for shifting the position of said fulcrum means.

13. In a breathable gas regulating apparatus having a respiration responsive movable wall and a valve member for controlling flow of a breathable gas from a source to a point of use, means operable in response to movement of said movable wall for opening said valve member comprising: a plurality of levers operably engagable with one side of said movable wall and extending to said valve member; fulcrum means for said levers; and means for maintaining substantially uniform the force required to move said levers regardless of changes in said gas pressure, said means having means responsive to changes in pressure at said gas source for shifting the position of said fulcrum means.

14. In a breathable gas regulating apparatus having a respiration responsive movable wall, a valve member and a cooperating pressure responsive floating valve seat for controlling flow of a breathable gas from a source to a point of use, means operable in response to movement of said movable wall for opening said valve member comprising: a plurality of levers operably engagable with one side of said movable wall adjacent the outer periphery thereof and extending to said valve member; fulcrum means for said levers, said fulcrum means being operatively associated with said floating valve seat; and means for positioning said fulcrum means in response to changes in the pressure of said gas from said source and relative to said movable wall, thereby to maintain substantially uniform the force required to move said levers regardless of said changes in said gas pressure.

15. In a breathable gas regulator of the type having a respiration responsive movable wall: valve means for controlling the flow of a breathable gas from a source into said regulator; an element engaging said valve means and tending to resist opening movement thereof; means responsive to pressure of gas at said source to move said valve means and vary the effective resistance of said element, a reduction in gas pressure at said source causing movement of said valve in a direction to proportionally decrease the resistance of said element; and actuating means operable in response to movement of said movable wall for moving said valve means toward an open position in opposition to said resistance element.

16. In a breathable gas regulator of the type having a respiration responsive movable wall: valve means for controlling the flow of a breathable gas from a source into said regulator; a spring tending to resist opening movement of said valve means; means responsive to the pressure of gas at said source to move said valve means and vary the effective resistance of said spring, a reduction in gas pressure at said source causing movement of said valve means in a direction to proportionally decrease the resistance of said spring; and actuating means operable in response to movement of said movable wall for moving said valve member toward an open position in opposition to said spring.

17. In a breathable gas regulator of the type having a respiration responsive movable wall: valve means for controlling the flow of a breathable gas from a source into said regulator; means forming a valve seat for said valve means, said seat-forming means being disposed for movement in response to variations in pressure of the gas at said source; resilient means tending to resist movement of said valve means toward an open position; actuating means operable in response to movement of said movable wall to move said valve member toward an open position in opposition to said resilient means; and means movable simultaneously with said valve seat-forming means for maintaining predetermined characteristics of said actuating means regardless of variations in gas pressure at said source.

18. In a breathable gas regulator of the type having a respiration responsive movable wall: valve means for controlling the flow of a breathable gas from a source into said regulator; means forming a valve seat for said valve means; resilient means tending to resist movement of said valve means toward an open position, said valve seat-forming means being disposed for movement in response to variations in pressure of the gas at said source to change the effective resistance of said resilient means; actuating means operable in response to movement of said movable wall to move said valve means toward an open position in opposition to said resilient means; and means movable with said valve seat-forming means for maintaining predetermined relationships between said actuating means and said valve member during movement of said valve seat-forming means.

19. In a breathable gas regulator of the type having a respiration responsive movable wall: valve means for controlling the flow of a breathable gas from a source into said regulator; means forming a valve seat for said valve means; resilient means tending to urge said valve means toward said seat; means on said valve seat-forming means responsive to changes in gas pressure at said source to move said valve seat-forming means and valve means in a direction to change the effective resistance of said resilient means in direct proportion to the change in gas pressure; actuating means operable in response to movement of said movable wall to move said valve means toward an open position in opposition to said resilient means; and means movable simultaneously with said valve seat-forming means for maintaining predetermined relations of said actuating means and said valve member in different positions of said valve seat-forming means.

20. In a breathable gas regulator of the type having a respiration responsive movable wall: a valve element for controlling the flow of a breathable gas from a source into said regulator, said valve element having an area exposed to source pressure which tends to move said valve element toward an open position; means forming a floating seat for said valve element; resilient means tending to urge said valve element toward said seat with a force slightly exceeding the force exerted by said pressure; a surface area on said seat-forming means exposed to source pressure, such pressure tending to cause movement of said seat-forming means and valve element, a reduction in source pressure causing movement of said seat-forming means and valve element to reduce the effective force of said resilient means in direct proportion to said pressure reduction; actuating means operative in response to predetermined movement of said movable wall to move said valve toward open position in opposition to said resilient means; and means movable in unison with said valve seat-forming means for maintaining predetermined relations between said actuating means and said valve element regardless of the change in effective force of said resilient means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,269,500 Wildhack ---------- Jan. 13, 1942

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,828,739 April 1, 1958

Robert Kimes

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 25, for "hardness" read -- harness --; column 10, line 38, strike out "associated", second occurrence.

Signed and sealed this 27th day of May 1958.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents