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2,872,919

DIVER'S BREATHING APPARATUS

Filed July 12, 1956

2 Sheets-Sheet 1

FIG. 3.

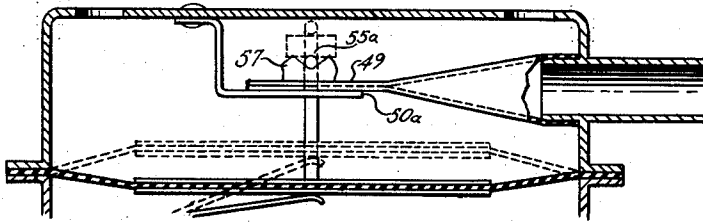


FIG. 2.

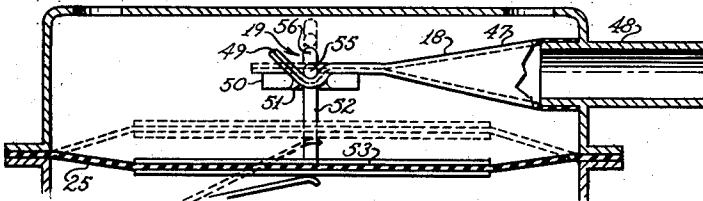
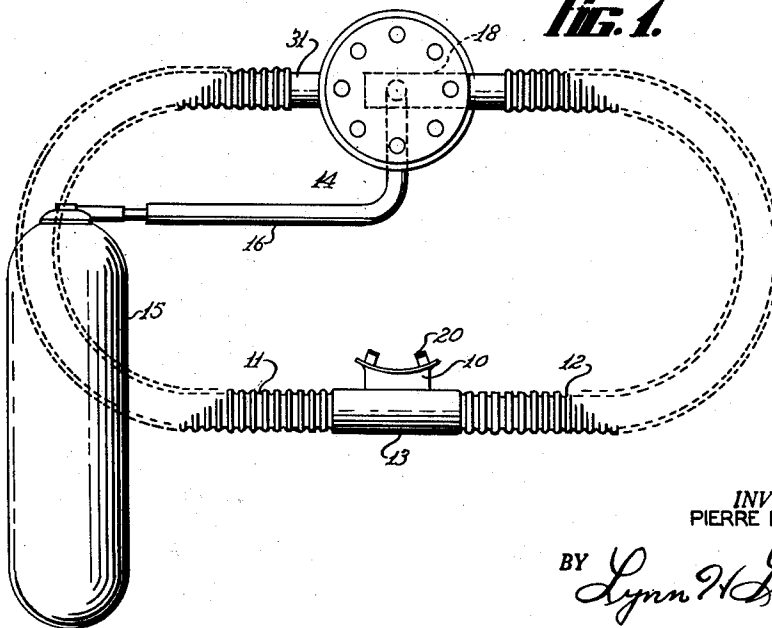


FIG. 1.



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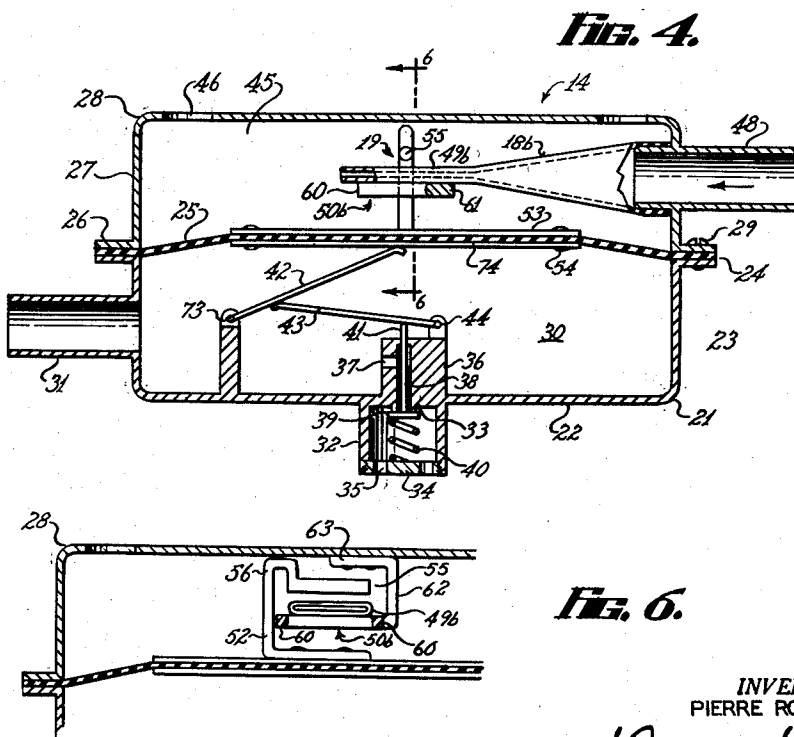
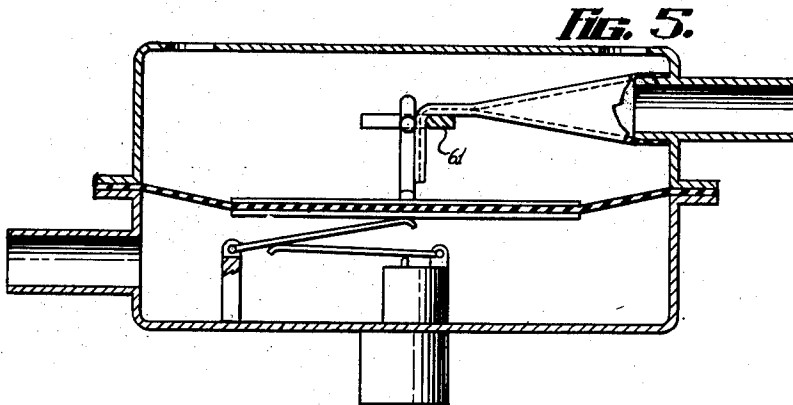
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DIVER'S BREATHING APPARATUS

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4 Claims. (Cl. 128—142)

This invention relates to diving apparatus of the general type wherein the flow of air or other breathable gas from a pressurized source (such as a container carried on the back of a diver) to a mouthpiece held in the diver's mouth, is controlled by a regulator that is located at a distance from the diver's face and connected to the mouthpiece by an exhalation conduit, and an inhalation conduit.

In a commonly known type of such breathing apparatus, the exhalation valve is located within or immediately adjacent the regulator so as to control exhalation by an automatic operation induced by a small water pressure differential which normally maintains the exhalation valve closed but is overcome by the exhaling effort of the diver's lungs. In order that this exhaling effort may be kept at a minimum, the exhalation valve in such apparatus is necessarily located relatively close to the regulator diaphragm, within a specific maximum distance.

The major object of the present invention is to provide a breathing apparatus utilizing an exhalation valve which can be located at any selected distance from the regulator diaphragm without adversely affecting its operation. More specifically, the invention contemplates a breathing apparatus having means for controlling the operation of the exhalation valve independently of any water pressure differential acting thereon.

A primary object is to provide a breathing apparatus wherein the breathing effort required for operation, which in the conventional regulator is equivalent to a water column of two inches or more, can be reduced to one inch or less, so as to make breathing easier. More specifically, the invention provides an exhalation valve which will open during exhalation without requiring any exhalation effort, and which will be positively closed automatically upon each inhaling portion of the breathing cycle.

Another object is to provide a breathing apparatus of relatively simplified and cheapened manufacturing construction and cost.

Other objects will become apparent in the ensuing specification and appended drawings in which:

Fig. 1 is a schematic diagram of a breathing apparatus embodying the invention;

Fig. 2 is a sectional view of the regulator thereof, with the exhalation valve closed;

Fig. 3 is a sectional view of a modified form of the regulator, with the exhalation valve closed;

Fig. 4 is a sectional view of another modified form of the regulator with the exhalation valve in its normally open position;

Fig. 5 is a sectional view of the regulator of Fig. 4 with the exhalation valve closed;

Fig. 6 is a sectional view of the regulator of Fig. 4, taken on the line 6—6 of that figure.

Referring now to the drawings in detail, and particularly to Figs. 1 and 2 thereof, I have shown, as an example of one form in which the invention may be embodied, a breathing apparatus embodying a fitting 10

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(e. g. mouthpiece) for attachment to the diver's face, to establish a connection to the lungs; inhalation and exhalation conduits 11 and 12 respectively, connected to a tubular section 13 of the mouthpiece 10; a regulator 14 to which the inhalation conduit 11 is connected; a source of compressed air, such as the tank 15, connected through a supply tube 16 to the regulator 14; an exhalation valve 18 connected to the end of exhalation conduit 12; and an actuator 19 for positively closing the exhalation valve 18.

The mouthpiece 10 may be of the type commonly utilized in underwater breathing apparatus, including lugs 20 to be gripped between the diver's teeth for holding the mouthpiece in the diver's mouth; or may be a face mask. The conduits 11 and 12 are of flexible, lightweight, corrugated hose of waterproof material.

Regulator 14 (Fig. 4) includes a casing 21 which may be of cylindrical drum shape including a flat end wall 22, a peripheral wall 23 and a peripheral flange 24 projecting radially outwardly. A diaphragm 25 in the form of a thin, lightweight disc of highly flexible material such as rubber, synthetic rubber or impregnated fabric, is sealed and secured to the flange 24 by a mating flange 26 on the peripheral wall 27 of a cover 28 which is attached to casing 21 by means of screws or bolts 29 extending through the flanges 24 and 26. Defined between diaphragm 25 and casing 21 is a transfer chamber 30. Joined to peripheral wall 23 and communicating with chamber 30 is a nipple 31 to which the inhalation conduit 11 is connected. End wall 22 is provided (preferably at the center thereof) with a pressure line fitting 32 defining a valve chamber, a valve seat 33 at the bottom thereof, a cap 34 at the outer end thereof, having apertures 35, and an inlet port boss 36 having an inlet 37 connected to valve seat 33 by a passage 38. The inlet 37 is closed by a poppet valve 39 which normally engages valve seat 33 under the yielding pressure of a coil spring 40 engaged between the valve 39 and cap 34, under light compression. Poppet valve 39 has a stem 41 extending through passage 38.

Valve casing 32 functions to connect the inlet 37 to the supply tube 16 coming from the pressurized reservoir 15, and when open, admits pressurized breathing gas into the transfer chamber 30 from which it may be drawn through nipple 31 and inhalation hose 11 and mouthpiece 10 into the diver's lungs.

Valve 39 is controlled in response to suction (lowered pressure) induced in chamber 30 by the inhaling action of the diver's lungs. To this end, the invention utilizes a conventional actuator linkage between the diaphragm 25 and valve stem 41. Merely by way of illustration, said linkage is shown schematically as a compounded lever arrangement including a primary lever 42, having one end pivoted at 73 to the casing 21 and having its other end in engagement with a bearing plate 74 attached to diaphragm 25; and a secondary lever 43 having one end pivoted at 44 to inlet member 36, having an intermediate portion engaging the end of stem 41 and having its opposite end bearing against the lever 42 at a point near the pivot 73, the bearing of lever 43 against stem 41 likewise being relatively near pivot 44 so that a satisfactory compounded leverage multiplication factor is attained. The relationship is selected so as to provide for overcoming the resistance of spring 40 plus the pressure of the gas against the head of poppet valve 39, with only a moderate breathing effort, including the effort necessary to actuate the escape valve closing actuator in accordance with the explanation given hereinafter.

Defined between cover 28 and diaphragm 25 is a chamber 45 which communicates freely with the ambient fluid (e. g. the body of water in which the diver is immersed) through apertures 46 therein. The chamber 45

and cover 28 may serve merely to provide a protected space for movement of diaphragm 25, protecting it from contact with external objects, or may function additionally as a housing for the exhalation valve 18. To anchor the exhalation valve in a fixed position with relation to the balance of the apparatus it is preferred to attach it to the regulator and in this case the preferable arrangement is to enclose and protect it within the cover 28 although such arrangement is not essential to the operation of the regulator in accordance with the principles of this invention.

The exhalation escape valve 18 (Fig. 2) may be of any selected form that is satisfactory to provide a normally open valve arrangement. A suitable valve is the duck-bill type commonly utilized in breathing regulators, comprising a length of relatively thin flexible tubing 47 which may be contained and protected within chamber 45 and mounted upon the inner end of a nipple 48 extending through and fixed in the peripheral wall 27 of the cover 28. Such a valve has a split outlet mouth 49 comprising flat lips tending to normally assume positions engaging one another to close the valve although responding to the slightest pressure to release exhalation gas passing through the valve.

Because the lips of the valve mouth 49 do not embody any appreciable resistance to outflow, the valve of Fig. 2 may be regarded as a normally open valve (considering the normal position of the diaphragm to be that shown in dotted lines in Fig. 2 and in full lines in Fig. 2, i. e. the position to which it is urged by spring 40 when no fluid pressure differential is applied to the regulator). As an alternative construction, the valve 18b (Fig. 4) may be of tubular construction throughout its length including a flat outlet end portion 49b which remains open as shown except when positively closed by the actuator 19.

The mouth 49 of the valve 18 of Fig. 2 normally rests in a straight position upon a saddle 50 having therein a transverse slot 51 slightly longer than the width of mouth 49. Actuator 19 includes a shaft portion 52 which is anchored to a disc 53 on the outer face of diaphragm 25. Discs 53 and 74 may be secured to one another and to the diaphragm by rivets 54 extending through the diaphragm, whereby the actuator shaft 52 moves in unison with the movement of the central portion of the diaphragm. On its other end, actuator shaft 52 has an actuator finger 55 which projects transversely over the outlet end 49 of valve 18, being connected to shaft 52 by a goose-neck 56 which permits finger 55 to enter the slot 51 sufficiently to warp the mouth 49 into the indented form shown in Fig. 2 in full lines, thereby positively clamping the lips of the mouth 49 together to close the valve.

In the form of the invention shown in Fig. 3, instead of warping the mouth 49 into a slot in the saddle, a pad 57 of soft material such as sponge rubber is inserted between actuator finger 55a and mouth 49 and when the diaphragm is drawn inwardly in chamber 30 pressure is applied through pad 57 to clamp the lips of mouth 49 together against saddle 50a, thereby positively closing the valve.

The closing of valve 18 is effected by the movement of diaphragm 25 inwardly in chamber 30 in response to suction applied in chamber 30 by the inhaling action of the diver's lungs, the actuator 19 secured to diaphragm 25 as described, moving in unison with the diaphragm movement. Since the valve closing movement is thus transferred positively through mechanical linkage the distance of valve 18 from the diaphragm does not affect the actuation of the valve, and the exhalation valve may thus be positioned at any selected distance from the diaphragm, regardless of the water pressure differential corresponding to the column of water existing between the diaphragm and the exhalation valve. Preferably, the valve is located above the diaphragm in the most normal position of the

regulator (i. e. with cover 28 facing upwardly when the diver is swimming face downwardly) and for compactness, it is preferable to have all parts located in fairly close proximity within the casing and cover assembly, as shown.

In the form of the invention shown in Figs. 4 and 5, saddle 50b is a horse shoe shape in plan, including laterally spaced arms 60 embracing a space that is open at one end of the saddle, and including a web portion 61 joining the arms 60 and defining a shoulder around which the mouth portion 49b of valve 18b is wrapped by the downward movement of actuator finger 55 when the diaphragm is drawn inwardly in chamber 30. This wrapping action, illustrated in Fig. 5, closes the mouth 49b against the web 61.

Fig. 6 illustrates how the saddle 50b may be supported by a bracket 62, integral with one of the arms 60, with the bracket being attached at 63 to the cover 28.

The apparatus in each form of the invention is adjusted so that the pressure normally existing in chamber 30 is slightly greater than the ambient pressure of the body of water in which the diver is operating, at the level of chamber 30. The metering valve 39 is regulated to admit air to chamber 30 whenever pressure therein drops below this normal value by a small increment sufficient to overcome the resistance of spring 40, to operate the metering valve linkage, and to close the exhalation valve. This increment can be regulated so that a normal breathing effort, without straining, will lower the pressure in chamber 30 so as to establish the required differential of pressure in the ambient water acting through opening 46 against diaphragm 25, over the pressure in chamber 30, to move the diaphragm inwardly, operating the metering valve and the exhalation valve to open the former and close the latter.

Since the chamber 30 is directly connected to the lungs through nipple 31, inhaling conduit 11 and mouthpiece 10, the normal pressure in chamber 30 at values higher than ambient pressure provides the same pressure in the diver's lungs equal to or slightly greater than the ambient water pressure so that the diver will experience no sensation of pressure against his chest.

During the inhaling portion of the breathing cycle, the pressure within or applied to valve 18, 18b etc., will be reduced the same as the pressure in chamber 30 so as to reduce the net pressure required to be exerted against the valve by the water. While the exhalation valve from the center of the diaphragm greatly exceeds the distance required in the conventional apparatus.

The invention has the primary advantage that it does not require a hydrostatic pressure differential to maintain the exhalation valve closed. That principle, as utilized in the conventional diving apparatus, providing for a differential of ambient water pressure over air pressure in the exhalation conduit at its normal value (mean between inhalation and exhalation pressure) calls for a slight differential at the highest elevation of the exhalation valve above the diaphragm level, and a consequently noticeable maximum differential (e. g. two inch water column) at the lowest position of the exhalation valve below the diaphragm level. The present invention eliminates the need for a hydrostatic differential by utilizing a positive mechanical closing of the exhalation valve.

The invention provides for positive closing of the exhalation valve not only when full inhalation suction is applied, but also at normal stage (the mean between inhalation and exhalation—or when no breathing is occurring). This is attained by a yieldable overtravel connection in the valve closing actuator mechanism. For example, in the form shown in Fig. 3, the sponge rubber pad 57 may be compressible sufficiently to provide the required range of overtravel, and may have an elastic loading capacity sufficiently to establish the positive closing of valve 49 at the median (undeflected) diaphragm position and from there to the position of maximum de-

pression under inhalation, shown in full lines. Again, in Figs. 2, 4 and 5, the parts are arranged so that the actuator fingers 55 will engage the valves 49, 49b to positively close them at median diaphragm position, and overtravel is provided for by warping the valve 49 into aperture 51 in Fig. 2, and by bending valve 49b around shoulder 61 in Fig. 5.

I claim:

1. A regulator for controlling flow of breathable gas from a source of such gas under pressure to a fitting that is attachable to a diver's face in communication with his lungs, through an inhalation conduit extending from the regulator to such fitting, and for controlling the escape of expired gas from said fitting into a body of water in which the diver is immersed, through an exhalation conduit extending from said fitting to said regulator, comprising: a casing having an inlet for receiving the compressed gas from said source and an outlet for delivering the gas to said inhalation conduit; a diaphragm cooperating with said casing to define a transfer chamber in communication with said inlet and outlet, through which the compressed gas is metered from said source to said inhalation conduit in response to suction applied to said chamber by the diver's inhalation; a normally closed metering valve controlling the flow through said inlet; means for opening said metering valve in response to inhalation-induced inward movement of said diaphragm; a cover attached to said casing and securing said diaphragm thereto in sealed relation thereto, said cover defining an exhalation chamber and having an opening through which the water will fill said exhalation chamber; a normally open exhalation escape valve supported by said cover within said exhalation chamber; a union extending through the wall of said cover, communicating with said escape valve, and providing for connection of said exhalation conduit thereto; and an actuator attached

to the outer side of said diaphragm, moving therewith and operable, in response to said inhalation induced inward movement of the diaphragm, to mechanically actuate said escape valve to a closed condition; said escape valve being of flexible tubular form, including a normally free flexible outlet end portion; said actuator including a shaft fixed to said diaphragm and projecting axially therefrom and a finger extending laterally from said shaft across said flexible outlet end portion of the escape valve; and a saddle fixed to said cover and positioned to provide a seat against which said outlet end portion is adapted to be pressed by said finger to close said escape valve.

2. A regulator as defined in claim 1, wherein said saddle is of U-shape, defining a notch to receive said outlet end portion, and having a transverse shoulder portion around which said finger is adapted to bend said outlet end portion in order to close said escape valve.

3. A regulator as defined in claim 1, wherein said saddle is of square loop form, defining a central opening into which said outlet end portion is adapted to be indented in order to close the valve.

4. A regulator as defined in claim 1, wherein the saddle includes an imperforate seat portion and the actuator includes a shaft portion secured to the diaphragm and projecting axially therefrom, and a finger projecting laterally from said shaft portion, and a pressure pad carried by said finger and positioned for pressure engagement with said outlet portion of the escape valve, to flatten the same against said seat portion of the saddle.

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