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INHALATION-EXHALATION REGULATOR SYSTEM WITH SUCTION CONTROL

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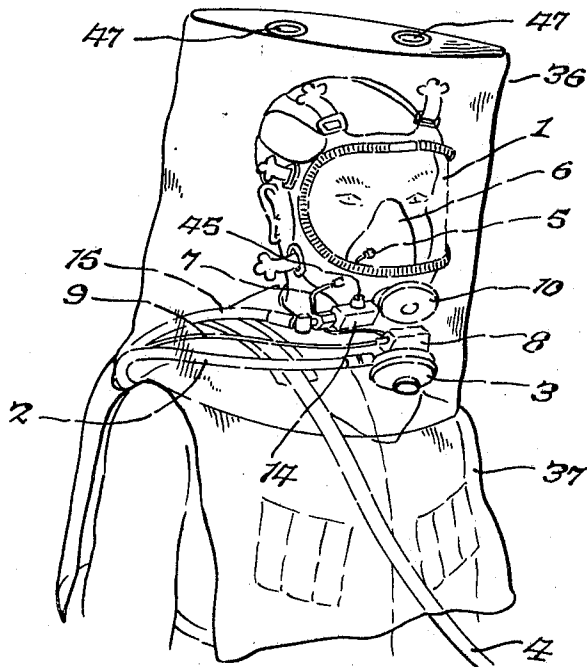
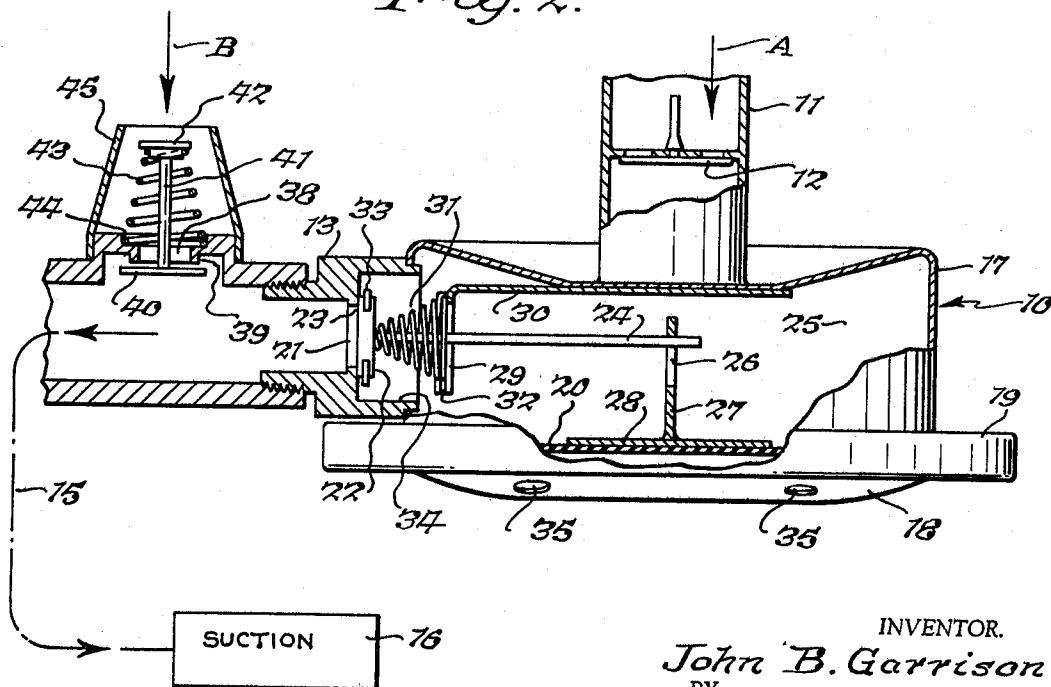


Fig. 1.

Fig. 2.



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INHALATION-EXHALATION REGULATOR SYSTEM WITH SUCTION CONTROL

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ABSTRACT OF THE DISCLOSURE

A control chamber with a movable wall has a fluid inlet communicating with a fluid outlet from a breathing mask or other life support system for movement of the wall upon fluid flow into the chamber from the system, and a fluid outlet communicating with a source of suction. A normally closed valve controlling fluid flow through the chamber outlet is opened by such wall movement to place the chamber in communication with the suction source. A bleed passage communicating with the suction source exhausts fluid from within a hood covering the head of a wearer, and a bleed control valve operates in conjunction with the chamber outlet valve to enable opening of the latter against high suction pressure from the source with a minimum exhalation effort.

This invention relates generally to the control art, and more specifically to a new and useful suction control for life support systems.

When a person must subsist in an atmosphere which is dangerous or incapable of supporting human life, he is equipped with a life support system comprising, for example, a breathing mask supplied with oxygen from either a fixed or portable source, through a demand regulator. Under ordinary circumstances, the exhalation from the life support system can be exhausted to the ambient atmosphere.

However, under some circumstances it is essential that the surrounding atmosphere not be contaminated with exhalation or any other gas from the life support system. Pending application Ser. No. 409,065, filed Nov. 5, 1964, now U.S. Patent 3,348,538 by Howard A. Benzel and assigned to the assignee of this application discloses a suction control arrangement for receiving exhalation from a breathing mask, pressure suit or the like, and removing it under pressure in a manner avoiding contamination of the surrounding atmosphere.

It is desirable to obtain a large volume of flow from the suction control regulator, and thereby literally take away the exhalation. However, it also is desirable to keep the weight of the suction line to a minimum and thereby reduce the total weight which must be carried about by the user. This poses a problem because a relatively high suction pressure must be provided to obtain a large flow rate through a small diameter line, and this in turn requires a relatively large cracking force to open the outlet valve from the suction regulator. This is undesirable, because of the expiration effort needed to develop such a force.

A primary object of this invention is to provide a suction control arrangement for life support systems enabling the utilization of a high pressure suction source and opening to the source with a minimum of effort.

The foregoing and other objects, advantages and characterizing features of this invention will become clearly apparent from the ensuing detailed description of an illustrative embodiment thereof, reference being made to the accompanying drawing depicting the same wherein like

reference numerals denote like parts throughout the various views and wherein:

FIG. 1 is a perspective view showing a life support system incorporating the instant invention as it appears in use; and

FIG. 2 is a schematic view, partly in elevation and partly in section, showing a suction control arrangement of this invention.

Referring now in detail to the illustrative embodiment depicted in the accompanying drawing, there is shown a man equipped with a life support system comprising a full face breathing mask supplied with a breathing fluid from suitable source (not shown) via a breathing hose 2 and a conventional demand regulator 3. Regulator 3 can be of any desired type, such as that set forth in United States Patent 3,145,721 and is mounted either on mask 1 or on the wearer's suit and connected to mask 1 by a suitable hose, either arrangement being well known in the art. Also, the breathing fluid can be supplied from either a fixed source, or a portable source such as a cylinder of compressed air or oxygen, not shown, carried on the back by means including a harness 4, both arrangements being well known in the art and requiring no elaboration here.

The life support system can also include a communications system, including a microphone 5 mounted in the oro-nasal cavity 6 of the mask and connected via lead 7 to a connector 8 and service line 9.

A suction control is provided in the form of a regulator 10 having an inlet conduit 11 connected to face mask 1 for receiving exhalation or other gas therefrom. A one-way check valve 12 permitting fluid flow only in the direction of arrow A is positioned in conduit 11, valve 12 being of the flapper type. Regulator 10 has an outlet fitting 13 connected to a bleed valve housing 14 communicating therethrough and via suction line 15 with a source of suction 16. Suction source 16 can be positioned either nearby or a substantial distance away and can be in another room.

Regulator 10 can be identical with the regulator 6 of the aforesaid application Ser. No. 409,065, and can have a vacuum break flapper type check valve to relieve the vacuum if the regulator should stick in open position, as shown therein. In the illustrated embodiment, regulator 10 comprises a housing including a generally cup-shaped body 17 and a cover 18 held together by a generally U-shaped clamping ring 19. A movable wall, herein shown as a resiliently flexible diaphragm 20 is suspended across the open end of body 17, being clamped between body 17 and cover 18 by the clamping ring 19.

The outlet fitting 13 provides a fluid outlet passage 21 controlled by a tilt valve having a body 22 of any suitable construction. Body 22 engages a valve seat 23 around the outlet passage 21, and a valve stem 24 extends from valve body 22 into the chamber 25 provided in housing 17 by diaphragm 20. Stem 24 extends generally parallel to diaphragm 20 through an elongated opening or slot 26 in a connecting link member 27 carried by a back up plate 28 secured to diaphragm 20 for movement therewith. Connecting link 27 can be integral with and of the diaphragm material.

Inlet conduit 11 communicates with chamber 25 of the control 10, and stem 24 normally engages the outer end of slot 26, this being the upper end of the slot as viewed in FIG. 2, whereby movement of diaphragm 20 toward cover 18, in the direction enlarging chamber 25, will tilt stem 24 downwardly, pivoting valve body 22 on valve seat 23 at the lower portion thereof as seen in FIG. 2, thereby opening fluid outlet passage 21 and placing the suction source 16 in communication with chamber 25. Movement of diaphragm 20 in a direction reducing the size of chamber 25 will not tilt stem 24, because of the lost motion connection

provided by slot 26 and interference of the nearly rigid link 27 with the bottom of housing 17.

A bifurcated arm 29 at the valve body end of a spring bracket 30 has a vertical slot through which stem 24 extends and in which it can tilt vertically, in the plane of the pap as viewed in FIG. 2, without interference. However, undue lateral movement of stem 24 is prevented by arm 29. A helical spring 31 encircles stem 24 between arm 29 and valve body 22, bearing at one end against the latter. At its opposite end, spring 31 bears against arm 29, being held against lateral shifting by flanges 32 extending from the opposite sides of the bifurcated arm 29 at generally a right angle thereto. Multiple protrusions 33 project radially from body 22 for engagement with the wall 34 of fitting 13, to center valve 22 on its seat.

The chamber between cover 18 and diaphragm 20 is at ambient atmospheric pressure, being open to the surrounding atmosphere through several openings 35.

It will be noted from FIG. 1 that a transparent hood 36 of plastic material is provided, the hood covering the head and having an apron 37 extending downwardly to also cover the shoulders and upper body of the wearer. Hood 36 encloses breathing mask 1, regulators 3 and 10, and the associated equipment including the bleed housing 14, and provides a space about this equipment in which any leakage of air from the life support system will be trapped. For example, if the mask 1 does not have a fluid tight seal with the head of the wearer, some breathing fluid may escape. This would be trapped within hood 36. To remove such trapped fluid, there is provided a bleed connection into the suction line 15, and it is a particular feature of this invention that the bleed connection is provided with a control valve operating in conjunction with valve 22 to cause the latter to open against a high suction pressure from source 16, with a minimum of exhalation effort. This is accomplished as follows.

Referring now to FIG. 2, there is provided a bleed passage 38 into the housing 14, the passage 38 communicating with the interior of hood 36 for fluid flow in the direction of arrow B. Passage 38 is smaller in area than the outlet passage 21 from chamber 25, and is provided with a valve seat 39 adapted for engagement by a bleed valve body 40. A stem 41 extends from body 40 through passage 38 and has a head 42. A helical spring 43 extends between a recessed seat 44 in the wall of housing 14 and the head 42, encircling stem 41 and biasing the body 40 into closed position against seat 39. An open ended, hood-like skirt 45 encircles spring 43 and the bleed valve stem 41 and head 42, to protect the same.

Spring 43 is arranged so that when valve 22 is closed, valve 40 is opened by the suction influence from source 16. This opens the interior of hood 36 to suction source 16, for exhausting trapped fluid from within hood 36. In addition, it will draw fluid from beneath hood 36, and thereby utilize the ambient atmosphere to ventilate the interior of the hood, for the comfort of the wearer. In other words, it will not only draw fluid from within the hood, but in doing so it will cause fluid to leak under the hood from the exterior thereof, into the hood and through the suction line 15. To prevent collapsing of the hood about the wearer, should such ventilating leakage somehow be prevented, there are provided a pair of one way, inlet check valves 47 of the flapper type, and of sufficient stiffness to open only upon a predetermined negative pressure, whereby normally they will be closed but will open should that be the only way for ambient atmosphere to enter the hood.

It is a particular feature of my invention that fluid flow through the bleed passage reduces the suction force which must be overcome to open valve 22. When valve 22 is cracked open, the suction pressure is further reduced, because of fluid flow through passage 21, whereupon valve 40 closes under the influence of spring 43. For example, with a suction pressure equal to 29 inches of mercury, spring 43 can be arranged to close valve 40 when the effective suction pressure thereon drops below 15 inches of mercury.

This means that with fluid flow through bleed passage 38, valve 22 must open against an effective suction force of only 15 inches of mercury, or approximately half the full suction pressure. Upon cracking valve 22 open, the effective suction pressure on valves 40 and 22 drops, causing valve 40 to close whereby the full suction force is applied to the fluid in chamber 25. Once valve 22 is cracked open, the application of full suction pressure thereon does not impede further opening movement of the valve, because the maximum effort is required at the initial opening or cracking of the valve.

Therefore, a high suction force can be utilized with my invention, with a modest effort required to crack open the valve, and with the full suction effect being immediately applied to the regulator 10 because the bleed passage is closed whenever the chamber 25 is opened to the suction source 16. Also, closing of the bleed passage 38 whenever chamber 25 is opened ensures that no gas from chamber 25 will escape through the bleed passage 38, thereby precluding possible contamination of the ambient atmosphere by a malfunction in this aspect of the system.

It will be appreciated that the demand regulator 3 of the breathing fluid supply can have a check valve arrangement between it and the mask 1 corresponding to check valve 12 but opening in the opposite direction, whereby all exhalation will be delivered to regulator 10, and all inhalation will be from regulator 3.

Accordingly, it is seen that my invention fully accomplishes its intended objects. While I have disclosed and described in detail only one embodiment, that has been done by way of illustration only without thought of limitation.

Having fully disclosed and completely described my invention, and its mode of operation, what I claim as new is:

1. In combination with a life support system having a fluid outlet, a source of suction, and a control including a chamber having a movable wall, a fluid inlet to said chamber communicating with said system outlet for movement of said wall upon fluid flow into said chamber from said system, a fluid outlet from said chamber communicating with said source of suction through a suction line, normally closed chamber valve means controlling fluid flow through said chamber outlet, means connecting said chamber valve means to said movable wall for placing said chamber in communication with said source of suction upon such movement of said wall, a bleed passage into said suction line, bleed valve means controlling fluid flow through said passage and operative to influence the effort required to open said chamber valve means, and means biasing said bleed valve means to close said bleed passage, said bleed valve biasing means being arranged to close said bleed valve means against the suction influence thereon of said source when said influence falls below a first pressure level, said source being operative to exert a suction influence on said bleed and chamber valve means at a second pressure level substantially above said first level, said bleed valve means opening against said bleed valve biasing means when said suction influence is above said first level and said chamber means is closed, said chamber valve means being arranged to reduce the suction influence on said bleed valve means below said first level upon opening of said chamber valve means and said bleed valve biasing means coacting with said chamber valve means to maintain said bleed valve means closed whenever said chamber valve means is open, whereby the suction force which must be overcome to open said chamber valve means is reduced to said first level and the full suction effect is applied to said chamber upon opening said chamber valve means.

2. The combination of claim 1, wherein said life support system includes a breathing mask connected to said fluid inlet, together with a hood of gas impermeable material adapted to enclose the head of a person wearing said mask, said bleed passage opening into said hood for withdrawing fluid from within said hood.

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3. The combination of claim 2, wherein said hood is open at the lower end thereof, whereby said hood is ventilated by said suction source when said chamber outlet is closed.

4. The combination of claim 3, wherein said hood has a relief passage through a wall thereof, together with check valve means normally closing said relief passage, said check valve means opening inwardly under a predetermined suction influence to admit fluid into said hood and thereby prevent collapsing thereof against the wearer.

5. The combination of claim 2, wherein said life support system has means including a demand regulator for supplying breathing fluid to said mask.

6. The combination of claim 1, wherein said life support system includes means for supplying fluid under positive pressure thereto.

7. The combination of claim 1, wherein said movable wall comprises a flexible diaphragm, and said connecting means comprises an actuating stem extending from said chamber valve means, a spring encircling said stem and urging said chamber valve means into a position closing said chamber outlet, and lost-motion means connecting said actuating stem to said diaphragm for tilting the former to open said chamber outlet upon movement of said diaphragm in a direction enlarging said chamber.

8. The combination of claim 7, wherein said bleed valve biasing means comprises a spring.

9. The combination of claim 1, said bleed passage being smaller in area than said fluid outlet from said chamber.

10. In combination with a life support system having a fluid outlet, a source of suction, and a control including

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a chamber having a movable wall, a fluid inlet to said chamber communicating with said system outlet for movement of said wall upon fluid flow into said chamber from said system, a fluid outlet from said chamber communicating with said source of suction through a suction line, chamber valve means controlling fluid flow through said chamber outlet, means connecting said chamber valve means to said movable wall for placing said chamber in communication with said source of suction upon such movement of said wall, a bleed passage into said suction line, bleed valve means controlling fluid flow through said passage and operative to influence the effort required to open said chamber valve means, said bleed valve means moving to open said bleed passage in response to the suction influence of said source of suction, and means biasing said bleed valve means to close said bleed passage, together with means providing an enclosure about a portion of said life support system, said bleed passage placing said suction line in communication with the interior of said enclosure exteriorly of said life support system.

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WILLIAM E. KAMM, Primary Examiner

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