

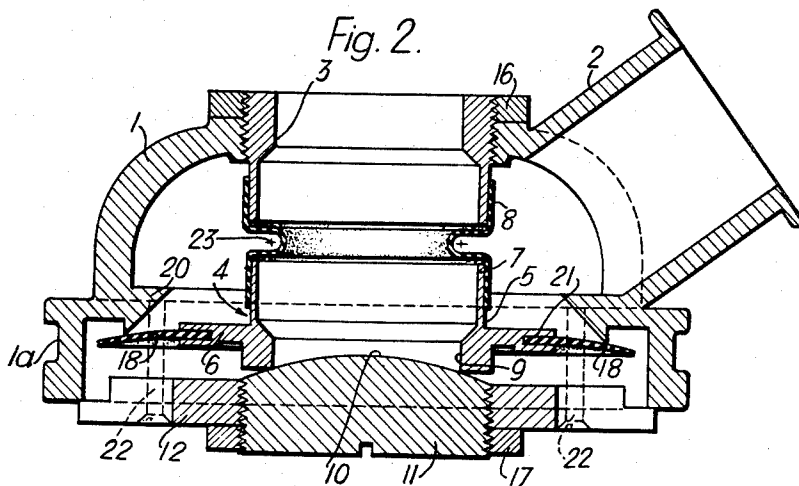
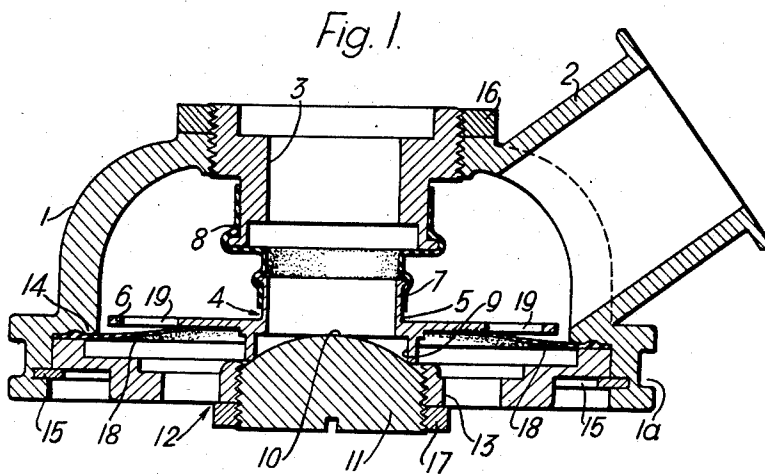
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TWO-WAY VALVE

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TWO-WAY VALVE

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This invention relates generally to a two-way valve which operates in response to the difference between the pressure within a hollow body, container or the like which the valve serves and the supply pressure at the inlet to the valve and more particularly but not exclusively to such a valve for use as a respiratory valve for a pressure suit, pressure helmet, breathing mask and the like.

When a breathing system is pressurised with respect to the ambient pressure it is necessary to provide both an inlet (inspiratory) valve and an outlet (expiratory) valve. It is desirable to balance the expiratory valve with the supply pressure since it is then only necessary to control the supply pressure to maintain the required mean pressure in the pressure suit, pressure helmet, breathing mask or the like.

A known combination of valves for the breathing system comprises a non-return inspiratory valve and a separate expiratory valve. The non-return expiratory valve comprises a flat circular valve member which is spring biased to engage an annular knife edge and thus close the valve. The valve member of the expiratory valve is also balanced with the supply pressure to the inspiratory valve by means of a circular flexible rubber diaphragm of larger diameter than the valve member which diaphragm is secured at its centre to the centre of the rear face of the valve member. The annular edge portion of the diaphragm is clamped between a seat and a closure member to provide a gas tight chamber at the rear of the valve member into which the supply pressure is introduced by a tube from the inlet valve and which pressure is transferred through the diaphragm to the rear face of the valve member. Around the periphery of the valve member the diaphragm has an annular corrugation formed therein which allows for movement of the valve member between its open and closed position. Movement of the valve member is constrained by a spindle thereof extending through a central aperture in the diaphragm which spindle slides in a tubular portion of the closure member.

It is a disadvantage of the above valve that owing to the practical difficulty of obtaining a reliable seal between the flat valve member and the annular knife edge which requires great accuracy in the manufacture of the parts involved, the valve member is of small area and a fairly robust spring bias is employed. The combination of the small area of the valve member and the spring bias renders necessary an appreciable breathing-out pressure to operate the expiratory valve. Moreover the tube leading from the inlet valve to the expiratory valve is very vulnerable if, as is normal, it is disposed outside the breathing mask or the like while to protect it in any way is a further undesirable complication. Again owing to the introduction of the supply pressure behind the valve member of the expiratory valve through the tubular pipe and a number of associated relatively narrow orifices it is possible following fluctuations in the supply pressure for a difference between the supply pressure at

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the inlet valve and hence within the breathing system and the balancing pressure at the rear of the expiratory valve member, to be created and to exist for an appreciable length of time. Thus, if, as can occur, the balancing pressure is appreciably less than the supply pressure at the inlet valve and hence within the breathing system the outlet valve will open and thus render it possible to breath in through the expiratory valve for the short period of time before the pressures equalize.

It is an object of the present invention to provide a simple two-way valve suitable for use as a respiratory valve and comprising an (inlet) inspiratory non-return part and an (outlet) expiratory part balanced with the supply pressure which is an improvement on the known combination of valves referred to hereinabove. It is a further object of the present invention to provide a two-way valve which is simple and cheap to manufacture.

Thus according to the present invention there is provided a two-way valve comprising a valve housing having an inlet and an outlet, a differential valve member and a flexible diaphragm associated therewith both disposed within said housing, said valve member having a tubular portion which communicates with the valve outlet by means of a flexible resilient connection which also serves normally to urge the end of said tubular portion remote from said valve outlet into engagement with a seat thereby closing the valve outlet, the flexible diaphragm and the valve member together serving, in operation, to close the inlet to the valve in response to an increase in the pressure within a body, container or the like served by the valve over the supply pressure at the inlet to the valve, whereby the differential valve member is displaced from said seat thus opening the valve outlet.

In one embodiment of the invention the flexible diaphragm is carried by the differential valve member and the valve housing has an annular seat therein surrounding the valve member, the flexible diaphragm being so shaped that upon an increase in the pressure within said body, container or the like over the supply pressure at the inlet to the valve, it engages the annular seat to close the valve inlet. In this embodiment the seat for the diaphragm may be so disposed in relation thereto and the diaphragm may be of such resilience that the diaphragm normally reacts against the seat and thereby helps to maintain the remote end of the tubular portion in engagement with the seat therefor to close the valve outlet.

The flexible diaphragm may be secured to the valve member by any suitable adhesive, rivets or other means. Preferably however an annular diaphragm is employed of which the inner annular edge portion thereof is located within a circumferentially disposed slot in the valve member which slot preferably extends radially of the tubular portion of the valve member.

Alternatively in another embodiment of the invention the flexible diaphragm is generally annular in shape and is mounted at its periphery in the valve housing, the diaphragm being so dimensioned and disposed that when there is an increase in the pressure within the said body, container or the like over the supply at the inlet to the valve it seats on the valve member to close the valve inlet.

In this case although the valve member may be of various shapes it is preferred that it be formed with a disc-shaped portion extending radially of the tubular portion thereof on which disc-shaped portion the diaphragm may seat. A plurality of apertures may be provided in the disc-shaped portion of the valve member which are so disposed in relation to the diaphragm as to be sealed with respect to the valve inlet by the diaphragm when it seats on the disc-shaped portion. These

apertures serve to assist the flow through the valve to the hollow body, container or the like.

While the end of the tubular portion of the valve member may seal on a flat seat it is preferred that the end of the valve member be formed with a circular knife edge and that the seat be formed as part of a sphere. In this way a reliable seal is obtained despite any slight lateral displacements of the valve member.

The seat for the valve member may conveniently be mounted in a base for the valve, which base has a plurality of apertures therein giving access to the interior of the valve housing. Preferably the valve seat is adjustably mounted for movement along the axis of the tubular portion of the valve member.

The valve housing can be of any desired shape but is preferably generally cone or dome-shaped. The outlet of the valve may be conveniently located at the apex of the cone or dome-shaped housing and may be constituted by a bush axially adjustable in the housing.

In order that the invention may be readily understood, two preferred embodiments thereof will now be described by way of example only with reference to the accompanying drawings, in which:

Fig. 1 shows a side elevation in section of one preferred embodiment; and

Fig. 2 shows a side elevation in section of another preferred embodiment.

Referring to Fig. 1 the valve comprises a dome-shaped valve housing 1 having an inlet formed by a short tube 2 connected to the side wall thereof and an outlet formed by a bush 3 threadedly mounted in an aperture at the apex of the housing. The housing 1 is grooved at 1a to facilitate securing it in a gas tight manner in the wall of a body, container or the like which is to serve e.g. a pressure helmet or breathing mask. Within the housing 1 there is disposed a differential valve member 4 comprising a tubular portion 5 and a disc shaped portion 6 extending radially of the tubular portion adjacent one end thereof. The end 7 of the tubular portion of the valve member 4 remote from the disc portion 6 has an external diameter less than the internal diameter of the bush 3 to permit it to move within the bush 3. The end 7 of the valve member is connected to the inner end of the bush 3 by means of a flexible resilient tubular rubber connection 8 which permits relative axial movement of the end 7 with respect to the bush 3. This resilient connection 8 also serves to maintain the other or remote end 9 of the tubular portion 5 of the valve member in contact with a seat 10 to close the valve outlet.

The seat 10 is shaped as part of a sphere and engages the circular knife edge formed by the end 9 of the valve member. The seat 10 is furthermore formed at one end of a threaded plug 11, which is mounted in a central threaded aperture of a base 12 for the housing 1. The base 12 which has a number of annularly disposed apertures 13 therein engages an annular seat 14 inside the end of the housing 1 and is held in position by a ring clip 15. It will be appreciated that the plug 11, tubular portion 5 of the valve member 4 and the bush 3 are coaxial. The bush 3 and plug 11 are both locked in the desired positions by the lock nuts 16 and 17 respectively. The provision for axial adjustment of the bush 3 and the plug 11 enables the bias imparted by the resilient connection 8 to the valve member to be adjusted at will.

A thin flexible annular rubber diaphragm 18 is mounted within the housing at its periphery between the annular seat 14 and the base 12. The diaphragm is so dimensioned and disposed that (as shown in the drawing) when the pressure within the valve housing 1 is less than the pressure within the body which the valve serves, the inner annular portion of the diaphragm seats on the disc shaped portion 6 of the valve member 4 to close communication between the inlet 2 to the valve and openings

13 and also to cover and thus seal from the valve inlet a number of annularly disposed apertures 19 in the disc-shaped portion 6.

The functioning of the valve is as follows. Normally i.e. when the interior of the valve is at the ambient pressure, the valve outlet is closed since the valve member 4 is biased by the connection 8 and engages the seat 11. When gas is supplied to the inlet tube 2 at a pressure greater than that within the body, container or the like which the valve serves, it flows through the apertures 19 and around the disc-shaped portion 6, through the central aperture in the annular diaphragm 18, and through the apertures 13 in the base 12 and thence into the body, container or the like. Conversely when the pressure within the body served by the valve is greater than the supply pressure the annular diaphragm is moved by the difference in pressure to seat on the disc-shaped portion 6 of the valve member 4 covering the apertures 19 and closing the inlet to the valve. The pressure difference existing on opposite sides of the valve member and diaphragm results in the valve member 4 being displaced axially off the seat 10 thus opening the valve outlet 3.

As mentioned previously the external diameter of the end 7 of the valve member 4 is less than the internal diameter of the bush 3 and hence when the pressure within the valve housing 1 is greater than the ambient pressure there is a tendency for pressure on the connection 8 to lift the valve member 4 and hence open the outlet of the valve. This effect of the connection 8 is countered by so forming the valve member that there is a small resultant force acting on the valve member tending to close the valve outlet as a result of the pressure within the valve housing and the resilience of connection 8. This is achieved by making the knife edged internal diameter of the end 9 of the valve member greater than the external diameter of the end 7 at the other side of the portion 6, by an amount equal to roughly half the difference between the outside diameter of 7 and the inside diameter of the lower end of the tubular bush 3, the exact ratio being dependent somewhat on the differential pressure expected in use and readily determinable by those skilled in the art.

Referring now to Fig. 2 a slightly modified form of valve is shown in which like reference numerals indicate like parts. In this valve the annular diaphragm 18 is carried by the valve member 4 and is of such resilience that it normally engages an annular seat 20 formed by the inside of the housing 1 and thus by reacting against the seat helps the connection 8 to maintain the valve member 4 in engagement with the seat 10 to close the valve outlet. When the pressure within the body or the like served by the valve exceeds the supply pressure then the diaphragm 18 is held against the seat to close the valve inlet. A circumferentially disposed slot 21 is provided in the edge of the disc-shaped portion 6 which in this embodiment has no apertures therein, which slot extends generally radially of the tubular portion 5 of the valve member 4 and receives the inner annular edge portion of the diaphragm. The operation of this valve is essentially the same as above described, the diaphragm serving to close the valve inlet by being held on the seat 20 whereafter the pressure difference on either side of the diaphragm and valve member causes the valve member to move axially off its seat 10. Other differences between the two embodiments are that in this valve the base 12 is secured to the housing 1 by a number of screws 22 and also that the internal and external diameters of the end 7 of the valve member and the bush 3 are the same, the connection 8 having an annular corrugation therein which protrudes between the opposed ends of the bush 3 and valve member 4 into the tubular outlet of the valve. It has been found that with a pressure within the valve housing 1 greater than the ambient pressure, there is a tendency for this corrugation of the connection 8 in expanding into circular form to increase the resilient

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bias normally exerted by the connection 8 to maintain the valve member 4 on its seat. In order to counter this effect the knife-edged internal diameter of the end 9 of the tubular portion 5 at one side of the disc-shaped portion 6 is made of less diameter than the external diameter of the tubular portion 5 at the other side of the disc-shaped portion 6, and roughly equal to the diameter of the circle defined by the locus of the centres of curvature 23 of the annular corrugation of the tubular connection 8. With the same pressure within the housing on opposite sides of portion 6, the relative dimensions described result in a slight net force on the valve member tending to open it which force cancels out the abovementioned effect tending to increase the closing bias exerted by the resilient connection 8 on the valve member 4.

In both of the illustrated forms the flow path closed by the movable portions of the diaphragms engaging their respective seats (disc 6 in Fig. 1 and seat 20 in Fig. 2) may be termed the inlet port since it constitutes a port for admitting gas from the inlet 2 to the space below the diaphragm. The outlet from the space below the diaphragm to the enclosure being served will, for convenience, be called a third port.

It will be appreciated that valves according to the present invention are simple and effective in operation. In particular it will be noted that compensation to inlet pressure of the outlet part of the valve is achieved without any external connection and that moreover since the supply pressure acts directly to balance the valve member no possibility exists through fluctuations in the supply pressure of the outlet serving as an inlet for short periods of time. Valves according to the present invention are particularly suitable for use as respiratory valves in breathing masks, pressure helmets or the like such for example as those disclosed in my copending applications Serial Nos. 513,254 and 520,444, both of which are now abandoned. Such valves may also be incorporated in other equipment e.g. incubators and like apparatus in which gas under pressure is supplied to the apparatus, the interior of which is to be maintained at a predetermined supply pressure.

Although two preferred forms of valves according to the invention have been described in detail, it will be appreciated that modifications and alterations thereto may be made without departing from the scope of the invention as defined in the appended claims.

What I claim is:

1. A two-way valve comprising a housing member having an inlet port, an outlet, and a third port, valve means between said third port and said outlet comprising a tubular valve member, a seating surface engageable by one end of said tubular valve member and a flexible resilient tubular element connecting the other end of said tubular valve member to said outlet, said resilient tubular element yieldably urging said tubular valve member against said surface to close said outlet, a flexible diaphragm mounted on one of said members between said inlet port and said third port so that one face thereof is exposed to pressure at said third port and the other to pressure at said inlet port, said diaphragm having a movable portion engageable with the other of said members for effecting a seal between said housing member

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and said tubular valve member to close said inlet port when the pressure acting on said one face exceeds that on said other face, at least a portion of said diaphragm coacting with said tubular valve member and being movable therewith so that pressure at said third port acting on said one face tends to simultaneously close said inlet port and displace said tubular valve member to move the said one end thereof away from said seating surface to open a flow path from said third port through said tubular valve member to said outlet.

2. A valve as defined in claim 1 wherein said inlet port includes an annular seat surrounding said tubular valve member and wherein said diaphragm is carried by said tubular valve member, surrounding the same with its outer peripheral portion engageable with said annular seat.

3. A valve as defined in claim 2 wherein said diaphragm is of sufficient stiffness to react against said annular seat and urge said tubular valve member against said seating surface.

4. A valve as defined in claim 2 wherein said diaphragm is annular in shape with its inner peripheral edge disposed in a circumferential groove in said tubular valve member.

5. A valve as defined in claim 1 wherein said diaphragm is of annular shape surrounding said tubular valve member and secured at its outer periphery to said housing, said inlet port being defined in part by means on said tubular valve member and engageable by the inner peripheral portion of said annular diaphragm.

6. A valve as defined in claim 5 wherein said last-named means comprises a disc-shaped portion extending radially of said tubular valve member.

7. A valve as defined in claim 6 wherein said disc-shaped portion has apertures therethrough and arranged to be covered and sealed by said diaphragm.

8. A valve as defined in claim 1 wherein said seating surface is a spherical surface and wherein said one end of said tubular valve member defines a circular knife edge engageable with said surface.

9. A valve as defined in claim 1 wherein said seating surface is mounted on a portion of said housing having passage means therethrough constituting said third port.

10. A valve as defined in claim 1 wherein said seating surface is formed on a member adjustable in the direction of the axis of said tubular valve member.

11. A valve as defined in claim 1 wherein said housing is generally dome-shaped.

12. A valve as defined in claim 1 wherein said outlet is defined by a generally tubular member extending through and axially adjustable in a wall of said housing.

13. A valve as defined in claim 1 wherein said flexible resilient tubular element is provided with an inwardly extending annular corrugation therein between said other end of said tubular valve member and said outlet.

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