Feb. 22, 1966 C. COLOMBO 3,236,250

APPARATUS FOR CONTROLLING THE GAS DISCHARGE FROM PRESSURE RESERVOIRS FOR BREATHING, PARTICULARLY IN DIVING APPLIANCES

Filed June 1, 1962

3 Sheets-Sheet 1

Fig. 1

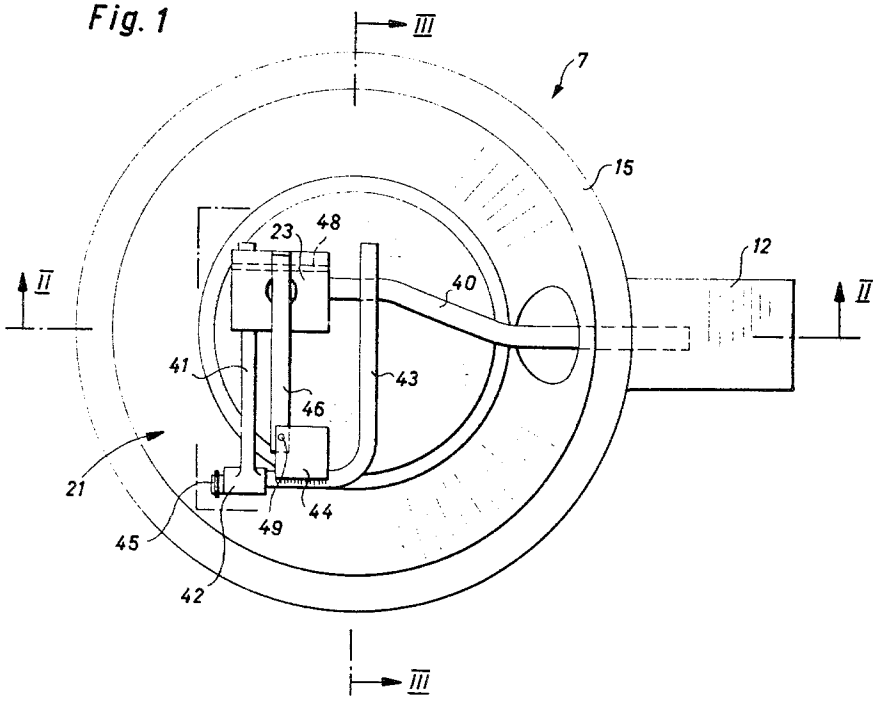
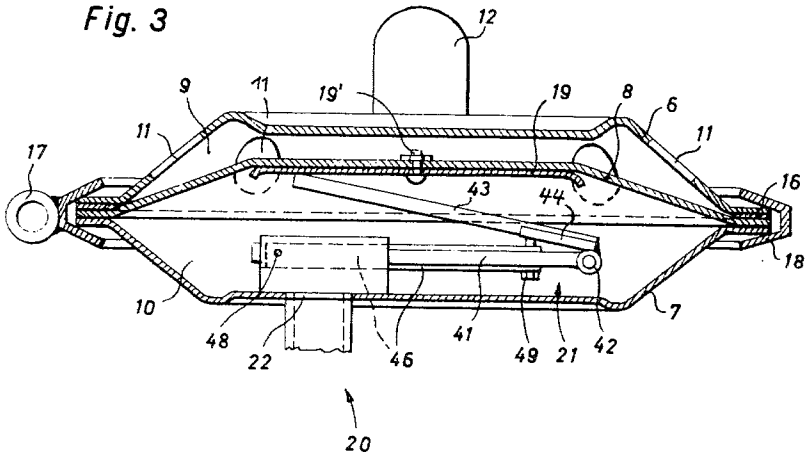


Fig. 3



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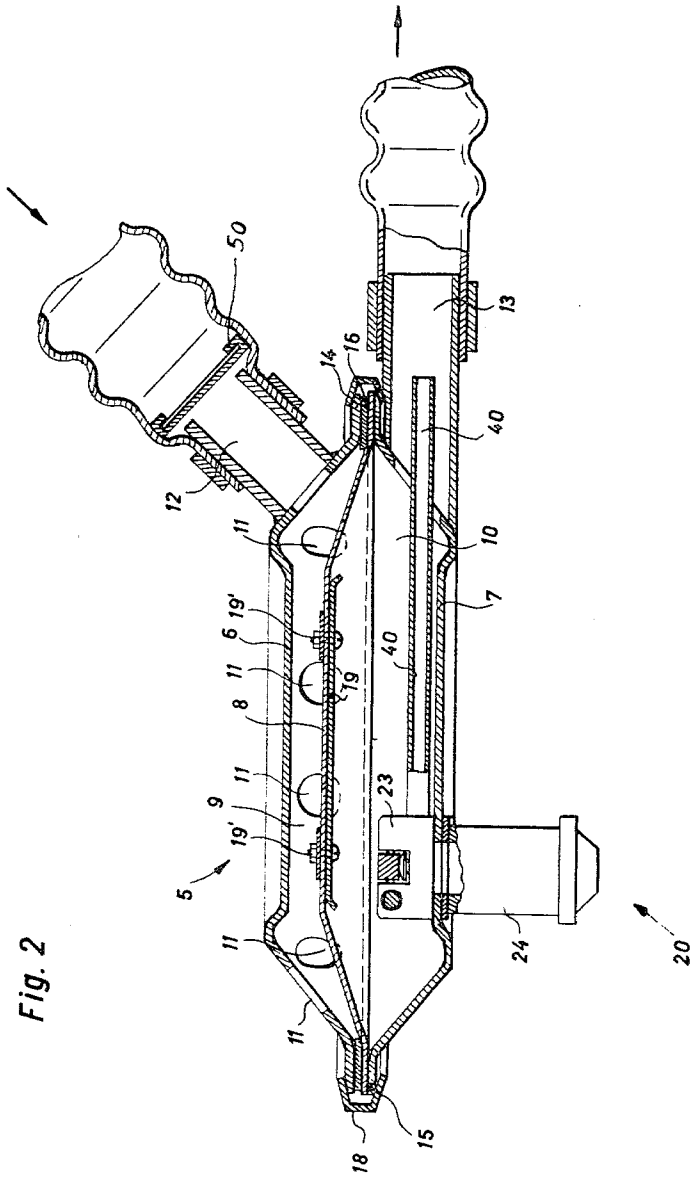


Fig. 2

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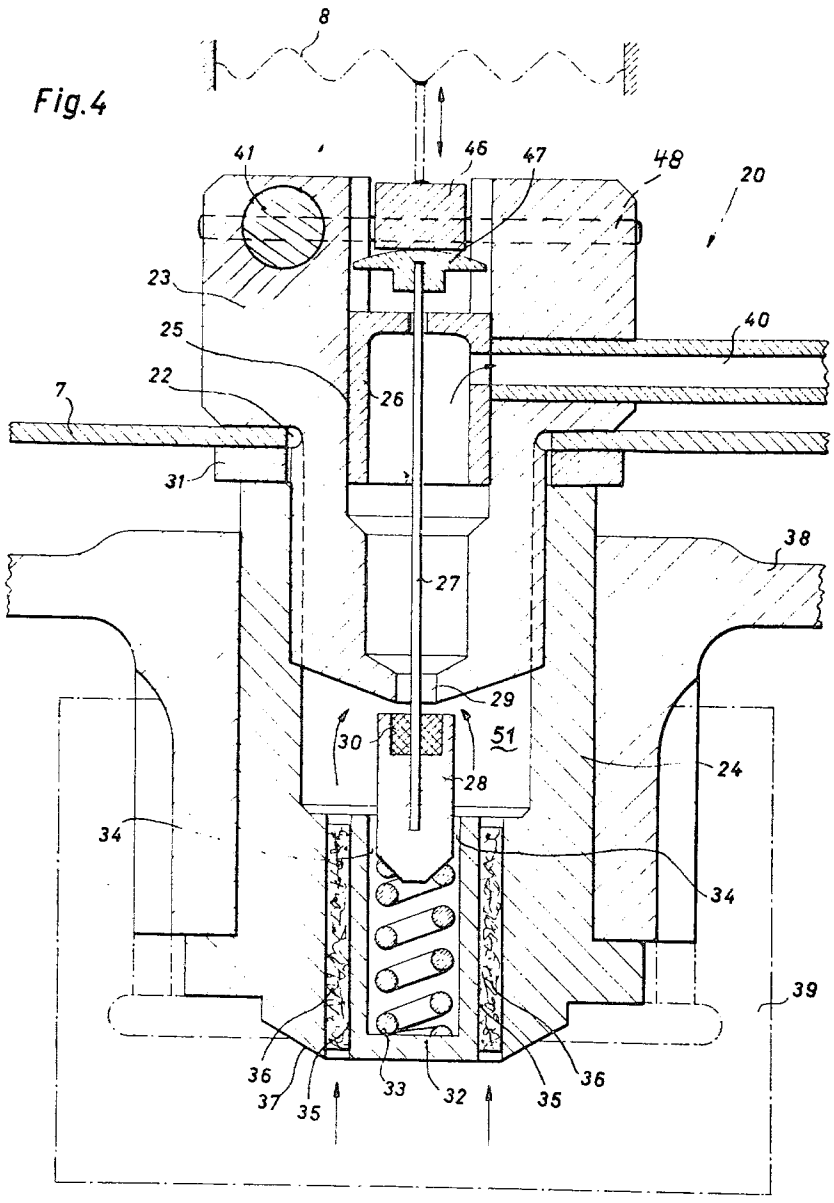
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Fig.4



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APPARATUS FOR CONTROLLING THE GAS DISCHARGE FROM PRESSURE RESERVOIRS FOR BREATHING, PARTICULARLY IN DIVING APPLIANCES

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Claims priority, application Germany, June 5, 1961, C 24,289
3 Claims. (Cl. 137—64)

This invention relates to an apparatus for controlling the gas discharge from pressure reservoirs for breathing, particularly in diving appliances, whereby the gas is led to the user through a mouthpiece controlled by a valve which is located between the pressure reservoir and a gas user and loaded in part by the unthrottled gas pressure, whereby the valve is either opened or closed in dependence on the direction of movement of a diaphragm which separates one space, having therein the medium surrounding the apparatus, from another space communicating with the user, the diaphragm being movably connected with a sealing body whose position determines the valve opening.

In such apparatuses as known heretofore, the gas necessary for breathing is supplied to the diver when he opens the valve by a suction force, i.e. the diver must by sudden suction create such a vacuum on one side of the diaphragm, that the diaphragm moves and the valve is opened. Thereby the valve is only opened during the suction force and the respiratory gas only flows as long as such force is exerted by the diver. As long as the diver exerts a suction force, in the space adjoining the diaphragm and communicating with the user a lower pressure prevails, than the water pressure acting on the outside of the diaphragm. As long as this pressure difference prevails, gas flows to the diver. In prior art apparatuses this pressure difference can only be maintained by the suction force of the diver. Such a control of the gas flow has therefore the following disadvantages:

During the whole inhalation the diver must exert a suction force. With increasing diving depth the respiratory gas in the lungs is more strongly compressed because of the pressure balance. Therefore, in order to be able to fill the lungs with more highly compressed gas, much more gas must flow through the valve when inhaling. But, in order to open the valve wider, a greater suction force must be exerted by the diver. A great suction force may, however, be exerted by the diver for a short time, and this strong suction force renders breathing very difficult and abnormal. If consequently the diver exerts only a slight suction force, the flowing gas in the compressed state does not suffice to fill his lungs, and if the diver exerts a great suction force, he can maintain this for only a very short time; it is very arduous, and with this short intermittent inhaling the lungs are only incompletely filled.

Moreover, in the known apparatuses, the flowing gas acts upon a valve body so as to cause it to be moved more forcibly into a position in which the valve closes. If, consequently, with increasing diving depth, the diver must exert a greater suction force in order to open the valve wider so that the greater need for respiratory gas is covered, a greater force thereby achieved by greater gas flow acts on the valve body in order to close the valve. Against the increasing suction force of the diver to press the diaphragm down, there acts an increasing closing force of the valve to press the diaphragm upwards.

The object of the invention is to provide an apparatus for easier breathing. Thereby the lungs shall be filled entirely, and at great depths breathing shall be as easy as

in the normal atmosphere. In addition, the apparatus shall be simple in construction and not liable to breakdowns. The gas shall thereby flow into the lungs as with a normal breathing movement in such a way that, at the commencement of the breathing, at first a great flow occurs into the breathing organs and then, as the breathing organs gradually fill, the flow is diminished until complete standstill of the gas current, when the lungs are quite full. Therewith the kind of flow shall exactly be adapted to normal breathing and, with increasing diving depth, the gas shall flow at an increased rate.

In accordance with the invention this problem is solved in that the pipe, leading the gas-flow from the valve to the user, together with the space communicating with the user forms a jet apparatus known per se in respiratory appliances, in order to have a gas-flow to the user even at pressure balance of the medium surrounding the apparatus and the gas issuing at the mouthpiece, and that the jet apparatus is put into operation by a suction force and put out of operation by a greater pressure of the gas issuing at the mouthpiece with respect to the pressure of the medium surrounding the apparatus.

A respiratory appliance has, indeed, already been made known, which has an injector. But this device relates to a high-altitude respiratory appliance and is not thought as a diving appliance. In this appliance, according to the principle of the injector, i.e. of a jet apparatus, the rarefield atmospheric air is entrained by a gas jet of a pressure reservoir. However, an acting of the injector in the sense of the instant invention is impossible in that the gas jet, after having entrained the atmospheric air, no longer possesses such a high speed as still to create, in the space adjoining the diaphragm, the vacuum necessary to keep the valve in the open position. Furthermore, the gas jet for entraining the rarefield atmospheric air has already been reduced by an additional pressure-reduction valve, so that the valve to be actuated by the diaphragm is not loaded by the unthrottled gas pressure.

Further features of the invention will appear from the following description and claims, taken in conjunction with the accompanying drawing, wherein there is shown, purely by way of example, one preferred form of embodiment of the control apparatus incorporating the invention.

In said annexed drawing:

FIG. 1 is a top view of the opened diaphragm box;

FIG. 2 shows a sectional view taken on the line II—II in FIG. 1 of the closed diaphragm box;

FIG. 3 shows a sectional view taken on the line III—III of the closed diaphragm box;

FIG. 4 is a longitudinal section through a valve.

A diaphragm box 5 comprises two circular shells 6 and 7. An inner space formed by the two shells is divided by a rubber diaphragm 8 into two chambers 9 and 10, whereby chamber 9 communicates by means of openings 11 with the outside, and by means of a pipe 12 through a conventional one-way valve 50 with a mouthpiece (not shown) of a diving appliance. Through a pipe 12 the used respiratory gases are led in the direction of the arrow to the open via chamber 9 which is filled with water when diving, and the openings 11. Chamber 10 is connected to pipe 13. Through pipe 13 the respiratory gas is conveyed in the direction of the arrow to the diver by means of the aforementioned mouthpiece.

Said diaphragm shells 6 and 7, provided with two beaded rims 14 and 15, are held together by means of U-sectioned annular member 18 with the interposition of a rubber gasket 16 and the diaphragm 8, and sealingly pressed together by means of a screw which extends through an eye 17 (FIG. 3) as passage bore and is screwed into another threaded eye at the other end of

said member. The side of the diaphragm 8 facing chamber 10 has a slide plate 19 fixed thereon by screws 19'.

Chamber 10 accommodates a valve 20 and its actuating members 21. The valve 20 is inserted in an opening 22 of the box shell 7. The casing of valve 20 is constructed in two parts and comprises an insert piece 23 and a cover piece 24. These two parts have a space 51 therebetween. A sleeve 26 inserted in a bore 25 has axially movably guided therein a pushrod 27 with a sealing body 28. Said pushrod is displaced by the movement of the diaphragm 8 by means of the actuating members 21 (FIG. 3). Together with said sealing body, an opening 29 in the insert piece 23 provides the valve seat, with which a choking of the high pressure, as it prevails in the pressure reservoir and space 51, is accomplished. The cylindrical sealing body 28 has inserted therein an annular sealing packet 30, made for instance of a polyamide synthetic material. Said cover piece 24 threadedly engages the insert piece 23 with interposition of a disk 31 and thus holds the valve in place in the bottom of the box shell 7. In a casing 32 open at one side, the sealing body 28 is, with lateral clearance 34, axially slidable against a compression spring 33 which is in series with the sealing body 28 and supported on the bottom of casing 32. If the same pressure prevails in the chambers 9 and 10, the sealing body 28 closes the opening 29 tight by the thrust of the prestressed spring 33. The end of the body 28 designed without longitudinal bore and facing the bottom of the casing 32 open at one side, always communicates through the lateral clearance 34 with the space 51, i.e., whether valve 20 is closed or open.

Within bores 35 which are arranged in the cover piece 24 and through which the unthrottled gas of the pressure reservoir flows, metal wool 36 is brought in to keep out dust. Said bores are disposed substantially parallel to the direction of movement of the sealing body 28. They extend outside and along the casing 32. The cover piece 24 includes a tapered metallic seat 37 which is sealingly engaged by a valve piece 39 (shown dash-dotted) of the pressure reservoir without interposition of a soft gasket. By means of a union 38 arranged to turn on the cover piece 24, the whole diaphragm box 5 is mounted on the valve piece 39 of the pressure reservoir. The reduced gas current flows through the insert piece 23 and a pipe 40 into chamber 10 and pipe 13.

FIGS. 1 and 3 illustrate the actuating members 21 for the sealing body 28. A rod 41, fixed in the insert piece 23, has pivotally mounted in its bearing eye 42 a double-armed lever which is secured against axial displacement by means of a circlip 45. Said lever includes an offset round rod 43 and a lobe 44 welded thereto. The round rod abuts on the slide plate 19 of the diaphragm 8 (FIG. 3). The insert piece 23 has pivotally mounted therein about a bearing pin 48 a one-armed lever 46 adapted to actuate the pushrod 27 through a thrust plate 47. Inserted into the other end of said lever 46 is a setscrew 49 on which the lobe 44 rests.

The action of the control apparatus is as follows:

By means of the setscrew 49 the control apparatus is adjusted in such a way that, for instance, already a pressure of 1 cm. water column on the diaphragm 8 causes same, via actuating members 21, to raise the sealing body 28 from the opening 29 against the action of spring 33, thus allowing gas to flow. Through the dynamic action of the gas flowing through the opening 29, the sealing body 28 is moved against the thrust of spring 33, since the gas flowing through the bores 35 and opening 29 entrains with it in the same direction the gas present in the casing 32, thus reducing the gas pressure in the casing 32. Thereby on the underside of the sealing body 28 a lower gas pressure acts than on the upper side, and the valve is still further opened by the flowing gas. The gas then passes through pipe 40 into chamber 10. This flowing of the respiratory gas from the pressure reservoir into chamber 10 is independent of the gas required by the diver; it continues to flow until the same pressure prevails in the chambers 9 and 10. With increasing depth of the diving appliance under water, the gas thus passes into chamber 10 for increase of pressure, in order to maintain equilibrium with the pressure acting on the diaphragm 8. If the diver wants to breathe, he must produce the slight pressure difference of 1 cm. water-column by one brief suction, and with this pressure gradient from pipe 13 to chamber 10 the gas flows through pipe 40 into pipe 13. Pipe 40 constitutes with chamber 10 a jet apparatus, and the gas flowing out of pipe 40 at a high speed entrains the gas volume from chamber 10. Because of the reduced pressure in chamber 10, the diaphragm acts, via actuating members 21, on the sealing body 28 and keeps the valve open.

By means of the slight pressure difference of 1 cm. water-column between the chambers 10, 9, by brief suction of the diver the flow of gas is started and, assisted by the kinetic energy through the parts 40, 13 and 34, 35 of the gas acting as injector, the valve remains open.

The more gas required by the diver, i.e., the greater the depth of dive, the greater is the pressure in chamber 9 and the more open the valve. But this additionally outflowing gas cannot build up the same pressure by the injector action of the parts 40, 12 in chamber 10 as in chamber 9, so that the diaphragm remains depressed. With valve 20 open and with gas passing through pipe 13 to the diver, the flowing gas can give no pressure balance in the chambers 9, 10, so that with increasing diving depth and increasing pressure in chamber 9 the valve is opened wider.

The gas continues to flow automatically (without suction force of the diver) until in his lungs there prevails a slight overpressure with respect to the water pressure. The valve will only close when, because of the overpressure in his lungs, a pressure surge reacts into the pipe 13 to injector 40, 13.

Because of the injector 40, 13, in chamber 10 a lower pressure prevails than in chamber 9, even if the diver no longer exerts any suction force, i.e. if at the gas outlet of the mouthpiece for the diver and/or in pipe 13 the same pressure prevails as in chamber 9. Further, with increased diving depth, i.e. with increased need of gas, a greater quantity of gas is taken automatically from the pressure reservoir (oxygen bottle). The sealing body 28 of the valve is opened still more by the gas current in the opening 29 and in the gap 34.

As soon as the gas current in pipe 13 is interrupted, say, by closing the respiratory organs, the pressure surge building up in the pipe 13 reacts at once on chamber 10 and causes the diaphragm to move in the closing direction of the valve; the valve is then again closed, and the sealing body 28 is kept closed by the thrust of spring 33 and the force of the body 28 loaded by the unthrottled gas pressure, resulting from the difference in the effective fluid pressure areas of the ends of body 28.

What I claim is:

1. Apparatus for controlling the gas discharge from pressure reservoirs for breathing, particularly in diving appliances, comprising; a valve controlling fluid flow between an inlet adapted for connection with a pressure reservoir and an outlet adapted for connection with a mouthpiece and loaded by the unthrottled gas pressure, a casing with a diaphragm therein defining with said casing expansible chambers on opposite sides of said diaphragm with one chamber communicating with the outlet and the other communicating with ambient pressure, said valve including a movable cylindrical sealing body, said diaphragm being connected with the sealing body for moving same to open and closed positions with respect to a valve seat facing upstream, a pipe leading gas flow from the valve to the outlet and together with said one of said expansible chambers forming a jet assembly to provide a gas flow to a user even at pressure

balance of the ambient pressure and the gas issuing at a mouthpiece, the movable cylindrical sealing body being guided with lateral clearance within a recess formed in said casing, gas conveying passages leading from a pressure reservoir to the valve seat and surrounding said recess and being disposed longitudinally and substantially parallel to the direction of movement of said sealing body, said lateral clearance and passages providing an aspirating structure reducing pressure within said recess upon fluid flow through said apparatus, whereby opening of said valve results in the aspirating structure effecting a reduction of pressure in said recess supplementing the action of the jet assembly to urge the valve to an open position.

2. Apparatus according to claim 1, in which said sealing body is provided with a pocket facing the valve seat together with a sealing member therein so that the cylindrical sealing body may tightly cover the valve seat.

3. Apparatus according to claim 1, in which a one-armed lever and a push rod are operatively supported within the casing and is itself movably associated with

the sealing body by the pushrod, and said lever and push rod being associated with the diaphragm.

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