

PATENT SPECIFICATION

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(54) PRESSURE CONTROL VALVE

(71) We, SUBMARINE AND SAFETY ENGINEERING LIMITED, a British company, formerly of Daux Road, Billingshurst, Sussex, now of Industrial Estate, Bognor Regis, Sussex, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to pressure control valves and is particularly, though not exclusively, concerned with demand valves for breathing apparatus.

15 In breathing apparatus, demand valves are commonly operated by a diaphragm to meter the breathing gas to the user's face mask or other supply space. The diaphragm is arranged to be moved in one direction upon inspiration and in the other direction upon expiration by the user. The diaphragm is generally connected with the demand valve by a system of levers having a high mechanical advantage. It has been 20 proposed to replace the mechanical linkage between diaphragm and valve by a pneumatic amplifier. The present invention is concerned with pressure control apparatus including a diaphragm coupled to a demand valve by a pneumatic amplifier. 30

Pressure control apparatus according to the present invention comprises: a housing defining a substantially cylindrical bore and a cylindrical assembly mounted within 35 the housing to leave an annular passage between the outer wall of the assembly and the inner wall of the housing; a valve which has a seat and a valve element for cooperating with the seat for closing the valve and which forms part of the cylindrical assembly; a gas inlet communicating with a central portion of the valve element and, when the valve is open, communicating across the valve seat into the said annular passage such that the said annular 45

passage provides the outlet path from the housing for gas discharged through the valve; a control chamber forming part of the cylindrical assembly, located on the side of the valve element remote from 50 the gas inlet and receiving a substantially constant supply of the gas through a perforation in the valve element, irrespective of whether the valve is open or closed, the control chamber having a jet opening 55 through which the gas can escape continuously; and a diaphragm, at the end of the cylindrical assembly remote from the valve element, which is positioned so that the gas escaping from the jet opening impinges on one side thereof and which is 60 vented on that side to a reference pressure, the diaphragm being exposed on the other side to a region into which the said outlet path opens, whereby when the pressure to 65 which the diaphragm is exposed in the said region is less than a value which is a function of the reference pressure the back pressure in the control chamber due to the position of the diaphragm relative 70 to the jet opening is such that the valve opens and permits the flow of gas outwardly across its seat into the said annular passage and thence to the said other side of the diaphragm in said region and when 75 the pressure on the said other side of the diaphragm reaches the said value the back pressure in the control chamber is such that the valve closes.

It will be seen that in this arrangement 80 the gas flow, after passage through the demand valve in the housing, remains in the housing during its passage to the front of the diaphragm, passing through the annular channel between the cylindrical 85 assembly and the housing bore. No external pipe is necessary in such an arrangement. Additionally, the flow of gas from the centre of the disc of the demand valve outwardly across the seat to the annular pass- 90

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age is a convenient arrangement and is advantageous from the viewpoint of valve sensitivity.

In a demand valve in breathing apparatus, the diaphragm communicates with the interior of the face mask and when the valve disc lifts, gas flows through the annular passage to the face mask. The position of rest of the diaphragm in relation to the jet opening can be adjusted to vary the reference pressure at which the demand valve opens.

In general, the reference pressure at which the metering or demand valve opens and closes in conventional apparatus is atmospheric pressure. In apparatus embodying the present invention, the pressure within the face mask can be maintained positive during the whole of the inspiration/expiration cycle, thereby avoiding the danger of poisonous or harmful materials entering the face mask under suction due to leakage paths in the apparatus or to inadequate fitting of the mask to the wearer's face.

The pressure within the mask may suitably be maintained within the range of about 1.5 millibars on inspiration and 2.0 millibars on expiration relative to that of the atmosphere.

The perforation in the demand valve disc must be suitable for supplying a controlled steady flow of gas to the control chamber and thence to the jet opening. It may suitably be formed by passing a thread of cotton or other porous material through the disc or by a loop of thread sewn into the disc. The porosity serves as a filter for the gas passing through the opening.

In breathing apparatus, the gas which passes through the jet opening to the diaphragm chamber may be allowed to escape to atmosphere or, if desired, may be fed into the face mask.

The breathing gas supplied to the demand valve must be at a substantially constant pressure usually of the order of 90 p.s.i. and is generally supplied from a gas cylinder at about 3,000 p.s.i. by means of a reducing valve.

The demand valve according to the invention is preferably formed of a pile of discs comprising the control chamber, the valve disc, and the jet opening, and a sleeve holding the sensitive membrane, the membrane being adjustable in its set position in relation to the jet opening.

In order that the invention may be better understood, one example of pressure control apparatus embodying the invention will now be described with reference to the accompanying drawing, in which:—

Figure 1 is a cross-sectional view of the apparatus showing the demand valve open;

Figure 2 is a view similar to that of Figure 1 showing the demand valve closed; and

Figure 3 is a view similar to that of Figure 2 but showing a by-pass valve open.

In Figure 1, gas flows from an inlet 1 through a passage 2 to a bore 3 and thence to the central portion of a valve disc 4 in which is sewn a thread 5, providing a porous passage for the gas. Gas passing through this porous passage enters a control chamber 6 and escapes through a jet opening 7 into a diaphragm chamber 8, across which extends a diaphragm 9, which has a spring bias. The diaphragm chamber 8 is vented to atmosphere through apertures (not shown) to provide a pressure reference. As explained above, the diaphragm 9 moves in relation to the jet opening with the inspiration and expiration of the user of the breathing apparatus and the back pressure in the control chamber 6 reacts on the valve disc 4 to cause the latter to lift away from its seating as required. When the valve lifts off its seating, gas passes round the seating to two radially opposite chambers 10 from which the gas flows through an annular passage 11 to the side of the diaphragm 9 remote from the jet 7. There is a screw-threaded connection (not shown) between an adjuster housing 12 in which the diaphragm is fitted and a disc 13 in which the jet opening is formed, thereby permitting adjustment of the diaphragm position relative to the jet.

The diaphragm may be loaded with a spring if desired, as an alternative means of obtaining the necessary bias, and the flow from the control jet may be fed into the mask by a suitable means instead of out to atmosphere.

In the form shown, the demand valve includes a by-pass device comprising a spindle 14 which, when moved to the right in the drawing, permits gas to flow directly into an annular chamber 15 and thence through the annular passage 11 to the face mask as will be more fully explained with reference to Figure 3.

The operation of the apparatus is illustrated in Figures 1, 2 and 3. Figure 1 shows the condition of the apparatus during inhaling. Air entering the valve at inlet 1 reaches the bore 3 and as the disc valve is open it flows across the valve seat to the annular passage 11 and thence to the face mask. At the same time, air passes through the restrictor thread in the perforation in the valve disc assembly and through the jet opening 5 to the diaphragm chamber 8, which is vented to atmosphere. The position of the diaphragm 9 is dictated by the pressure differential across it, the force of the air issuing from the jet and the spring bias of the diaphragm. Conse-

quently it requires a pressure greater than atmospheric (i.e. maximum operating pressure in the mask) to deflect the diaphragm 9 from the position shown.

5 Since air escapes more freely through the jet than through the restrictor thread, pressure above the valve disc 4 is greater than pressure below this disc and the disc is held off its valve seat, permitting flow of 10 air to the mask.

When pressure in the mask reaches operating maximum (on exhaling), the diaphragm 9 is deflected upwards, thereby restricting air flow through the jet. Forces 15 above and below the valve disc assembly then approach equilibrium and the disc 4 lifts, throttling the air flow to the annular passage. Due to the differential areas above and below the valve disc assembly now 20 exposed to inlet air pressure, the valve disc is firmly held against the valve seat, as shown in Figure 2.

As pressure in the mask approaches operating minimum (still in excess of 25 atmospheric), the diaphragm 9 return to its position away from the jet opening and the inhaling cycle is repeated.

During normal operation, the by-pass valve is retained closed by the spindle 14 30 which holds the liner 19 in a position in which it seals against the O-ring 20. To open the by-pass valve, the knob 21 is rotated so as to unscrew it from the spindle. The larger diameter of the liner acts as a 35 piston head and the inlet air pressure drives the liner 19 to the right, taking with it the spindle 14, so that the thrust washer 22 is retained against the valve body. The liner 19 is unseated from the O-ring 20 and 40 air flows directly to the mask, i.e. bypassing the disc valve, as shown in Figure 3.

In the arrangement shown, the liner and spindle assembly form a swivel connection coupling the hose to the demand 45 valve. If the hose is rotated, the assembly turn with it as one unit without affecting the by-pass setting.

The invention has been described in relation to breathing apparatus. However, it 50 is not to be considered as limited to breathing apparatus and in particular it may be scaled up to control for example the flow of an inert gas into fuel tanks to avoid ingress of air as the fuel level is decreased, 55 which might otherwise produce an explosive mixture with the vapour of the fuel.

The by-pass valve described above is the subject of our co-pending application No. 60 41296/75 (Serial No. 1569876).

WHAT WE CLAIM IS:—

1. Pressure control apparatus comprising: a housing defining a substantially cylindrical bore and a cylindrical assembly 65 mounted within the housing to leave an

annular passage between the outer wall of the assembly and the inner wall of the housing; a valve which has a seat and a valve element for cooperating with the seat for closing the valve and which forms part 70 of the cylindrical assembly; a gas inlet communicating with a central portion of the valve element and, when the valve is open, communicating across the valve seat into the said annular passage such that 75 the said annular passage provides the outlet path from the housing for gas discharged through the valve; a control chamber forming part of the cylindrical 80 assembly, located on the side of the valve element remote from the gas inlet and receiving a substantially constant supply of the gas through a perforation in the valve element, irrespective of whether the valve 85 is open or close, the control chamber having a jet opening through which the gas can escape continuously; and a diaphragm, at the end of the cylindrical assembly remote from the valve element, 90 which is positioned so that the gas escaping from the jet opening impinges on one side thereof and which is vented on that side to a reference pressure, the diaphragm 95 being exposed on the other side to a region into which the said outlet path opens, whereby when the pressure to which the diaphragm is exposed in the said region is 100 less than a value which is a function of the reference pressure the back pressure in the control chamber due to the position of the diaphragm relative to the jet opening is such that the valve opens and permits the flow of gas outwardly across its seat into the said annular passage and thence 105 to the said other side of the diaphragm in said region and when the pressure on the said other side of the diaphragm reaches the said value the back pressure in the control chamber is such that the valve 110 closes.

2. Apparatus in accordance with claim 1, in which a porous thread passes through the perforation in the valve element to restrict and filter the gas passing to the control chamber. 115

3. Apparatus in accordance with claim 1 or 2, in which the said cylindrical assembly comprises the valve element, a disc mounted coaxially with the valve element and defining the control chamber, 120 and a sleeve supporting the said diaphragm.

4. Apparatus in accordance with claim 3, in which the sleeve is mounted for axial adjustment in relation to the position of the jet opening. 125

5. An assembly including apparatus in accordance with any one of claims 1-4, in combination with a bypass valve permitting the flow of gas from the said inlet to the annular channel through a passage by- 130



quently it requires a pressure greater than atmospheric (i.e. maximum operating pressure in the mask) to deflect the diaphragm 9 from the position shown.

5 Since air escapes more freely through the jet than through the restrictor thread, pressure above the valve disc 4 is greater than pressure below this disc and the disc is held off its valve seat, permitting flow of
10 air to the mask.

When pressure in the mask reaches operating maximum (on exhaling), the diaphragm 9 is deflected upwards, thereby restricting air flow through the jet. Forces
15 above and below the valve disc assembly then approach equilibrium and the disc 4 lifts, throttling the air flow to the annular passage. Due to the differential areas above and below the valve disc assembly now
20 exposed to inlet air pressure, the valve disc is firmly held against the valve seat, as shown in Figure 2.

As pressure in the mask approaches operating minimum (still in excess of
25 atmospheric), the diaphragm 9 return to its position away from the jet opening and the inhaling cycle is repeated.

During normal operation, the by-pass valve is retained closed by the spindle 14
30 which holds the liner 19 in a position in which it seals against the O-ring 20. To open the by-pass valve, the knob 21 is rotated so as to unscrew it from the spindle. The larger diameter of the liner acts as a
35 piston head and the inlet air pressure drives the liner 19 to the right, taking with it the spindle 14, so that the thrust washer 22 is retained against the valve body. The liner 19 is unseated from the O-ring 20 and
40 air flows directly to the mask, i.e. bypassing the disc valve, as shown in Figure 3.

In the arrangement shown, the liner and spindle assembly form a swivel connection coupling the hose to the demand
45 valve. If the hose is rotated, the assembly turn with it as one unit without affecting the by-pass setting.

The invention has been described in relation to breathing apparatus. However, it
50 is not to be considered as limited to breathing apparatus and in particular it may be scaled up to control for example the flow of an inert gas into fuel tanks to avoid ingress of air as the fuel level is decreased,
55 which might otherwise produce an explosive mixture with the vapour of the fuel.

The by-pass valve described above is the subject of our co-pending application No.
60 41296/75 (Serial No. 1569876).

WHAT WE CLAIM IS:—

1. Pressure control apparatus comprising: a housing defining a substantially cylindrical bore and a cylindrical assembly
65 mounted within the housing to leave an

annular passage between the outer wall of the assembly and the inner wall of the housing; a valve which has a seat and a valve element for cooperating with the seat for closing the valve and which forms part
70 of the cylindrical assembly; a gas inlet communicating with a central portion of the valve element and, when the valve is open, communicating across the valve seat into the said annular passage such that
75 the said annular passage provides the outlet path from the housing for gas discharged through the valve; a control chamber forming part of the cylindrical assembly, located on the side of the valve
80 element remote from the gas inlet and receiving a substantially constant supply of the gas through a perforation in the valve element, irrespective of whether the valve is open or close, the control chamber
85 having a jet opening through which the gas can escape continuously; and a diaphragm, at the end of the cylindrical assembly remote from the valve element, which is positioned so that the gas escaping
90 from the jet opening impinges on one side thereof and which is vented on that side to a reference pressure, the diaphragm being exposed on the other side to a region
95 into which the said outlet path opens, whereby when the pressure to which the diaphragm is exposed in the said region is less than a value which is a function of the reference pressure the back pressure
100 in the control chamber due to the position of the diaphragm relative to the jet opening is such that the valve opens and permits the flow of gas outwardly across its seat into the said annular passage and thence
105 to the said other side of the diaphragm in said region and when the pressure on the said other side of the diaphragm reaches the said value the back pressure in the control chamber is such that the valve closes.

2. Apparatus in accordance with claim 1, in which a porous thread passes through the perforation in the valve element to restrict and filter the gas passing to the control chamber.

3. Apparatus in accordance with claim 1 or 2, in which the said cylindrical assembly comprises the valve element, a disc mounted coaxially with the valve element and defining the control chamber,
120 and a sleeve supporting the said diaphragm.

4. Apparatus in accordance with claim 3, in which the sleeve is mounted for axial adjustment in relation to the position of the jet opening.

5. An assembly including apparatus in accordance with any one of claims 1-4, in combination with a bypass valve permitting the flow of gas from the said inlet to the annular channel through a passage by-
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passing the valve.

6. An assembly in accordance with claim 5, in which the by-pass valve includes a closure member of generally cylindrical form mounted within a bore for axial sliding movement to open and close the said bypass valve, and in which the generally cylindrical member is capable of rotation within the said bore.
- 10 7. Breathing apparatus including pressure control apparatus in accordance with any one of the preceding claims, and in

which the diaphragm is fitted in a face mask to be subjected to the inhalation and exhalation pressures of the user.

8. Breathing apparatus including pressure control apparatus substantially as herein described with reference to the accompanying drawings.

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