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(54) Lung-controlled respiratory device

(57) A respiratory protective mask (1) operating at superatmospheric pressure has a lung-controlled valve (2) for controlling the supply of compressed air from a supply line (3) to the mask (1). The valve (2) includes a diaphragm (5) movable by changes in the pressure in the interior (7) of the mask (1). The movement of the diaphragm (5) causes a pivoting lever (9) to pivot which in turn causes a piston (11) to slide in its guide cylinder (27). The piston (11) has an opening (13) which allows compressed air from the supply line (3) to enter the mask (1) when the piston (11) is at the mid-point of its movement but which prevents compressed air from entering the mask (1) when the piston (11) is at either of its two end positions. Thus, when the mask (1) is not being worn, loss of compressed air is prevented due to the fact that the piston (11) is at an end position so preventing compressed air from entering the mask (1). However, when the mask is put on, the pressure generated in the interior (7) of the mask (1) when the user exhales moves the piston (11) from the end position and thus allows compressed air to enter the mask (1) from the supply line (3). When pressure builds up further, the piston moves to its other end position and the air is again cut off.

Fig. 1.

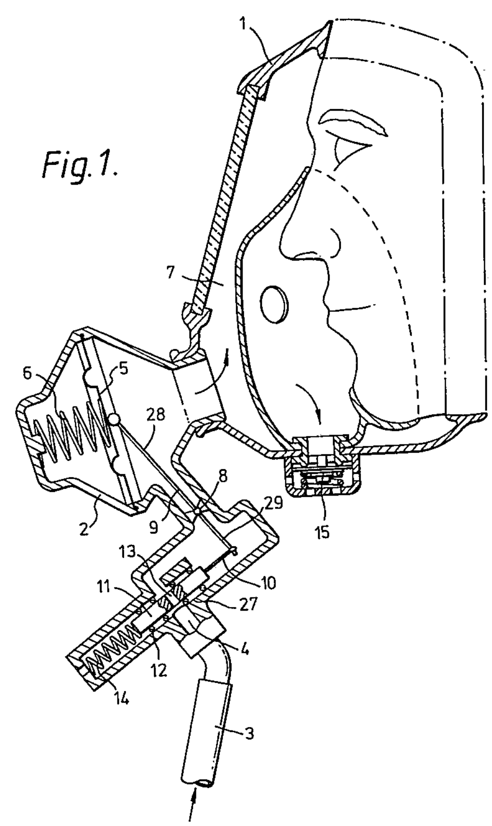

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Fig.1.

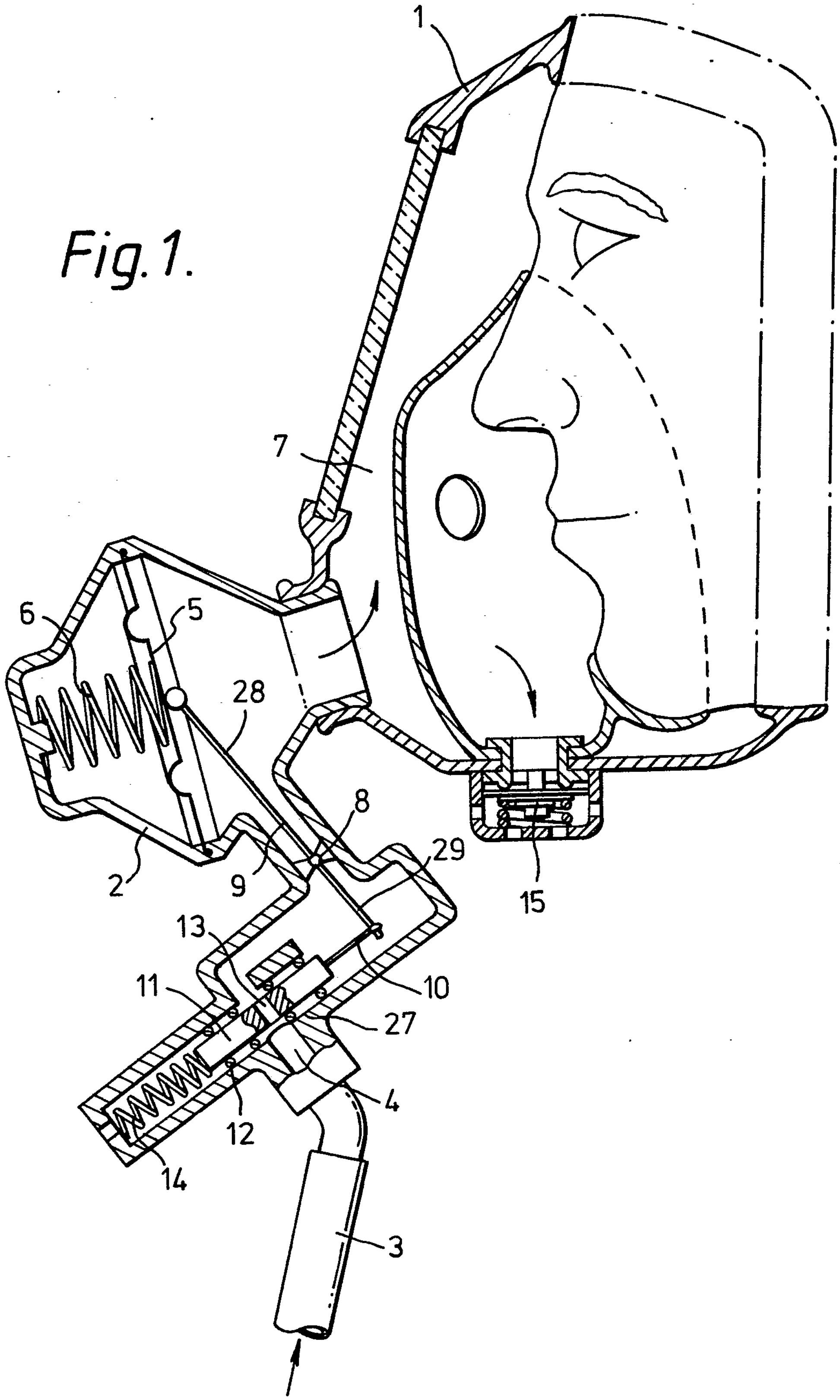


Fig. 2.

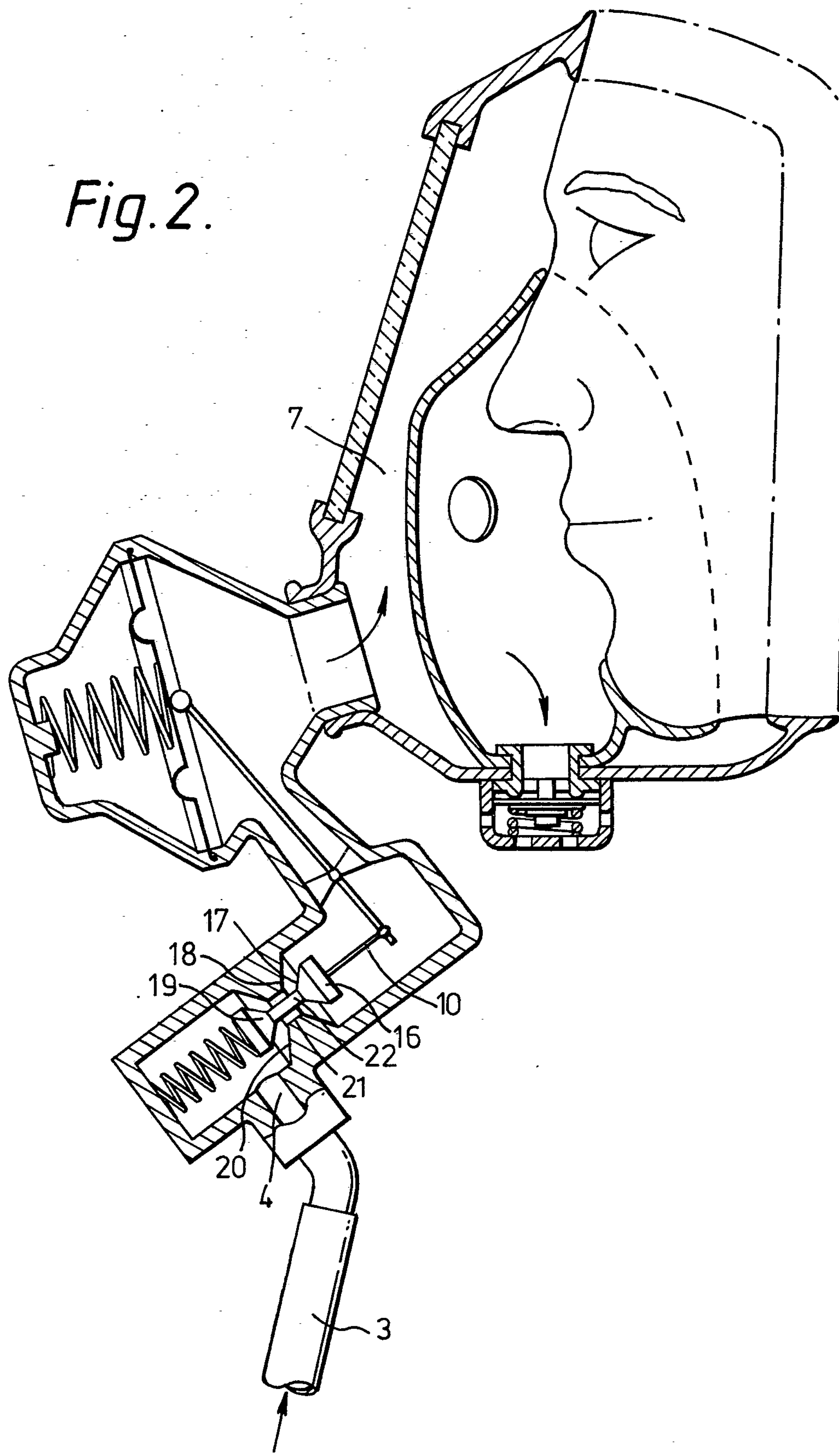
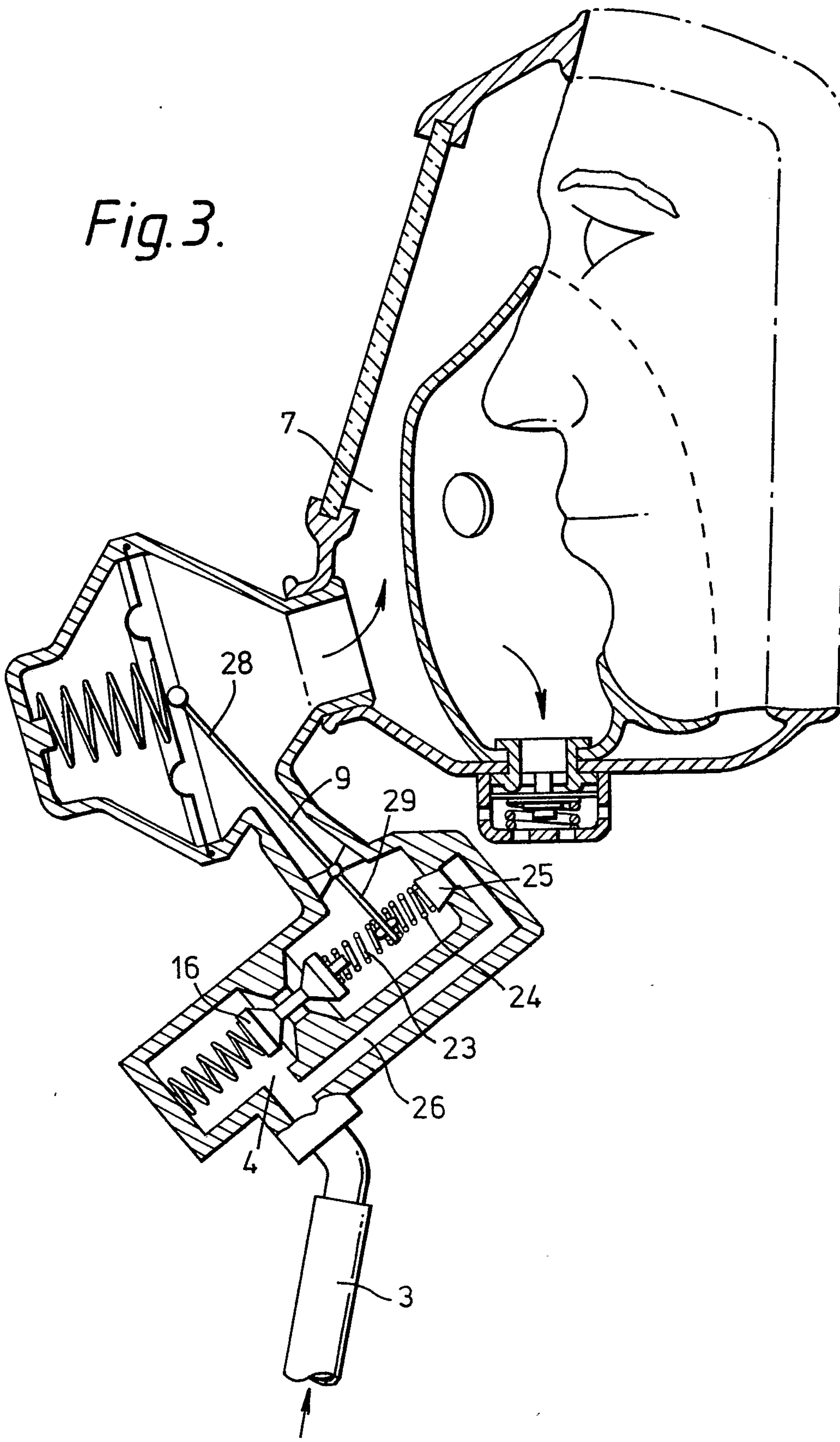


Fig. 3.



SPECIFICATION

Lung-controlled respiratory device

This invention relates to a lung-controlled compressed gas respiratory protective device which operates at superatmospheric pressure.

In the compressed gas respiratory protective devices which operate at superatmospheric pressure, a superatmospheric pressure prevails in the device during exhaling as well as during inhaling. This superatmospheric pressure prevents, in all circumstances during use, the infiltration of the surrounding atmosphere, which could possibly be dangerous, into the respiratory mask. In the event of a leakage, gas always passes from the interior towards the exterior. All known devices necessarily have the disadvantage that when the device is removed from the user, i.e. when the respiratory circuit is opened, the respiratory gas supply container must be closed (or the function of the automatic lung must be switched over), as otherwise the respiratory gas flows out and therefore the utilisation time is shortened.

A known lung-controlled compressed air respiratory device which operates at superatmospheric pressure is disclosed in German Offenlegungsschrift No. 2,620,170. This device has a lung-controlled valve the closure element of which is actuated by a pivoting lever which in turn is actuated by a control diaphragm which is acted upon from the outside by recirculated air and from the inside by the internal pressure in the device. The movement of the control diaphragm is limited by a longitudinally travelling spacing pin, guided along from the control area towards the outside. The spacing pin is urged by a compression spring against an eccentric lever opposite the control diaphragm in such a way that the pin, in the closed position, holds the control diaphragm in a position in which the valve is closed by the pivoting lever, and, in the open (superatmospheric pressure) position, allows movement of the control diaphragm. In the closed position in which the eccentric lever points upwards and the valve is open, there is no unnecessary out-flow of respiratory gas even when the respiratory mask is removed by the wearer or when large leakages arise. In the superatmospheric pressure position in which the eccentric lever points downwards, the respiratory gas flows and the desired superatmospheric pressure builds up in the respiratory mask. The superatmospheric pressure position comes into operation again from the closed position when the respiratory mask is put on with a deep intake of breath by the user, due to automatic turning downwards of the eccentric lever. In spite of this, it is a disadvantage that, when the respiratory mask is removed, the eccentric lever must be turned manually from the superatmospheric pressure position to the closed position. If the user fails to do this, respiratory gas is lost.

A circulatory-respiratory protective device which operates at superatmospheric pressure is disclosed in "Prospect" BP-0878, Biomarine Industries Inc. This device requires an act of will in order to avoid unnecessary respiratory gas loses. In this device, the respiratory gas flows from a respiration bottle via an inhalation tube and an inhalation valve to a respiratory protective mask. Exhaled gas returns, via an exhaling tube, an exhaling valve and a CO_2 absorber, to the respiratory bottle. In order to produce a superatmospheric pressure, the respiratory bottle is acted upon from the outside by a spring. Oxygen is continuously and additionally fed from an oxygen bottle into the respiratory bottle through a demand valve by way of a pressure-reducing device. The demand valve is controlled by the movement of the respiratory bottle, resulting from the respiratory gas movement. The demand valve opens with the deflation of the respiratory bottle and closes when the bottle is inflated. Before the respiratory protective device is removed from the wearer, the bottle valve must be closed. If the wearer fails to do this, then there is a large loss of oxygen as, when the respiratory circuit is opened (which occurs when the respiratory mask is removed or when a large leakage occurs) the superatmospheric pressure falls, the respiratory bag is compressed by the external spring and the demand valve is opened, and the oxygen can flow.

It is desirable to provide compressed gas respiratory devices and circulatory respiratory devices which have a lung-controlled valve such that, when the devices are not being worn, the flow of respiratory gas (when the valve of the container supplying respiratory gas to the device is open) is automatically prevented, yet the devices are ready for use.

According to the present invention, there is provided a respiratory device which operates at superatmospheric pressure, the device including an inlet through which in use compressed respiratory gas is supplied to the device and a closure means displaceable from a first end position (whereat it closes the inlet) to a second end position (whereat it closes the inlet) via an intermediate position (whereat it opens the inlet), the closure means being displaceable from the first end position to the second end position and vice versa by means of a pivotally-mounted lever which in turn is displaceable by means of a diaphragm whose position is dependent upon the pressure in the device.

In a preferred embodiment, the closure means comprises a piston having an opening therethrough, which opening overlaps with the inlet in the intermediate position and which opening does not overlap with the inlet in the end positions. Preferably, the piston is displaceable within a guide cylinder therefor the guide cylinder having therein seal members which form a seal between the cylinder and the piston.

In another preferred embodiment the closure means comprises a piston having a cone at each of its two ends, one of the cones bearing against a first conical seat when the piston is at one end position and the other of the cones bearing against a second conical seat when the piston is at the other end position.

In another preferred embodiment, the device further comprises a by-pass line connecting the inlet to the device and by-passing the closure means, the by-pass being provided with a closure member, each of the closure member and the closure means being connected to the pivotally-mounted lever by spring means whereby, in the event that the wearer of the device inhales sufficiently deeply to cause the closure means to close the inlet, the closure member can open to allow compressed respiratory gas to enter the device along the by-pass line.

The device of the invention may be used in a compressed air respiratory device or a circulatory device. Thus, for example, the device of the invention may be used in a circulatory device such as a compressed air respirator, the device of the invention, rather than being disposed directly on the mask, being disposed in the respiratory circuit and being connected in parallel to the respiratory bag. In this case, the construction of the device of the invention may be the same as its construction when used in a compressed air respirator. Furthermore, for example, the device of the invention may be disposed in an oxygen circuit such that the wall of the respiratory bag acts as the diaphragm.

For a better understanding of the invention, reference will now be made, by way of example, to the accompanying drawings each of Figures 1 to 3 of which is a sectional view of a device of the invention.

Figure 1 shows a lung-controlled valve 2 connected to a respiratory protective mask 1 of a compressed air protective device. The mask 1 is supplied with respiratory gas by way of a supply line 3 connected to the outlet of a pressure-reducing device (not shown), the respiratory gas being supplied to an inlet 4. Inside the lung-controlled valve 2, one side of a control diaphragm 5 is acted upon at atmospheric pressure by a spring 6. The other side of the diaphragm 5 is acted upon by pressure in the interior 7 of the mask 1. One arm 28 of a pivoting lever 9, swivel-mounted in a pivot 8, bears against the diaphargm 5, while the other arm 29 of the lever 9 is connected to a closure piston 11 by means of a rod 10. The piston 11 is sealed with seals 12 in its guide cylinder 27, and in one position connects the inlet 4 with the interior of the lung-controlled valve 2, by means of an opening 13. A spring 14 acts on the piston 11 and holds the arm 28 in contact with the diaphragm 5. The mask 1 has an exhaling valve 15 to the outside atmosphere.

The device shown in Figure 1 operates as follows.

(1) In the preparatory state, the closure valve of a supply device for supplying compressed air to the respiratory device is opened, the mask 1 not being worn by the user so that, in the interior 7 of the mask, ambient pressure prevails. The pressure is released from spring 6 and the diaphragm 5 is displaced to its inward end position. Thus, the piston 11 is forced by the lever 9 against the spring 14 so as to close the inlet 4 and so as to interrupt the respiratory gas stream.

(2) For the supply of the respiratory gas stream after the mask 1 has been put on, the wearer breathes out so that a superatmospheric pressure is attained in the interior 7 of the mask. The exhaling valve 15 does not open until a superatmospheric pressure of about 7 mbar exists; when the pressure is less, it remains closed. Accordingly, the diaphragm 5 is forced outwardly and the spring 6 is compressed. The piston 11 is correspondingly displaced from its (first) end position by the spring 14. When the superatmospheric pressure in the interior 7 of the mask reaches about 0.5 mbar, the opening 13 reaches the inlet 4 and the supply of respiratory gas begins. The respiratory gas raises the superatmospheric pressure in the interior 7 of the mask, and with a further movement of the piston 11, brings about firstly an increasing overlap and then a decreasing overlap between the opening 13 and the inlet 4. When the superatmospheric pressure in the interior 7 of the mask reaches about 6.5 mbar, the opening 13 in the piston 11 is cut off from the inlet 4 and the respiratory gas stream is interrupted, the piston 11 then being in its other (second) end position.

(3) During inhalation, a decrease in the superatmospheric pressure in the interior 7 of the mask occurs. Due to the related inward movement of the diaphragm 5, the piston is displaced from its second position to its first end position, this allowing the respiratory gas stream to enter the mask. Thus, with full overlap between the opening 13 and the inlet 4, the respiratory gas stream is sufficient to replenish the largest amounts inhaled and any losses through normal leakages. When inhalation ceases, the piston has attained again its second end position. Upon exhalation, the exhaling valve 15 opens when a superatmospheric pressure in the interior 7 of the mask of above about 7 mbar is attained, and the exhaled respiratory gas escapes into the atmosphere. The piston 11 remains in the second end position during this exhalation.

(4) When the mask is removed from the wearer, the superatmospheric pressure in the interior 7 of the mask is released. By displacement of the diaphragm 5, the piston 11 is forced quickly from its second end position to its first end position, whereby the respiratory gas stream is interrupted. The preparatory position is therefore reattained.

The device shown in Figure 2 is silimar to that previously described, except that a double-cone piston 16 is used as the closure device. In the first end position of piston 16, cone 17 thereof bears against seat 18. In the second end position of the piston 16, cone 19 thereof bears against seat 20. The largest respiratory gas stream results from a symmetrical middle position of the piston 16, in which position the respiratory gas from the inlet 4 flows through the annulus between cylindrical surface 21 and shaft 22 into the interior 7 of the mask.

The device shown in Figure 3 is similar to that shown in Figure 2. However, the double cone piston is connected to lever 9, not via the rod 10, but via a coupling spring 23. The lever 9 is also connected, by means of a valve spring 24, to a valve 25 which closes a by-pass line 26 from the inlet 4. This construction is intended for respiratory protection of the wearer when the wearer is carrying out physically strenuous work. Thus, the annulus around the double-cone piston 16 is chosen for a normal respiratory gas throughflow. If, during heavy work, particularly deep intakes of breath occur so that the double-cone piston 16 reaches its first end position, then further lowering of the pressure in the interior 7 of the mask occurs as a result of inhalation, the valve 25 opens and the additional respiratory gas necessary flows via the by-pass line 26 into the interior 7 of the mask 7. When pressure returns to a normal demand for respiratory gas, the device again operates automatically with constant superatmospheric pressure in the interior of the mask.

It can be seen from Figures 1, 2 and 3 that, when the devices are not being worn and when compressed air is being supplied along line 3, any unnecessary outflow of respiratory gas is prevented. Nevertheless, the devices are able to be used again for respiration when put on. When the devices are removed from the user, the lung-controlled valve is automatically closed. When the devices are put on, the lung-controlled valve is opened by the pressure which is generated when the wearer exhales, and the required superatmospheric pressure is maintained by the action of the piston. A further advantage of the device shown in Figure 3 is that, because of the larger amounts of respiratory gas supplied to the device, it is possible for the wearer to carry out physically strenuous work.

CLAIMS

1. A respiratory device which operates at superatmospheric pressure, the device including an inlet through which in use compressed respiratory gas is supplied to the device and a closure means displaceable from a first end position (whereat it closes the inlet) to a second end position (whereat it closes the inlet) via an intermediate position (whereat it opens the inlet), the closure means being displaceable from the first end position to the second end position and vice versa by means of a pivotally-mounted lever which in turn is displaceable by means of a diaphragm whose position is dependent upon the pressure in the device.

2. A device as claimed in claim 1, wherein the closure means comprises a piston having an opening therethrough, which opening overlaps with the inlet in the intermediate position and which opening does not overlap with the inlet in the end positions.

3. A device as claimed in claim 2, wherein the piston is displaceable within a guide cylinder therefor, the guide cylinder having therein seal members which form a seal between the cylinder and the piston.

4. A device as claimed in claim 1, wherein the closure means comprises a piston having a cone at each of its two ends, one of the cones having a cone at each of its two ends, one of the cones bearing against a first conical seat when the piston is at one end position and the other of the cones bearing against a second conical seat when the piston is at the other end position.

5. A device as claimed in any of claims 1 to 4, further comprising a by-pass line connecting the inlet to the device and by-passing the closure means, the by-pass being provided with a closure member, each of the closure member and the closure means being connected to the pivotally-mounted lever by spring means whereby, in the event that the wearer of the device inhales sufficiently deeply to cause the closure means to close the inlet, the closure member can open to allow compressed respiratory gas to enter the device along the by-pass line.

6. A device as claimed in claim 1, substantially as hereinbefore described with reference to, and as shown in, any of Figures 1 to 3 of the accompanying drawings.

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