March 22, 1960 J. M. KEMPER 2,929,376

UNDERWATER BREATHING APPARATUS

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Fig. 1.

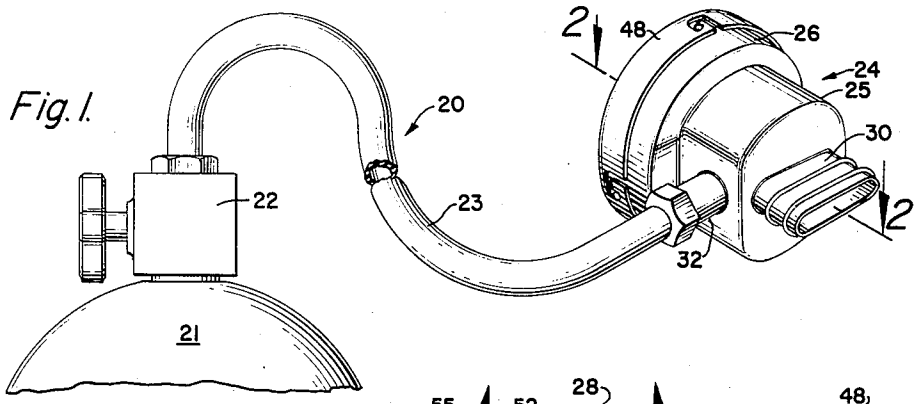


Fig.2

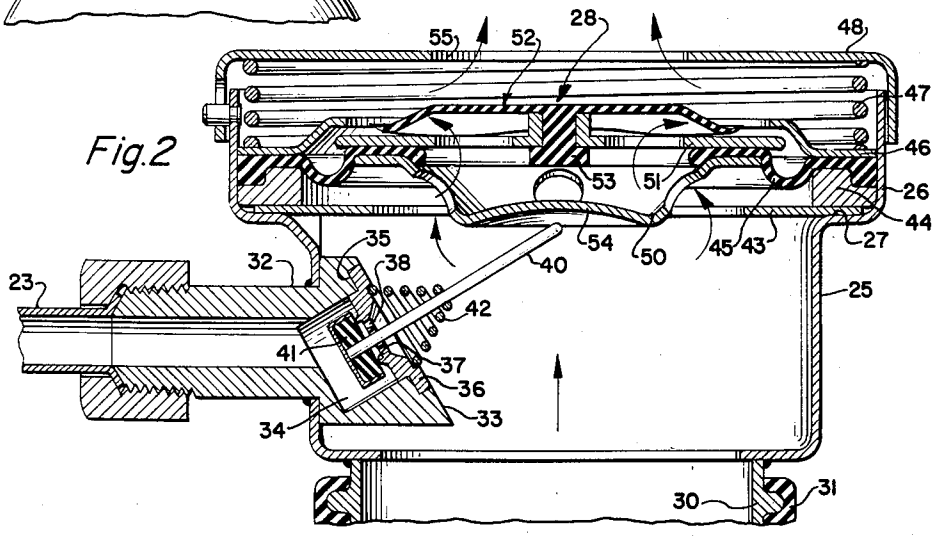


Fig.3.

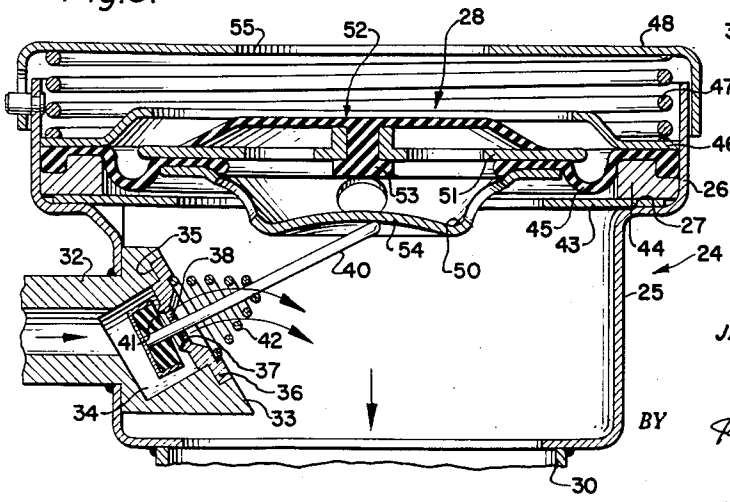
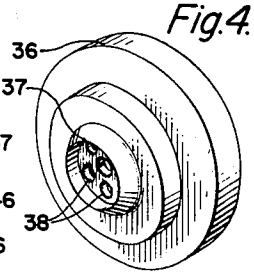


Fig.4.



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UNDERWATER BREATHING APPARATUS

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This invention relates generally to breathing apparatus and more particularly to that class of mechanism known as self-contained underwater breathing apparatus. Still more particularly the invention relates to pressure regulating mechanism for use in underwater breathing apparatus.

An object of this invention is to provide a regulator mechanism which may be held in or close to and in direct communication with the mouth so that when the user occupies a prone position in the water, while swimming, the regulator will be at the same depth as the user's lungs and, therefore, both will be subjected to the same hydrostatic pressure. Breathing effort will thus be minimized.

Another object of this invention is to provide a regulator mechanism which may be held close to and in direct communication with the mouth so that the usual inhalation and exhalation conduits, with their attendant resistance to the flow of air, may be eliminated, the breathing effort being further reduced in this manner.

Another object is to provide a combination regulator and mouthpiece for underwater breathing apparatus which, by eliminating the usual conduits, reduces the chances of failure of the device and increases the ease with which the apparatus may be cleared of water in the event the mouthpiece is dislodged during use.

A further object of the invention is to provide a regulator for underwater breathing apparatus, the regulator having a casing with a portion to be held in the user's mouth and forming a chamber closed at one side by diaphragm means and communicating through a valved inlet with a source of breathable gas, the diaphragm means moving in response to pressure differences between the gas in the chamber and the water surrounding the casing, means being provided, between the valve at the inlet and the diaphragm means, to cause the valve to open when the diaphragm means is moved by the water to admit breathable gas to the chamber for inhalation by the user.

A still further object of the invention is to provide a regulator for underwater breathing apparatus, the regulator having a casing with a diaphragm assembly closing one side and arranged to move inwardly and outwardly, relative to the casing, in response to differences between the pressures of the fluids inside and outside of the casing, the casing having a valve for controlling the flow of breathable gas from a source into the casing, the valve being a simple, disc-like poppet member which is rocked, when the diaphragm assembly moves in one direction, to an open position to admit breathable gas substantially without restriction.

Another object of the invention is to provide a regulator of the type mentioned in the preceding paragraph having simple means for securing the diaphragm assembly to the casing to facilitate the fabrication of the device and cleaning thereof after use.

Other objects and advantages will be apparent from the following description taken in connection with the accompanying drawing in which the invention has been illustrated in one of its simplest forms.

In the drawing:

Figure 1 is a perspective view of breathing apparatus formed in accordance with the present invention.

Figure 2 is a longitudinal sectional view taken through the combination regulator and mouthpiece forming a part of the breathing apparatus shown in Figure 1, the plane of the section being indicated by the line 2—2 of Figure 1.

Figure 3 is a view similar to Figure 2, but showing the mechanism in a different operating condition.

Figure 4 is a perspective view of a valve seat insert used in the combination regulator and mouthpiece.

Referring more particularly to the drawing, the numeral **20** designates generally the underwater diving apparatus shown in Fig. 1. As is customary in such apparatus, a tank **21** is provided to contain a supply of air under pressure. The upper end of the tank **21** is provided with apparatus **22** which includes a first stage pressure reducing regulator and a reserve control valve. The tank, the first stage regulator, and the reserve control valve form no part of the present invention. They are shown merely for the purpose of facilitating an understanding of the invention.

A flexible tube **23** of required length and relatively small diameter leads from the outlet of the pressure reducing regulator to the combined demand regulator and mouthpiece **24** which forms the subject matter of the present invention. As shown in Figs. 2 and 3, the device **24** includes a casing **25** which may be formed in any suitable manner such as by spinning, stamping or molding, the device illustrated being formed from sheet metal. Casing **25** is provided at one side with an enlarged portion **26** which forms a shoulder **27** for receiving and supporting a diaphragm assembly, designated generally by the numeral **28**. The enlarged side **26** of the casing is open so that the diaphragm assembly will be exposed on one side to the pressure of the fluid medium surrounding the casing **25**. The diaphragm assembly will also be exposed at the other side to pressure internally of the casing. At the side opposite the diaphragm assembly, the casing is provided with a tubular projection **30** of generally oval cross-section, this projecting forming a part of the device to be inserted in the user's mouth. It is obvious that suitable means such as a rubber covering or mouthpiece, indicated at **31**, may be provided on the projection **30** to permit the device to be comfortably gripped and held between the teeth or otherwise supported in the user's mouth.

At one side between the diaphragm assembly and the mouthpiece, the casing **25** is formed with a fitting **32** having an angularly directed end surface **33** in which a recess **34** is formed, the fitting having an axially extending bore communicating with the opening and with the tube **23**, the latter being secured to the end of the fitting in any suitable manner. The inner end of the opening **34** is counterbored as at **35** to receive a valve seat insert **36** shown in detail in Fig. 4. This insert may be pressed or otherwise secured in place in the fitting **32** to be permanently retained therein. It is obvious that, if desired, the insert could be made removable for cleaning or replacement purposes. One side of the insert has an annular valve seat **37** formed thereon, this seat surrounding a plurality of openings **38** which establish communication between the recess **34** and the interior of the casing **25**. One of the openings **38** is centrally located to receive the stem **40** of a valve element **41**, this element being disposed in the recess **34** for engagement with the seat **37** to control communication between the recess **34** and the chamber formed within the casing **25**.

Breathable gas under pressure from the tank **21** flowing

through the tube 23 will tend to maintain the valve 41 in engagement with the seat 37. It will be obvious, however, that when the outer end of the stem 40 is moved laterally, valve 41 will be rocked on seat 37 to an open position to permit breathable gas to flow from the tank 21 into the casing 25. When the valve 41 is rocked to an open position the pressure differential between the upstream and downstream sides of the valve will be reduced and the tendency of the breathable gas to close the valve will be decreased. Breathing with the device is facilitated by this feature. The valve seat insert has a recess formed on one side to receive a conical spiral spring 42 which serves to return the stem 40 to a normal position following lateral movement thereof. Breathable gas flowing into the casing may be inhaled by the user through the tubular projection 30. The user may also exhale spent gas through the projection 30 into the casing 25.

The diaphragm assembly 28 has been provided to move the valve stem laterally when inhalation by the user causes the pressure in the casing to fall below that of the pressure of fluid surrounding the casing. Diaphragm assembly 28 includes a ring-like plate 43, a collar 44, a flexible diaphragm 45, which may be formed of rubber or other suitable material, and a clamp plate 46, the assembly being engaged with the shoulder 27 and yieldably held in engagement therewith by a coil spring 47, the spring being abutted at one end with a cover member 48 carried by the casing 25. Cover 48 may be secured in any desirable manner, pins and bayonet slots being shown for purposes of illustration only. The diaphragm assembly also includes inner and outer clamp plates 50 and 51, respectively, these being vulcanized or otherwise secured to corresponding sides of the diaphragm 45. In this instance, the diaphragm is formed with a central opening which is normally closed by an exhalation valve designated generally by the numeral 52. This valve is a disc-like flap valve secured to the clamp plate 51 by a projection 53 extending downwardly from the central portion of the valve 52. The projection 53 is disposed in a central opening in the plate 51, the projection being provided with a head at its lower end to retain the valve in place on the plate 51. The central portion of the plate 51 has a plurality of openings formed therein so that when the pressure in the casing 25 exceeds the pressure of the fluid surrounding the casing, the edges of the valve 52 will be raised and gas or air within the casing will flow outwardly around the edge of the valve 52. As soon as the pressure within the casing falls to that of the fluid at the exterior thereof, the resiliency of valve 52 will cause it to move into engagement with the plate 51 and prevent the entrance of fluid from the exterior of the casing into the casing through the openings in plate 51.

Plate 50 is provided with a depressed central portion 54, this portion engaging the stem 40 when the diaphragm assembly moves inwardly due to a differential in pressure between the fluid at the exterior of the casing and the gas or air therein. This differential will be created upon inhalation by the user. As explained previously, lateral movement of the stem 40 causes the valve 41 to rock to an open position, as shown in Fig. 3, in which breathable gas may flow into the interior of the casing 25 from which it may be drawn by the user. When the desired amount of air has been inhaled, continued flow of breathable gas into the casing will increase the pressure therein and cause the diaphragm to move in an outward direction until spring 402 and gas flowing through the inlet causes the valve 41 to again engage the seat 37 and interrupt gas flow to the casing. When the user exhales, the spent gas will flow through the exhalation valve to the surrounding medium. The extent of movement of the diaphragm assembly in response to pressure differentials at opposite sides thereof will be limited by the ring-like plate 43 and clamp plate 46.

It will be noted from Figs. 2 and 3 that the cover 48 is provided with a central opening 55. By engaging the diaphragm assembly through this opening, with a finger or other suitable means, the user may depress the diaphragm assembly and cause the valve 41 to be moved to an open position, even though the pressure within the casing 25 exceeds the pressure of the fluid at the exterior. This operation is performed to facilitate the expulsion of water from the casing 25 in the event water should gain access thereto, for sometimes in the use of underwater breathing apparatus, the mouthpiece will be removed or may be accidentally displaced from the user's mouth and water will enter the casing. To effect the removal of this water, the mouthpiece may again be inserted in the user's mouth and the diaphragm assembly depressed as above described. It may also be desirable to exhale at the same time that valve 41 is opened, thus expediting the discharge of water from the casing. When the user is face down in the water with the combination mouthpiece and regulator held in his mouth, any water in the casing 25 will gravitate toward the diaphragm assembly. The water will be readily discharged.

While the invention has been described with reference to underwater breathing, it is not limited to such usage. The apparatus according to the invention may also be employed for breathing and rescue work in toxic or noxious atmospheres, such as in mines, smoke-filled buildings and various contaminated atmospheres where a self-contained source of air, oxygen or other breathable gas is indicated.

I claim:

1. In a breathing apparatus: regulator means comprising a casing open at one end, said casing forming a chamber with an inlet for breathable gas; valve means at said inlet urged in the closing direction by the pressure of said breathable gas and disposed to control the flow of breathable gas into said chamber; a diaphragm closing the open end of said casing and being exposed at one side to the pressure of gas in said chamber and at the other side to the pressure of a surrounding medium, said diaphragm being movable in response to differentials in such pressures; means operative when said diaphragm moves inwardly relative to said casing to open said valve means and admit breathable gas; a mouthpiece formed on the end of the casing opposite said diaphragm through which said breathable gas may be inhaled and spent gas exhaled; and an exhalation valve carried by and closing an opening in said diaphragm, said exhalation valve being movable toward open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount.

2. In a breathing apparatus: regulator means comprising a casing open at one end, said casing forming a chamber with an inlet for breathable gas; means provided on the end of said casing opposite said open end to be held in a diver's mouth to support said casing and through which the breathable gas may be inhaled and spent gas exhaled; valve means at said inlet urged in the closing direction by the pressure of said breathable gas and disposed to control the flow of breathable gas into said chamber; a flexible diaphragm closing the open end of said casing and exposed at one side to the pressure of gas in said chamber and at the other side to the pressure of a surrounding medium, said diaphragm being movable in response to differentials in such pressures; motion transmitting means engaging said valve means and operative when said diaphragm moves inwardly relative to said casing to open said valve means and admit breathable gas; and an exhalation valve carried by and closing an opening in said diaphragm, said exhalation valve being movable toward open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount.

3. In a breathing apparatus: regulator means comprising a casing open at one end, said casing forming a cham-

ber with an inlet for breathable gas; means provided on the end of said casing opposite said open end to be held in a diver's mouth to support said casing and through which the breathable gas may be inhaled and spent gas exhaled; a valve seat surrounding said breathable gas inlet; a valve element urged in the closing direction by the pressure of the breathable gas and disposed for engagement with said seat to control the flow of breathable gas into said chamber; diaphragm means closing the open end of said casing, one side of said diaphragm being exposed to the pressure of the surrounding medium and the other side being exposed to the pressure of gas within said chamber, said diaphragm being movable in response to differentials between such pressures; a stem projecting from said valve element toward said diaphragm means, movement of said diaphragm means inwardly relative to said casing being transmitted by said stem to said valve element to rock the same about said seat and admit breathable gas to said chamber; and an exhalation valve disposed to close an exhalation outlet for said casing, said exhalation valve being movable toward open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount.

4. In underwater breathing apparatus: regulator means comprising a casing open at one end, said casing forming a chamber with an inlet for breathable gas; means provided on the end of said casing opposite said open end to be held in a diver's mouth to support said casing and through which the breathable gas may be inhaled and spent gas exhaled; a valve seat surrounding said breathable gas inlet; a valve element urged in closing direction by the pressure of the breathable gas and disposed for engagement with said seat to control the flow of breathable gas into said chamber; diaphragm means closing the open end of said casing, one side of said diaphragm being exposed to the pressure of the surrounding medium and the other side being exposed to the pressure of gas within said chamber, said diaphragm being movable in response to differentials between such pressures; a stem projecting from said valve element toward said diaphragm means, movement of said diaphragm means inwardly relative to said casing being transmitted by said stem to said valve element to rock the same about said seat and admit breathable gas to said chamber; and an exhalation valve carried by and closing an opening in said diaphragm, said exhalation valve being movable toward open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount.

5. In underwater breathing apparatus: regulator means comprising a generally cylindrical casing open at one end, said casing forming a chamber with an inlet for breathable gas; valve means at said inlet to control the flow of breathable gas into said chamber; a diaphragm closing the open end of said casing and being exposed at one side to the pressure of gas in said chamber and at the other side to the pressure of a surrounding medium, said diaphragm being movable in response to differentials in such pressures; means operative when said diaphragm moves inwardly relative to said casing to open said valve means and admit breathable gas; a mouthpiece formed on the end of the casing opposite said diaphragm through which said breathable gas may be inhaled and spent gas exhaled; an exhalation valve disposed to close an exhalation outlet for said casing, said exhalation valve being movable toward an open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount; and a cover on said casing to protect said diaphragm means, said cover having an opening concentric with the axis of said casing through which said diaphragm means can be manually moved inwardly relative to said casing to open said inlet valve means irrespective of the pressure differential at opposite sides of said diaphragm means.

6. In underwater breathing apparatus: regulator means comprising a casing open at one side, said casing forming a chamber having a breathable gas inlet with the longitudinal axis thereof at an acute angle to the plane of the open side of the casing, said casing also forming an opening through which the breathable gas may be inhaled and spent gas exhaled; valve means at said inlet to control the flow of breathable gas into said chamber, said valve means comprising a valve element and a stem disposed substantially on the longitudinal axis of said inlet; movable diaphragm means closing the open side of said casing and exposed at one side to the pressure of gas in said chamber, the other side of said diaphragm means being exposed to the pressure of the surrounding medium, said diaphragm means being movable in response to differentials in such pressures, said diaphragm means engaging the stem of said valve means upon movement inwardly relative to said casing and rocking the valve element to an open position to admit breathable gas; and an exhalation valve disposed to close an exhalation outlet for said casing, said exhalation valve being movable toward open position when the pressure in said chamber exceeds the pressure of the surrounding medium by a predetermined amount.

7. In a breathable gas regulating apparatus: a casing forming a chamber having an open end; a diaphragm closing the open end of said casing, said diaphragm being exposed on one side to the pressure of the gas in said chamber and on the other side to the pressure of a surrounding medium; a normally closed exhalation valve carried by said diaphragm; means formed on the end of said casing opposite said open end to be held in a diver's mouth to support said casing and through which the breathable gas may be inhaled and spent gas exhaled; and a breathable gas inlet valve operably associated with said diphragm to control the flow of breathable gas into said chamber.

8. In a breathable gas regulating apparatus: a generally cylindrical casing forming a chamber having an open end; a diaphragm closing the open end of said casing, said diaphragm being exposed on one side to the pressure of the gas in said chamber and on the other side to the pressure of a surrounding medium; a normally closed exhalation valve carried by said diaphragm; a mouthpiece disposed on the axis of the casing and projecting from the end of the casing opposite said open end to be held in a diver's mouth to support said casing and through which the breathable gas may be inhaled and spent gas exhaled; and a breathable gas inlet valve operably associated with said diaphragm to control the flow of breathable gas into said chamber.

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