

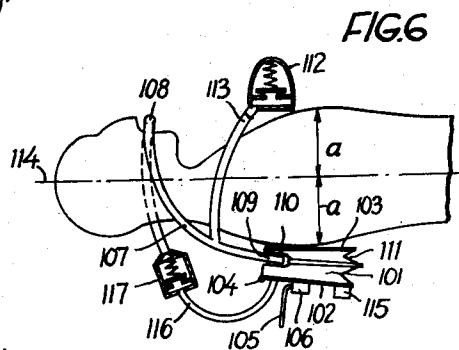
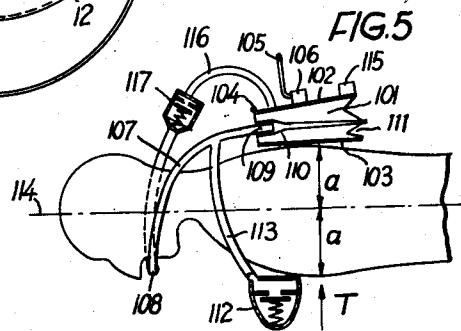
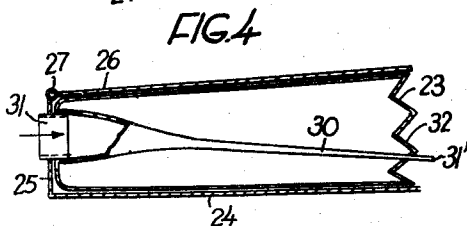
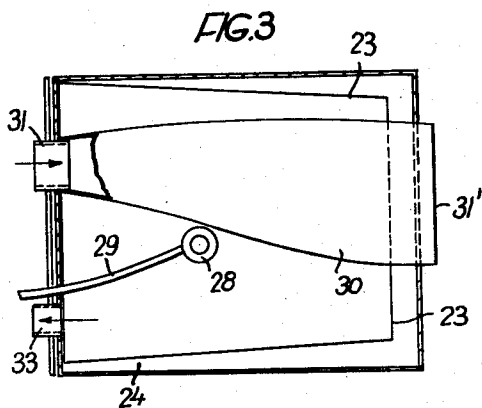
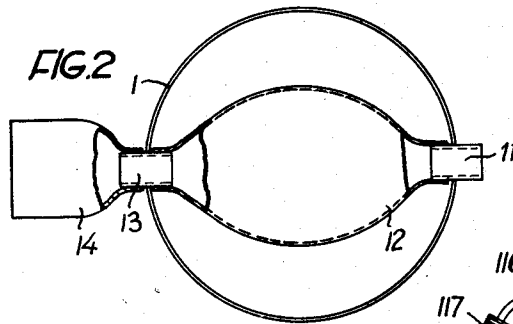
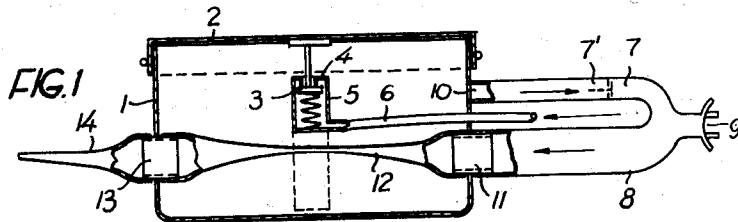
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RESPIRATORS, PARTICULARLY FOR SUBMARINE USE

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RESPIRATORS, PARTICULARLY FOR SUBMARINE USE

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In respirators for submarine use certain difficulties are met with on account of the deleterious varying breathing resistance created in different under water positions depending on the fact that the various parts of the apparatus and the thorax of the diver are at different depths and consequently subjected to different hydrostatic pressures varying relatively to one another.

In respirators for submarine use with a so-called open system, the apparatus consists of a control mechanism connected to a compressed gas container and of an exhaust valve. In breathing the control mechanism admits the requisite quantity of gas into an inhalation channel, the pressure of which gas is reduced at the same time. For the purpose in view a diaphragm valve actuated by the water pressure, generally a so-called demand valve, is made use of.

It is desirable that the demand valve and the exhaust valve be located in the apparatus in a manner such as to be near the lungs of the diver in the service position of the apparatus, in order to be permitted to operate as far as possible under the same pressure conditions as the diver's lungs. In known constructions, the demand and exhaust valves are arranged in different places, by reason of which in certain under water positions a pressure is created on the diaphragm of the demand valve which is greater than the pressure acting on the exhaust valve, gas being then permitted to escape continuously from the demand valve with gas losses in consequence thereto, inasmuch as the gas will then flow from the demand valve to the exhaust valve directly. Endeavours have been made in earlier constructions to avoid this drawback making the exhaust valve so as to open only at a certain overpressure, which is adapted by means of springs or the like so as to precisely exceed the maximum pressure difference that may set in between the demand valve and the exhaust valve. This, however, involves the disadvantage of an increased expiration resistance.

The object of the present invention is in respirators of the type in question to arrange the control mechanism and the exhaust valve so that the drawbacks touched upon will be obviated. To this end the exhaust valve is loaded, according to the invention, with a closing pressure, which is the same as the pressure prevailing in the gas chamber of the gas control mechanism. Since the gas control mechanism consists of an inlet valve for the compressed gas arranged in a diaphragm box, this may be attained in the simplest possible manner by incorporating the exhaust valve into the diaphragm box. According to another embodiment of the invention, however, the exhaust valve may instead be arranged in a chamber which is in open communication with the gas chamber of the gas control mechanism.

The invention refers also to an application, in which, irrespective of the position of the diver in the water—for instance a back position or a breast position—the expiration air is admitted to escape against the same pres-

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sure as or a lesser pressure than that resting on the diver's thorax, in spite of the pressure difference existing between the breast side and the back side of the diver in his horizontal swimming position. In this application the apparatus is provided with two exhaust valves connected to the expiration channel of the apparatus, one of which is intended to be arranged on the breast side of the diver and the other on the diver's back side, said valves being loaded with closing pressures of such magnitude that the expiration gas is caused to escape through said valves against a pressure, which is approximately equal to or lesser than the water pressure resting on the thorax of the diver. One of the exhaust valves may be that one which is generally arranged in the gas control mechanism through which the respiration gas enters from the container of compressed gas, whereas the other is constituted by an additional exhaust valve arranged on the opposite side of the body. The expiration air escapes always through that one of these valves in which the resistance is the least, that is to say, generally the valve taking the highest position in the water, where the water pressure is consequently the least. The additional exhaust valve is constructed so as to open only at an overpressure relatively to the ambient water which is adapted to the greatest pressure difference that may set in between any part of the remainder of the gas system and the additional exhaust valve.

A few examples of applying the invention will be described in the following with reference to the accompanying drawing, in which the invention is illustrated through a few diagrammatic figures. Fig. 1 shows a first embodiment in an axial section through a diaphragm box, and Fig. 2 shows a plan sectional view through the diaphragm box in this embodiment. Another embodiment is shown in Figs. 3 and 4 in two sections at right angles to each other. Fig. 5 illustrates the diver in his breast position and with the special embodiment of the invention, and Fig. 6 shows his back position, the main parts of the apparatus being indicated in a central sectional view.

In the embodiment according to Figs. 1 and 2, the control mechanism is taken to comprise a conventional demand valve. The diaphragm box is designated by 1 and the diaphragm thereof by 2. Reference numeral 3 denotes the valve body connected to the diaphragm 2 and cooperating with the seat 4 in the valve housing 5 of the inlet valve, in which compressed gas is supplied to the diaphragm box through a supply conduit 6 connected to a container of compressed gas. An inhalation tube 7 with a non-return valve 7' and an expiration tube 8 are connected to a respiration nozzle 9. The inhalation tube 7 is connected to an opening 10 in the wall of the diaphragm box, and the expiration tube 8 is connected to a pipe socket 11 in the same wall. The exhaust valve is in this case built into the diaphragm box. It consists of a soft-walled flattened tube 12 for instance from rubber, one end of which is slipped over the pipe socket 11, while its other end is connected to a pipe socket 13, which is preferably arranged diametrically opposite the pipe socket 11 in the wall of the diaphragm box. The pipe socket 13 projects outwardly on the outside of the diaphragm box, and the projecting part has arranged thereon a non-return valve 14, which in the construction shown is taken to consist of a so-called duck nib valve from rubber or other suitable material.

The mode of operation of the embodiment described is broadly as follows. When inhalation takes place through the tube 7 and the nozzle 9, the compressed air valve 3 is opened by the diaphragm 2 then bulging somewhat inwardly. On the other hand, no water is permitted to enter, inasmuch as this is prevented by the non-return valve 14, which is kept closed by the water

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pressure. When expiration takes place through the nozzle 9 and the tube 8, the valve 3 is first automatically closed by reason of the resiliency of the diaphragm 2, and then non-return valve 7' prevents the expiration air from flowing through the tube. In the expiration tube, and thus also in the lungs, the pressure need only exceed the gas pressure of the box 1 acting on the walls of the valve 12 and the water pressure resting on the valve 14 to cause the expiration air to escape through the valve 14. This does not involve any difficulties in the construction shown, when the lungs are at a greater depth than the valve. These operating conditions prevail in the control mechanism even if the pressure in the diaphragm box is altered relatively to the pressure of the ambient water through loading with a weight or spring.

The exhaust valve may be built into a bladder or sack instead of being arranged in a diaphragm box. A particularly suitable construction may be obtained, if the bladder or sack is formed as a bellows in the manner shown in Figs. 3 and 4.

As shown in Figs. 3 and 4, a bladder or sack is formed with three bellows-shaped sides 23, while it is secured on the other sides on a pair of flaps, one of which 24, 25 is formed by an angularly bent plate covering the bottom (24) and the one side wall 25 of the sack, while the other flap 26 is connected to the upper edge of the lastmentioned side wall by means of a pivot 27 so as to be permitted to move toward and from the flap 24. Provided on the flap 26 is an inlet valve 28 for compressed gas or air supplied through a pipe 29. The exhaust valve has the shape of a duck nib valve 30 having its inlet end connected to a socket 31 in the wall 25 and its opposite flattened outlet end 31' projecting through the bellows wall 23. The duck nib valve is preferably made from soft rubber and is, for instance by vulcanization, secured tightly in a projecting fold 32 of the bellows wall 23. The bellows folds are large enough to cause the bellows walls to maintain their bellows-shape in all operating positions of the flaps. Connected to the socket 31 is an expiration tube, and connected to a second socket 33 arranged in the wall 25 is an inhalation tube, said tubes being united in a nozzle in the manner shown and described in connection with Fig. 1.

The mode of operation of the embodiment shown in Figs. 3 and 4 is broadly as follows:

When breathing air passes at expiration through the socket 31 into the exhaust valve 30, the pressure of the expiration air need only just exceed the outside pressure in the sack 23 to cause the valve 30 to open. For example, if at inhalation lower pressures are created in the sack 23 and thus in the valve 30 than in the water surrounding the sack, the water is prevented from penetrating into the valve 30, because the flattened end 31' of the valve 30 and the fold 32 act as a non-return valve. To permit the expiration air to escape from the valve 30, the pressure in the ambient water must be overcome.

In the construction shown in Figures 5 and 6, the apparatus consists of a bellow-shaped bladder or sack 1 with stiff walls on three sides, the same forming two flaps 2, 3, which are pivotally connected to each other by means of a hinge 4. Compressed gas is supplied to the bladder through a tube 5 and an inlet valve 6, which dispenses gas in suitable proportions. An expiration tube 7 from a nozzle 8 opens into the bladder through a socket 9, to which is connected an exhaust valve 10 built into the bladder, said valve taking the form of a so-called duck nib valve. This valve, which in principle consists of a tubular piece of rubber or other elastic material flattened toward its outlet end, opens with this outlet end outside the bellows wall 11 of the bladder through a fold in said wall. Arranged on the stiff wall 2 of the bladder is a weight 15, which by its action on the flap 2 increases or decreases the pressure in the bladder by a force that compensates for the difference in the static pressure of

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the water on the bladder in the breast position (Fig. 5) on one side and in the back position (Fig. 6) on the other side.

Connected to the expiration tube 7 or optionally to the bladder 1 directly, through a tube 13 is a second exhaust valve 12. This valve may consist of a spring-actuated diaphragm valve. The tubes 7 and 13 are in open communication with one another. The expiration air may consequently escape either through the exhaust valve 10 or through the exhaust valve 12 and then chooses the path offering the least resistance. Extending between the nozzle 8 and the bellows 1 is an inhalation tube 16 with a non-return valve 17.

In Figures 5 and 6 of the drawing, the average level of the diver's lungs in breast position as well as in back position is indicated by a chain-dotted line 14. The thickness of the diver's thorax is denoted by 2a cm. and the static pressure of the water on the bellows 1 in breast position (Fig. 5) by A.

In breast position of the diver, the bellows 1 is acted upon by a pressure of A cm. water column. The pressure in the diver's lungs is higher, however, depending on the pressure-compensating weight 15. Thus it amounts to (A plus 2) water column. The same pressure (A+a) acts on the exhaust valve 10 located in the bellows. The exhaust valve 12, which is at a 2a cm. greater depth than the bellows 1, is acted upon by a water pressure of (A plus 2a). Against the expiration is here added the pressure T on the spring of the exhaust valve 12; in other words, the diaphragm of the valve is acted upon by a pressure of (A plus 2a plus T) cm. water column.

The expiration air escapes through that one of the exhaust valves 10, 12 which is acted upon by the lowest pressure, that is to say, through the valve 10, where the pressure was (A plus a). The same average pressure prevails in the diver's lungs, which thus only have to overcome an immaterial resistance for expiration.

In the back position of the diver (Fig. 6), a pressure of (A plus 2a) cm. water column prevails on the bellows 1, and the same water pressure acts at the outlet opening of the valve 10. The pressure is less within the bellows, because the weight 15 now acts in the opposite direction, that is to say with a reducing effect on the pressure. The pressure in the bellows constitutes (A plus 2a minus a) = (A plus a) cm. The pressure (A plus a) also prevails in the lungs, and the valve 12 is acted upon by the pressure A plus T. The pressure of the expiration air must not exceed the pressure in the lungs, that is to say A plus a, for which reason the spring pressure T shall be equal to or somewhat higher than a cm. water column. The pressure in the bellows 1 must not exceed A plus T, for in that case gas would flow continuously out of the apparatus.

In back position, the expiration air also escapes through the uppermost exhaust valve, that is to say the valve 12 in this case, where the pressure is lower than in the lowermost valve. Obviously, the spring pressure T may be adapted so that the expiration resistance in back position becomes equal to or approximately equal to the resistance in breast position.

It has been assumed in the foregoing that the average level 14 of the lungs is midway between the valves 10 and 12, that is to say at the same distance from both of these valves. If the distance to one of the valves is greater, the spring pressure T should be adapted in consideration of this fact, so that it becomes equal or approximately equal to the difference in water pressure at the level of the lungs and the level of that one of the exhaust valves which is at the greatest distance from the average level in the back position or breast position of the diver.

The invention is not limited to the construction shown, which only relates to an example. For example, the bellows contrivance may be replaced by a diaphragm valve, for instance by a so-called demand valve; into the diaphragm box of which an exhaust valve of the same

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type as that designated by 10 or a similar valve may be incorporated. Certain embodiments of the invention can be modified for use also in smoke diving apparatus.

What we claim is:

1. In respirators an arrangement comprising a diaphragm box forming a gas chamber, an inlet valve for admitting compressed inhalation gas into said chamber in dependence upon the pressure in said chamber, an expiratory conduit with flexible walls passing through the chamber, said conduit forming an exhaust valve exposed to the gas pressure prevailing in the gas chamber.

2. A gas control apparatus for respirators for submarine use, comprising a diaphragm box including a gas chamber, an inlet valve for compressed inhalation gas controlled by the diaphragm of said diaphragm box, an exhaust valve for expiratory gas comprising a flattened hose passing through said diaphragm box so as to be exposed to the gas pressure prevailing therein, a non-return valve mounted outside the diaphragm box on the outlet end of said hose, an inhalation tube communicating with said gas chamber and an expiration tube connected to the inlet end of said hose.

3. An apparatus for respirators for submarine use, comprising a bellows having at least two stiff walls, said bellows forming a gas chamber, an inlet valve for compressed aspiration gas opening into said gas chamber, and an exhaust valve formed by a flexible conduit having an inlet end and an outlet end and extending through one stiff wall and passing said gas chamber and through a bellows fold at its outlet end, said outlet end forming a non-return valve adapted to open into the ambient water, but preventing water to flow into said conduit.

4. An apparatus for respirators for submarine use comprising an inlet valve for inhalation gas, an exhaust conduit for expiration gas and two exhaust valves communicating with said exhaust conduit, means for mounting one of said exhaust valves on the diver's breast side, the other of said exhaust valves being adapted to be mounted on the diver's back side and means to load said exhaust valves with closing pressures permitting expiration gas to escape through said valves against pressures, approximately equal

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to or lower than the water pressure resting on the thorax of the diver.

5. An apparatus for respirators for submarine use comprising an expiration conduit, a bellows communicating with the expiration conduit, an inlet valve for inhalation gas opening into said bellows, an exhaust conduit for expiration gas, two exhaust valves communicating with said exhaust conduit, means for mounting one of said exhaust valves on the breast side and the other exhaust valve on the back side of the diver, one exhaust valve being mounted in said bellows, said valve comprising means to load them with closing pressures permitting expiration gas to escape through the valves against pressures approximately equal to the water pressure residing on the thorax of the diver.

6. An apparatus as claimed in claim 5, in which the bellows comprises means to compensate for the difference in water pressure at the level of the exhaust valve mounted therein and that prevailing at the level of the diver's lungs.

7. An apparatus for respirators for submarine use comprising an expiration conduit, a bellows communicating with the expiration conduit, an inlet valve for inhalation gas opening into said bellows, an exhaust conduit for expiration gas, two exhaust valves communicating with said exhaust conduit, means for mounting one of said exhaust valves on the breast side and the other exhaust valve on the back side of the diver, one exhaust valve being mounted in said bellows, means to compensate for the difference in water pressure at the level of the exhaust valve mounted in the bellows and that prevailing at the level of the diver's lungs, the other exhaust valve being loaded with a spring force equal to or immaterially greater than the difference in water pressure at the level of the diver's lungs and the level of said other exhaust valve.

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