

Jan. 26, 1960

D. A. ROSENBAUM

2,922,430

VALVE ASSEMBLY

Filed Nov. 28, 1955

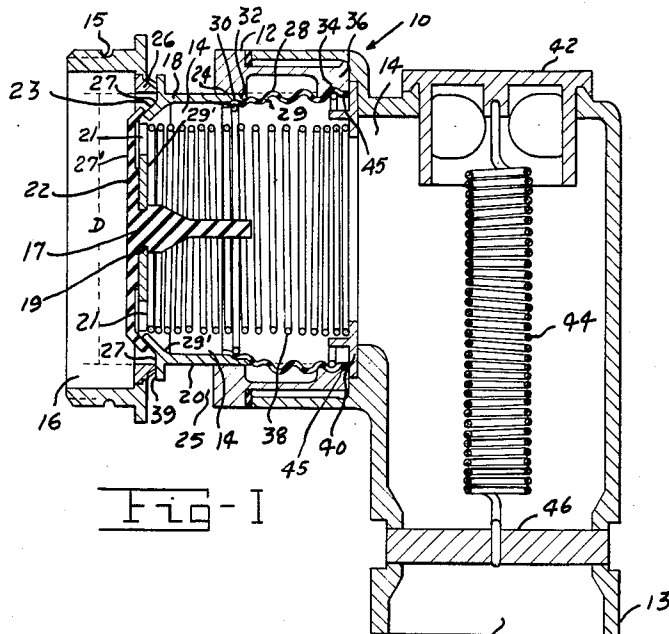


Fig-1

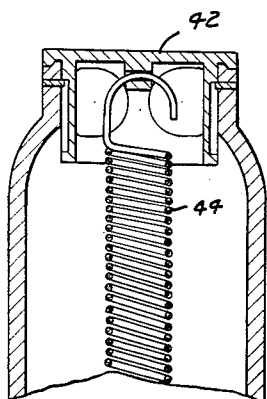


Fig-3

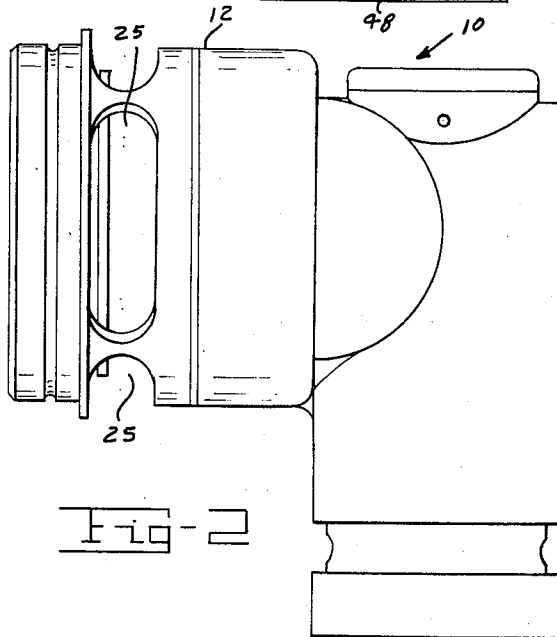


Fig-2

INVENTOR.
DONALD A. ROSENBAUM
BY *Wade L. Cooney*
Julius & Grubinstein
ATTORNEYS

1

2,922,430

VALVE ASSEMBLY

Donald A. Rosenbaum, Dayton, Ohio

Application November 28, 1955, Serial No. 549,577

3 Claims. (Cl. 137—64)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to valves and, more particularly, to a compensated inhalation and exhalation valve assembly for pressure breathing in a high altitude mask.

For high altitude military flights, it is customary to pressurize the cockpit or cabin of the aircraft and these pressures are maintained as low as possible. If the reduced pressure in the cabin is maintained at an altitude corresponding to 30,000 ft., for instance, the partial pressure of the oxygen in the air is so low that the amount of oxygen entering the lungs is insufficient to maintain life indefinitely. For this reason, during high altitude military flights, even in a pressurized cockpit, an oxygen mask must be almost continually worn, especially at altitudes in excess of 10,000 feet. At an altitude in excess of 50,000 feet it is necessary to use pressure breathing to get sufficient oxygen into the lungs. Since the internal body and lung pressure of an individual pressure breathing in a high altitude mask is substantially higher than his surroundings, it is necessary to use pressure suits to maintain a tolerable balance with the surrounding ambient pressure unless the cockpit is pressurized, or in the event canopy or cockpit pressurization completely fails. Pressure suits are skin tight and surround the body completely. They are connected to a source of air pressure and in the event of a substantially sudden decompression of the enclosing cabin cockpit, air pressure is transmitted into the suit balancing the internal pressure in the body and lungs and permitting the wearer to breathe pressurized air or oxygen through the mask. Since it takes a short time before the pressure suit becomes pressurized after explosive decompression of the surrounding cockpit cabin, and since during this time the breathing mask is supplying pressurized air or oxygen to the lungs of the individual wearing the mask, there is a danger that the lungs may rupture unless the pressure in them is almost instantaneously relieved. It is, therefore, a principal object of this invention to devise a compensated inhalation, exhalation and decompression valve assembly for a high altitude mask, designed to automatically relieve internal pressure in the lungs of the individual wearing the mask in the event of an explosive decompression in the cockpit cabin containing the individual.

A further object of this invention is to devise a compact inhalation and exhalation valve assembly for pressure breathing in a high altitude mask in which inhalation and exhalation valves are completely mounted in a common housing along with a safety decompression valve.

Still another object of this invention is to devise an inhalation and exhalation valve assembly having a decompression valve communicating with an exhalation valve so that when explosive decompression exterior of the valve occurs, it forces the decompression valve to open sufficiently far to permit an almost instantaneous pressure drop in the lungs of the individual wearing the mask to prevent them from injury or rupture.

These and other objects will become more apparent

2

when read in the light of the accompanying drawings and specification in which like reference characters refer to like parts in the several figures.

Fig. 1 is a sectional view of the present invention.

Fig. 2 is an elevational view of the present invention disclosing the construction of the port connecting the exhalation chamber with the ambient air.

Fig. 3 is a detail view of the decompression valve.

Referring to the drawings and more particularly to Fig. 1, the compensated inhalation and exhalation valve assembly is indicated generally as 10 and comprises a tubular L-shaped housing 12. An oxygen supply hose is connected to the housing at 13, and the assembly is mounted in an assembly receiving opening or aperture in a pressure breathing mask (not shown) by means of a mask receiving groove 15. An inhalation chamber 14 and an exhalation chamber 16 in the housing are separated by a dividing wall 18. The dividing wall includes an automatically pressure compensated exhalation valve 20 and an inhalation valve 22. As seen in Fig. 1, the inhalation valve 22 is mounted on and is concentric with the exhalation valve 20. The inhalation valve 22 comprises an annular resilient diaphragm having a centrally disposed axially extending boss portion 17. The boss portion is inserted in an opening 19 in the end of the exhalation valve. The periphery of the inhalation valve makes a one-way sealing contact with a valve seat 23 on the exhalation valve 20 closing a port 21 connecting the inhalation and exhalation chambers. With this arrangement, when an individual wearing the mask inhales, the gas pressure in the inhalation chamber exceeds the gas pressure in the exhalation chamber and causes the inhalation valve to open, and on exhalation the inhalation valve is forced to close. This arrangement substantially equalizes the gas pressures in both chambers.

A radially extending port 25 connects the exhalation chamber 16 with the ambient air. The exhalation valve is annular in cross section and is substantially cup-shaped. The sides of the cup are in sliding guided contact with surface 24 of the housing 12 which serves to keep the exhalation valve in proper alignment with valve seat 26. A pleated tubular axially expandable diaphragm 28, annular in cross section, has one edge 30 secured to the edge 32 of the side of the exhalation valve. The opposite end 45 of the diaphragm is secured to the housing at 36. A coil guide spring 38 has one end bearing against the exhalation valve and an opposite end bearing against an annular spring support 40 mounted in the housing, see Fig. 1. The guide spring serves to hold the annular portion 39 of the exhalation valve which directly cooperates with valve seat 26 on the housing, in engagement with the valve seat or uniform axial displacement from the valve seat.

A spring biased decompression valve 42 is also mounted in the inhalation chamber of the housing, see Figs. 1 and 3. A coil spring 44, anchored at one end to a crossbar 46 mounted wholly within inlet portion 48 in the inhalation chamber and anchored to the decompression valve at the other end, maintains the decompression valve in a normally closed position. This valve spring keeps the decompression valve closed so long as the pressure differential between the inhalation chamber and the ambient air does not exceed 150 millimeters of mercury. With this arrangement and remembering that oxygen under pressure is being continually supplied to the valve assembly, it can be seen that even if the pressure of the ambient air should drop to 0, the pressure of the oxygen inside the mask is held to a minimum of 150 millimeters of mercury. This pressure is sufficient to permit an individual to live in a vacuum if the individual is wearing a pressure suit while breathing this pressurized air.

3

Oxygen is supplied under pressure to the inhalation chamber through inlet portion 48. This pressure is transmitted to the exhalation chamber 16 through inhalation valve 22 resulting in equal pressures on both sides of the dividing wall 18. The exhalation valve has a surface 27' in the exhalation chamber and a surface 29' in the inhalation chamber. The force acting on the exhalation valve due to the pressure in the exhalation chamber is the product of the pressure multiplied by the area of the projection of surface 27' on a plane transverse to the direction of motion of the exhalation valve. This area is referred to as the effective area. As seen in Fig. 1, the effective area of the surface 27' is that of a circle having a diameter D which happens to be equal to the internal diameter of the exhalation chamber where the exhalation valve contacts valve seat 26. Therefore, the force acting on the exhalation valve due to the pressure in the exhalation chamber is the pressure multiplied by

$$\frac{\pi D^2}{4}$$

Since the pressure is the same in both chambers, the effective areas must be the same on both surfaces of the exhalation valve to completely pressure compensate the valve. This has been substantially accomplished by using an expandable pleated tubular diaphragm having a cross-sectional area equal to the effective area of the exhalation valve in the inhalation chamber. A consideration of Fig. 1 shows that the projection of surface 29' on a plane transverse to the motion of the exhalation valve is a circle having a diameter equal to the external diameter of the cup portion of the exhalation valve. This diameter is equal to the diameter D of the circular effective area of the surface 27'. This means that the exhalation force necessary to open the exhalation valve 20 is substantially independent of the pressure in the valve assembly.

In normal operation, when the wearer of the mask inhales, valve 22 readily opens, permitting oxygen to flow from the inhalation chamber 14 through exhalation chamber 16 into the lungs. When the individual exhales, the pressure of exhalation forces inhalation valve 22 into sealing engagement with valve seat 23 on exhalation valve 20 and, in addition, forces exhalation valve 20 out of engagement with valve seat 26 on the body 12, permitting the exhaled air to be exhausted from the exhalation chamber through the radially extending port 25 into the ambient air.

In the event of an explosive decompression at high altitudes, the pressure of the air surrounding the housing 12 drops rapidly to a very low value. This produces a pressure differential between the pressure of the oxygen inside the housing and the pressure of the air outside the housing in excess of 150 millimeters of mercury. The differential pressure causes the decompression valve to open, see Fig. 1, permitting the pressure in the inhalation chamber to immediately drop to a lower value. This rapid decrease in pressure in the inhalation chamber produces a large pressure differential between the inhalation and exhalation chambers. This pressure differential displaces the exhalation valve 20 axially and opens port 25 connecting exhalation chamber to the ambient air. This displacement is designed to be large enough to permit an almost instantaneous drop in pressure in the exhalation chamber, thus, involuntarily relieving the gas pressure in the lungs of the individual wearing the mask and preventing serious injury to that organ. After the pressure in the inhalation chamber drops sufficiently so the pressure differential between it and the ambient air is less than 150 millimeters of mercury, the decompression valve closes, and at about the same time his pressure suit becomes inflated, permitting the individual wearing the mask to resume pressure breathing.

Having thus described the invention in connection with a preferred form for purposes of illustration rather

4

than restriction, what is claimed as new and desired to be secured by Letters Patent is as follows:

1. A valve assembly for pressure breathing in a high altitude mask comprising a housing, said housing having inhalation and exhalation chambers and a first port connecting the exhalation chamber with the ambient air, a dividing wall including an automatically pressure compensated exhalation valve separating said chambers, said exhalation valve operable to open and close said first port, said housing having a second port therein connecting said inhalation chamber with the ambient air, a decompression valve normally closed against entrance of ambient air into said inhalation chamber and movable in said inhalation chamber to open said second port when the pressure differential between the ambient air and the pressure in the inhalation chamber exceeds a predetermined amount, said decompression valve being disposed in communication with said exhalation valve so that when the decompression valve opens, the pressure on the surface of the exhalation valve in the inhalation chamber decreases substantially with respect to the pressure on the surface of the exhalation valve in the exhalation chamber to move the exhalation valve to open position to permit a substantially instantaneous pressure drop in the exhalation chamber thereby preventing injury to the lungs of the individual wearing the high altitude mask with the valve assembly when subjected to exterior decompression.

2. The invention set forth in claim 1 wherein, said exhalation valve is formed with a third port connecting said inhalation chamber to said exhalation chamber and an inhalation valve is mounted on said exhalation valve and operates to open said third port whenever the pressure in the inhalation chamber exceeds the pressure in the exhalation chamber, said exhalation valve having opposed pressure actuated surface areas with one surface area thereof in each of said chambers, the effective surface area of the exhalation valve in the exhalation chamber being substantially equal to the effective surface area of the exhalation valve in the inhalation chamber so the pressure forces acting on the exhalation valve are substantially balanced.

3. A valve assembly for a high altitude oxygen mask comprising a housing having an inhalation and an exhalation chamber, said exhalation chamber having a peripheral exhalation port open to ambient air outside of said housing, a yieldable exhalation valve for closing said port to the entrance of ambient air outside of said housing in said exhalation chamber, a yieldable inhalation valve mounted on said exhalation valve and movable to establish communication from said exhalation chamber into said inhalation chamber, yieldable decompression valve means in said inhalation chamber normally closing said inhalation chamber to the entrance of air from outside of said housing opening outwardly to the exterior of the housing whereby upon decompression exterior of the housing, said decompression valve is immediately yieldable to vent said inhalation chamber to the exterior of the housing to immediately lower the relative pressure in said inhalation chamber so that the pressure on the surface of the exhalation valve in the inhalation chamber decreases substantially with respect to the pressure on the surface of the exhalation valve in the exhalation chamber to move said exhalation valve to open position immediately releasing a predetermined excessive pressure in the exhalation chamber relative to the decompression exterior of said housing.

References Cited in the file of this patent

UNITED STATES PATENTS

2,567,225	McKee	Sept. 11, 1951
2,615,463	Burns	Oct. 28, 1952
2,623,540	Palermo	Dec. 30, 1952