

March 3, 1953

B. B. HOLMES
RESPIRATORY DEVICE

2,630,129

Filed Jan. 22, 1947

2 SHEETS—SHEET 1

Fig. 1

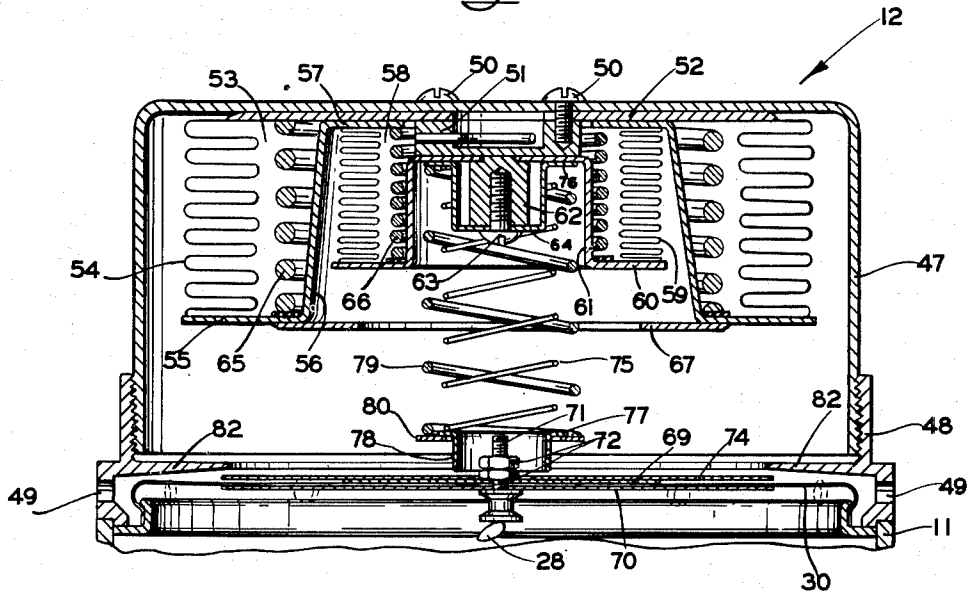
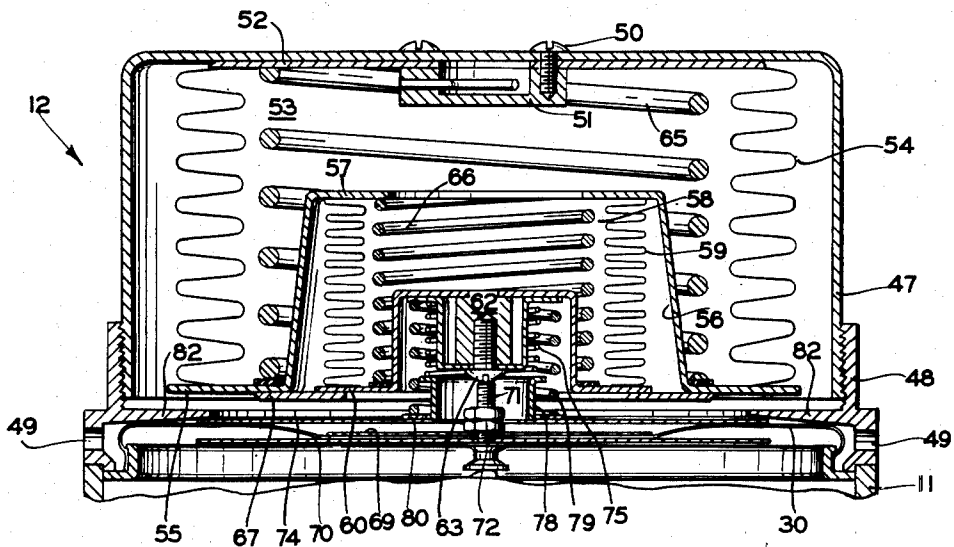


Fig. 2



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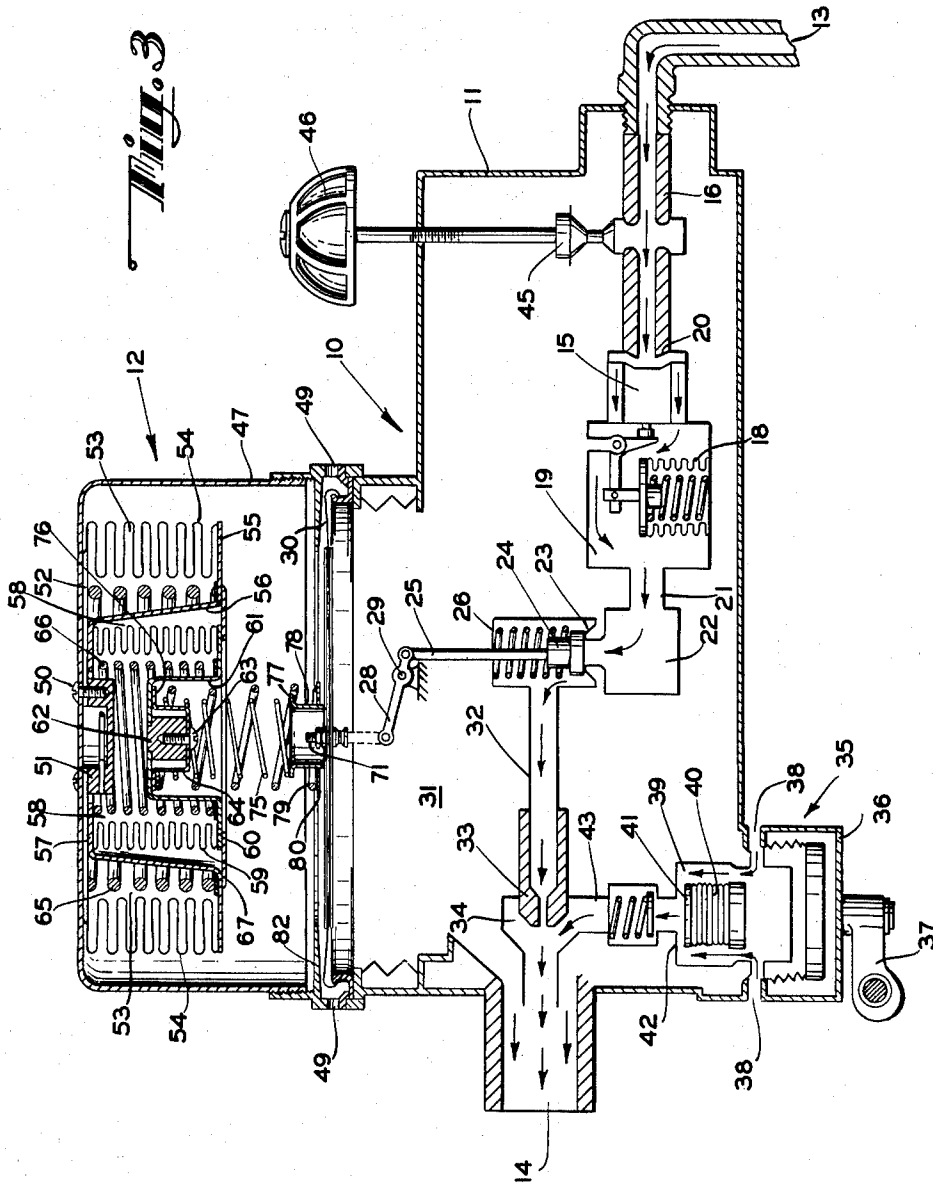
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2 SHEETS—SHEET 2



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2,630,129

RESPIRATORY DEVICE

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20 Claims. (Cl. 137-64)

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This invention relates to respiratory devices and more particularly to an automatic control for the demand valve of a diluter demand oxygen regulator.

In demand oxygen regulators used in flights over 10,000 feet to supplement the oxygen supply in these rarefied regions, respiratory responsive members are employed to control the quantity of oxygen delivered to the mask. The actuation of the responsive members will open and close a demand valve which will permit the oxygen to flow into the mask from a reducing chamber within the regulator. In diluter demand regulators, the oxygen is mixed with a quantity of air so that an air-oxygen mixture is delivered to the mask.

When higher altitudes are reached, the air-oxygen mixture must be enriched; and the oxygen, in cases of extreme high altitudes, delivered to the mask under pressure to maintain alveolar tension at a safe level. The diluter valves forming a part of these regulator will gradually decrease the supply of air entering the regulator, shutting off the air supply entirely at about 32,000 feet so that only oxygen is delivered to the mask. The oxygen as delivered to the mask is not of sufficient pressure to maintain the oxygen tension within the lungs at altitudes of 40,000 feet, or over. To prevent anoxaemia, the oxygen delivered at the mask must have sufficient pressure behind it to force its way into the lungs of the mask-wearer.

An object of my present invention is to provide a control for the demand valve of a regulator which will vary the operation of the regulator to deliver the oxygen to the mask at increasing pressures as atmospheric pressure decreases.

A further object of my invention is to provide a pressure responsive control for the demand valve of a regulator which shall exert a positive pressure on the respiratory responsive member controlling the demand valve for increasing the pressure of the oxygen delivered to the mask by the regulator.

Another object of this invention is to provide a pressure responsive control of the character indicated by which a light, positive pressure is applied to the respiratory responsive member controlling the demand valve to provide oxygen under a safety pressure of about .25 inch of water to prevent air intake due to a mask leak at high altitudes of 20,000 to 33,000 feet.

Still a further object of this invention is to provide a pressure responsive control of the character indicated by which a positive pressure is

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applied to the respiratory responsive member controlling the demand valve to provide oxygen under pressure of from .25 to 12 inches of water to the mask at altitudes from 33,000 to 50,000 feet.

Still another object of this invention is to provide a pressure responsive control of the character indicated by which a large positive force is applied to the respiratory responsive member controlling the demand valve to provide super pressure oxygen at the mask at increasing pressures from 12 to 56 inches, and more, of water; to permit flights over the 60,000 feet level.

Yet another object of my invention is to provide in a pressure responsive control of the character indicated with means whereby the effective area of the respiratory responsive member controlling the demand valve of a regulator upon which the positive pressure of the control acts, is gradually reduced at altitudes over a predetermined high altitude, to deliver oxygen at increasing super pressures to the mask.

Yet a further object of this invention is to provide a highly improved and rugged pressure responsive control for the demand valve of an oxygen demand regulator which shall be automatic and positive in its actions; relatively inexpensive to manufacture; which shall have a large variety of applications; and yet be practical and efficient to a high degree in use.

Other objects of the invention will in part be obvious, and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter described and of which the scope of application will be indicated in the appended claims.

In the accompanying drawings forming a part of this specification in which one of the various possible illustrative embodiments of this invention is shown, and wherein similar reference characters designate corresponding parts throughout the several views.

Figure 1 is a vertical section of a pressure responsive control for a demand valve embodying my invention.

Figure 2 is a view similar to Figure 1 showing the action of the control at an altitude over 50,000 feet, while

Figure 3 is a schematic of a diluter demand oxygen regulator showing the action of my pressure responsive control on the respiratory responsive diaphragm at an altitude of from 20,000 to 33,000 feet.

Referring now in detail to the schematic of

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Figure 3, 10 designates a demand oxygen regulator housed in a cylindrical body 11 having affixed thereto in a suitable manner the novel demand valve control 12.

The regulator body 11 is provided with an oxygen inlet port 13 to which oxygen storage cylinders (not shown) may be affixed and an outlet port 14 to which the hose line connecting the mask (not shown) may be attached. A pressure reducing valve 15 is provided in the inlet line 16 connected to the port 13 to reduce the pressure of the oxygen as delivered from the storage tanks. The valve 15 is adapted to be actuated by a pressure responsive capsule 18 placed within a reducing chamber 19 located within the body of the regulator 10. Expansion and contraction of capsule 18 due to the changes in the pressure within the chamber 19 will seat and unseat the valve on a valve seat 20 formed in the inlet to the chamber 19. A line 21 connects the reducing chamber 19 with a demand chamber 22.

The outlet of chamber 22 is provided with a valve seat 23. Cooperating with said valve seat is a demand valve 24 fixed to a valve stem 25. A coil spring 26 placed about the valve stem normally urges the valve against the seat 23. Pivoted to the upper end of the valve stem 25 is a lever 28 which is pivoted as at 29 within the regulator body 11. The link 29 is adapted to be oscillated about the pivot 29 by a respiratory responsive diaphragm 30 fixed across the open end of the cylindrical body 11 forming a chamber 31 within the body.

The respiration of the mask wearer will cause the diaphragm 30 to rise and fall to pivot the lever 28. Inspiration will reduce the pressure within the chamber 31 causing the diaphragm to fall. The lever 28 is thus pivoted in a counterclockwise direction to lift the demand valve 24 from the seat 23. The oxygen will then flow from the demand chamber 22 past the demand valve and into a line 32 as indicated by the arrows of Figure 3. Expiration will cause the diaphragm 30 to lift, permitting the demand valve 24 to be seated shutting off the oxygen supply.

The oxygen line 32 leading from the demand valve terminates in a jet nozzle 33. The oxygen from the nozzle 33 is directed into the mouth of a venturi 34.

Means is provided to mix the oxygen delivered by the nozzle 33 with a quantity of air.

To this end, the regulator body 11 is provided with a diluter assembly 35 (Figure 3). The diluter assembly comprises a threaded cup member 36 having a handle 37 adapted to be rotated to close the plurality of air inlet ports 38 provided in the assembly. A chamber 39 within the assembly is provided with aneroid capsule 40 carrying a plate valve 41. The plate valve 41 is adapted to be seated and unseated on a seat 42 formed in the outlet of the chamber 39. The capsule 40 will expand and contract with changes in barometric pressure. As the altitude increases the capsule will expand to reduce, and finally shut off the supply of air passing through the valve 41, 42. The capsule 40 will seat the plate valve 41 at approximately 32,000 feet, the regulator 10 then delivering 100 percent oxygen at higher levels. The air leaving chamber 39 will flow into the venturi 34 through a line 43, a check valve 44 in said line prevents leakage from the regulator 10. The air entering the venturi will be entrained by the oxygen from the nozzle 33, the air-oxygen mixture flowing from the venturi en-

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ters the outlet 14 of the regulator and thence out into the mask.

An emergency valve 45 is placed in the oxygen inlet line 16. Opening of the valve 45 by the knob 46 will permit the oxygen to flow into and through the regulator body to the outlet port 14, bypassing the valve mechanisms hereinbefore described.

For a further and more detailed description of the oxygen demand regulator and its operation, reference may be made to my copending application therefor, bearing Serial No. 482,016 filed on April 6, 1943.

Means is now provided for applying a positive pressure on the diaphragm 30 to decrease the suction required of the mask wearer in opening the demand valve 24, and to gradually increase the positive pressure applied as the atmospheric pressure decreases with increasing altitude for increasing the pressure of the oxygen delivered to the mask fixed to the regulator outlet 14.

To this end, the pressure responsive control member 12 is fixed over the diaphragm 30 of the regulator (Figures 1 and 2). The control member 12 is enclosed in a shell 47 which is threaded to an upstanding threaded annulus 48 on the regulator body 11. The lower portion of the annulus is provided with a series of ports 49 to permit ambient pressure to affect the control mechanism within the shell, as hereinafter described.

Fixed within the shell 47 and to the top thereof, as by screws 50, is an abutment member 51. Held between said member and the top of shell 47 by the screws 50 is a circular plate 52 forming the top wall of an aneroid 53. The aneroid 53 is formed with corrugated side walls 54, an annular bottom wall 55 and an interior side wall 56. The interior wall 56 terminates at the top thereof in an annular member 57 which forms the top wall of a nested aneroid 58.

The aneroid 58 comprises a corrugated side wall 59, an annular bottom wall 60, and a cup-formed interior wall 61. Fixed dependently within the cup-formed wall 61 is a block 62, having fixed thereto as by screw 63, a U-shaped member 64 forming a spring guide member and abutment plate.

The response of the nested aneroids 53 and 58 to atmospheric pressure within the shell 47 due to the ports 49 is such, that aneroid 58 will expand upon a decrease in pressure before the aneroid 53 expands, as will hereinafter be described. Both of the aneroids 53 and 58 are provided with internal calibrated springs 65 and 66, respectively, for aiding in applying a positive force to the diaphragm 30 as hereinafter described.

The bottom wall 55 of the aneroid 53 has affixed thereto an annular ring plate 67. The plate 67 forms a stop for the aneroid 58, the wall 60 thereof bottoming on plate 67 when said aneroid expands.

Resilient means are now provided to apply to the diaphragm 30 an increasing positive force to affect the actuation of the demand valve 24.

To this end, the diaphragm 30 is provided with reinforcing plates 69 and 70, the diaphragm 30 being clamped between them, as by post 71 and nuts 72; the plate 69 being of smaller diameter than that of plate 70. A large plate 74 is placed on the diaphragm plate 69 and over the post and nuts 72.

A light coil spring 75, hereinafter referred to as

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the safety pressure spring, is placed about the U-shaped member 64, one end of the spring being fixed to the flared upon end 76 of said member, while the lower end of said spring is welded to the flared top portion, or lip 77 of a sleeve 78. Sleeve 78 is thus suspended over the diaphragm 30 surrounding the post 71 and nuts 72, the lower end of the sleeve being spaced from the plate 74 as shown in Figure 1. A second coil spring 79, hereinafter referred to as the pressure breathing spring, is also disposed within the cup-formed member 61 and about the U-shaped member 64 and safety pressure spring 75. The upper end of this spring is fixed to the flared end 76, while the lower end has welded thereto, or fixed in any suitable manner, a ring 80, said ring being disposed about the sleeve 78. As indicated in Figure 1 of the drawings, ring 80 hangs freely just under the lip 77 of the sleeve 78 when the two aneroids 53 and 58 are collapsed. With the aneroid 58 bottomed in aneroid 53, the ring 80 is just above the large plate 74 of the diaphragm 30, as indicated in the schematic of Figure 3.

The regulator 10 as herein described will operate to deliver an air-oxygen mixture from sea level to an altitude of approximately 18,000 feet, the mixture delivered maintaining the oxygen pressure in the lungs of the user equivalent to that available from sea level to the 2,500 foot level. The suction required of the mask wearer is approximately .25 inch water pressure for operating the demand valve as described. The mixture ratio of air and oxygen will be varied as changes in altitude take place due to the diluter assembly 35, the plate valve 41 due to the expansion of the aneroid 40 gradually reducing and completely shutting off the air supply at approximately the 32,000 foot level.

At approximately 18,000 feet, the aneroid 58 will begin to expand, the lower edge of the sleeve 78 abutting the plate 74 of the diaphragm 30. The safety pressure spring 75 will be biased by the further expansion of the aneroid 58 to exert a small increasing positive pressure on the diaphragm 30 until a positive pressure of about .25 inches of water builds up in the regulator due to the opening of the demand valve by the deflection of the diaphragm. This positive pressure is reached at approximately the 20,000-foot level and is maintained up to an altitude of approximately 32,000 feet. The aneroid 58 will be fully expanded at about 22,000 feet, the plate 60 thereof bottoming on the ring 67 of the aneroid 53. The ring 80 fixed to the pressure breathing spring 79 will be lowered upon expansion of the aneroid 58, the ring however falling short of abutting the plate 74 (Figure 3).

With the positive pressure built up in the regulator, expiration of the user will close the demand valve 24 to shut off the oxygen supply momentarily. No suction is required to open the demand valve. There is thus provided a positive pressure within the mask to compensate for mask leakage.

The small positive pressure of .25 inches of water within the regulator is maintained as the altitude increases from 22,000 feet to about 32,000 to 33,000 feet. At this higher level the larger aneroid 53 begins to expand. The ring 80 affixed to the pressure breathing spring 79 will engage the plate 74 to exert a positive force thereon.

It will be remembered that at this level, the diluter assembly cuts off the air supply so that

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100 percent oxygen is now being delivered to the mask.

The force exerted by the pressure breathing spring will gradually increase the pressure within the regulator until at an altitude of about 50,000 feet, the oxygen pressure delivered by the regulator is about 12 inches of water. The oxygen delivered to the mask at these altitude levels is thus at a pressure sufficient to maintain the oxygen tension in the lungs to prevent anoxaemia.

Above the altitude of approximately 50,000 feet, the screw 63 in the abutment block 62 will abut the post 71 on the diaphragm 30 (Figure 2). The continued expansion of the aneroid 53 with increasing altitude will build up a pressure greater than that exerted by the spring 75 and 79. The pressure within the regulator will thus be built up due to the open demand valve, causing the edges of the diaphragm to bulge. See Figure 2. This will lift the plate 74 off the plate 69 against the bias of the springs 75 and 79, the edges of plate 74 rising against the stops 82 provided in the annulus 48.

The pressure exerted by the aneroid 53 is balanced by the regulator pressure multiplied by the area of the plate 69 and the adjoining area of the diaphragm 30. The area provided by plate 69 is smaller than that provided by plate 74 when the latter was effective in applying the aneroid pressures to the diaphragm. A greater pressure may thus be built up in the regulator. Any desired range of pressures may be attained by making the plate 69 of suitable diameter.

As the altitude continues to increase over the 50,000 foot level, no expansion of the aneroid will take place due to the abutment of bottom wall 55 on the stops 82. However, the continued increase in altitude will affect the aneroid 53 since the wall 60 thereof has separated from plate 67 during the expansion of aneroid 53 so that an ever increasing force is applied to the post 71, the pressure being balanced by the regulator pressure. The pressure in the regulator will rise to about 56 inches of water at an altitude of 60,000 feet, and to about 72 inches at an altitude of 100,000 feet, permitting safe flights at these extreme upper levels.

It will thus be seen that there is provided an oxygen demand regulator control in which the several objects of this invention are achieved, and which is well adapted to meet the conditions of practical use.

As various embodiments may be made in the above invention, and as various changes may be made in the embodiment above set forth, it is to be understood that all matter above set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of nested pressure responsive members adapted to sequentially and then concurrently expand upon decrease in ambient pressure, means connecting said members to said respiratory responsive diaphragm whereby the expansion of said members applies an increasing positive force to the respiratory responsive diaphragm as the ambient pressure decreases to open the demand valve controlled thereby.

2. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of nested pressure re-

sponsive members adapted to sequentially and then concurrently expand upon decrease in ambient pressure, resilient means between said members and said respiratory responsive diaphragm for applying an increasing positive force to the respiratory responsive diaphragm as said nested members expand sequentially and then concurrently with decreasing ambient pressure to open the demand valve controlled thereby.

3. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of two nested pressure responsive members adapted to sequentially and then concurrently expand upon predetermined decreases in ambient pressure, resilient means for connecting one of said members to said respiratory responsive diaphragm, and means connecting the other of said members to said one member upon a predetermined decrease in ambient pressure, whereby an increasing positive force is applied to the respiratory responsive diaphragm as said nested members expand with decreasing ambient pressure to open the demand valve controlled thereby.

4. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of a plurality of resilient members adapted to coact with the respiratory responsive diaphragm, and a plurality of interconnected pressure responsive means adapted to expand sequentially and then concurrently upon decrease in ambient pressure for biasing said resilient members to apply an increasing positive pressure on said respiratory responsive diaphragm to affect the control thereby of the demand valve.

5. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of a plurality of resilient members adapted to coact with the respiratory responsive diaphragm, and a plurality of interconnected pressure responsive means adapted to expand sequentially and then concurrently with decreasing ambient pressure for moving said members into sequential engagement with the respiratory responsive diaphragm and for biasing the same to apply an increasing positive force thereon to affect the control of the demand valve thereby with the continual decrease in ambient pressure.

6. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of pressure responsive means adapted to expand with decreasing ambient pressure, a pair of resilient members carried by said pressure responsive means, and means carried by said members whereby said members move into sequential and then concurrent engagement with the respiratory responsive diaphragm to bias the same to apply an increasing positive force thereon to affect the control of the demand valve thereby upon expansion of said pressure responsive means in response to a continual decrease in ambient pressure, the force of each of said resilient members being applied between different predetermined ambient pressure limits.

7. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of pressure responsive means adapted to expand with decreasing ambient pressure, a pair of resilient members carried by said pressure responsive means, and means carried by said members whereby said members move into sequential and then concurrent en-

gagement with the respiratory responsive diaphragm to bias the same to apply a pressure thereon to affect the control of the demand valve thereby upon expansion of said pressure responsive means in response to a continual decrease in ambient pressure, one of said resilient members applying an increasing pressure to said respiratory responsive diaphragm between predetermined ambient pressure limits, the other resilient member in conjunction with the first member applying a greater increasing pressure between lower predetermined ambient pressure limits than the first limits as the ambient pressure decreases.

8. In a demand regulator having a demand valve controlled by a respiratory responsive diaphragm, the combination of pressure responsive means adapted to expand with decreasing ambient pressure, a pair of resilient members carried by said pressure responsive means, and means carried by said members for moving said members into sequential and then concurrent engagement with the respiratory responsive diaphragm to bias the same to apply a pressure thereon to affect the control of the demand valve thereby upon expansion of said pressure responsive means in response to a continual decrease in ambient pressure, one of said resilient members applying an increasing pressure to said respiratory responsive diaphragm between predetermined ambient pressure limits, the other resilient member in conjunction with the first member applying a greater increasing pressure between lower predetermined ambient pressure limits than the first limits as the ambient pressure decreases, and abutment means on said pressure responsive member for applying a still greater increasing pressure directly to the respiratory responsive diaphragm between still lower predetermined ambient pressure limits as the ambient pressure continues to decrease.

9. In an oxygen demand regulator, the combination comprising, a respiratory responsive diaphragm, a demand valve operated thereby for controlling the oxygen supplied by the regulator, abutment plates for said diaphragm, resilient means adapted to coact with said diaphragm plates, pressure responsive means adapted to expand with decreasing ambient pressure for biasing said resilient means to apply a positive pressure to said diaphragm through said plates, and means on said pressure responsive means for reducing the effective area of said plates to increase the oxygen pressure in said regulator to balance the pressure on said diaphragm between predetermined limits of ambient pressure.

10. In an oxygen demand regulator, the combination comprising a respiratory responsive diaphragm, a demand valve operated thereby controlling the oxygen supplied by the regulator, abutment plates for said diaphragm, a plurality of resilient means adapted to apply positive pressures on said diaphragm through said plates, pressure responsive means adapted to expand with decreasing ambient pressure for biasing said resilient means against said plates, the pressure by said resilient means being sequentially and then concurrently applied between predetermined ambient pressure limits, and abutment means on said pressure responsive means to engage said diaphragm plates between predetermined lower ambient pressure limits reducing the effective area thereof to increase the oxygen pressure of said regulator to balance the greater pressure applied thereto by said pressure responsive means.

11. In an oxygen demand regulator the combination comprising a respiratory responsive diaphragm, a demand valve operated thereby controlling the oxygen supplied by the regulator, an abutment plate for said diaphragm, two nested aneroids in juxtaposition with said diaphragm, said aneroids being adapted to expand sequentially with decreasing atmospheric pressure, one of said aneroids expanding and bottoming within the other before the second aneroid begins to expand, a pair of springs carried by the inner aneroid, and means carried by said springs and engageable with said diaphragm plate upon expansion of said aneroids whereby said springs and aneroids apply sequentially and then concurrently increasing positive pressures on said diaphragm plate to affect the control of the demand valve by said diaphragm as atmospheric pressure decreases between predetermined limits;

12. In an oxygen demand regulator the combination comprising a respiratory responsive diaphragm, a demand valve operated thereby controlling the oxygen supplied by the regulator, an abutment plate for said diaphragm, a post for fixing said plate to said diaphragm, a second abutment plate of larger area than said first plate on said first plate and movable with respect thereto and said post, a pressure responsive member in juxtaposition with said diaphragm adapted to expand with decreasing atmospheric pressure, and a member movable with said pressure responsive member adapted to abut the post on said diaphragm between predetermined limits of atmospheric pressure, the positive pressure exerted on said post and said first plate by the expansion of said member causing said diaphragm to lift said second plate to decrease the effective area of positive pressure application on said diaphragm.

13. In an oxygen demand regulator the combination comprising a respiratory responsive diaphragm, a demand valve operated thereby controlling the oxygen supplied by the regulator, an abutment plate for said diaphragm, a post for fixing said plate to said diaphragm, a second abutment plate of larger area than said first plate on said first plate and movable with respect thereto and said post, two nested aneroids in juxtaposition with said diaphragm, said aneroids being adapted to expand sequentially with decreasing atmospheric pressure, one of said aneroids expanding and bottoming within the other before the second aneroid begins to expand; said aneroids being adapted to apply sequentially and then concurrently increasing positive pressures on said second diaphragm plate to affect the control of the demand valve by said diaphragm as atmospheric pressure decreases between predetermined limits; and a member movable with said aneroids adapted to abut the post on said diaphragm between lower predetermined limits of atmospheric pressure, the positive pressure exerted on said post and said first plate causing said diaphragm to lift said second plate decreasing the effective area of positive pressure application on said diaphragm to increase the oxygen pressure within the regulator by the open demand valve for balancing the positive pressure applied by the nested aneroids.

14. In an oxygen demand regulator the combination comprising a respiratory responsive diaphragm, a demand valve operated thereby controlling the oxygen supplied by the regulator, an abutment plate for said diaphragm, a post for fixing said plate to said diaphragm, a second abut-

ment plate of larger area than said first plate on said first plate and movable with respect thereto and said post, two nested aneroids in juxtaposition with said diaphragm, said aneroids being adapted to expand sequentially with decreasing atmospheric pressure, one of said aneroids expanding and bottoming within the other before the second aneroid begins to expand; a pair of springs biased upon expansion of said aneroids to apply sequentially and then concurrently increasing positive pressures on said second diaphragm plate to affect the control of the demand valve by said diaphragm at atmospheric pressures decreases between predetermined limits; and a member movable with said aneroids adapted to abut the post on said diaphragm between lower predetermined limits of atmospheric pressure, the pressure exerted on said post and said first plate causing said diaphragm to lift said second plate against the bias of the two springs by the decrease in the effective area of positive pressure application on said diaphragm for increasing the oxygen pressure within the regulator by the open demand valve balancing the positive pressure applied by the nested aneroids.

15. In an oxygen demand regulator having a demand valve controlled by a respiratory responsive diaphragm and means for applying a positive pressure to said diaphragm, the combination of an abutment plate for said diaphragm, a post for fixing said plate to said diaphragm, a second abutment plate of larger area than said first plate on said first plate and movable with respect thereto and said post, said second abutment plate and said post being adapted to be engaged by said pressure means to apply a positive pressure on said diaphragm within predetermined limits, said second plate being adapted to be lifted by said diaphragm from said first plate to decrease the effective pressure area on said diaphragm when the positive pressure is above said predetermined limit of pressure.

16. In an oxygen regulator of the demand type having a casing including an outlet adapted for connection to a breathing mask, a respiratory responsive diaphragm and a demand valve operatively connected to said diaphragm, said demand valve normally controlled by respiratory pressure on said diaphragm, a control mechanism for said demand valve comprising a first and second aneroid on one side of said diaphragm, means carried by said second aneroid and engageable with said diaphragm for biasing said diaphragm to operate at reduced respiratory pressures at predetermined ambient pressures, and means connecting said first aneroid to said second aneroid whereby said first aneroid cooperates with said second aneroid below said predetermined ambient pressures to bias said diaphragm to override the respiratory control and open said demand valve.

17. An oxygen demand regulator adapted for use with a breathing mask, comprising a casing, a pressure chamber in said casing having a respiratory controlled diaphragm defining one wall thereof, a demand valve operatively connected to said diaphragm permitting the flow of oxygen into said chamber, an outlet from said chamber adapted for connection to said mask and providing for the flow of oxygen to said mask, a pair of nested interconnected aneroids, said interconnected aneroids expanding sequentially and then concurrently in response to decreasing ambient pressure, and means connecting said aneroids to said diaphragm upon the sequential and then concurrent expansion of said aneroids, whereby

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one of said aneroids biases said diaphragm to decrease the respiratory pressure required to operate said demand valve at a predetermined ambient pressure, and both of said aneroids are operative below said predetermined ambient pressure to bias said diaphragm to retain said demand valve in open position.

18. In an oxygen demand regulator having a casing adapted for connection to a breathing mask, a chamber within said casing having a respiratory responsive diaphragm defining a wall of said chamber, an outlet from said chamber adapted for connection to a breathing mask, and a demand valve controlling the flow of oxygen into said chamber, a control mechanism for said demand valve comprising a lever mechanism operatively connected to said demand valve and to said diaphragm to open and close said demand valve, a plurality of interconnected aneroids set to distend sequentially and then concurrently at predetermined ambient pressures, and means carried by one of said aneroids and engageable with said diaphragm whereby the sequential and the concurrent expansion of said aneroids actuates said lever mechanism and thereby operates said valve to control the oxygen pressure in said chamber.

19. In an oxygen regulator of the demand type having a casing adapted for connection to a breathing mask, a chamber in said casing communicating with said mask and having a diaphragm defining one wall thereof, a demand valve permitting the flow of oxygen into said chamber, a control mechanism for said demand valve comprising lever mechanism connected to said demand valve and to said diaphragm and cooperating therewith to open and close said demand valve, a pair of interconnected aneroids responsive to ambient pressure, said aneroids set to distend sequentially and then concurrently at different desired altitudes, and means carried by one of said aneroids and sequentially and then concurrently engageable with said diaphragm upon the sequential and then concurrent

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distention of said aneroids for operating said diaphragm to operate said demand valve and regulate the flow of oxygen into said chamber.

20. In an oxygen demand regulator adapted for use with a breathing mask and including a casing having a pressure chamber adapted for communication with said mask, a respiratory responsive diaphragm forming one wall of said chamber, a demand valve controlling the flow of oxygen under pressure into said chamber, a lever mechanism connected between said diaphragm and demand valve for opening and closing said demand valve in response to respiratory pressure applied to said chamber, in combination therewith, a pair of nested interconnected aneroids set to distend sequentially and then concurrently in response to increasing altitude, resilient means carried by one of said aneroids and engageable with said diaphragm, one of said aneroids set to distend at predetermined altitudes to engage said resilient means to said diaphragm and operate the same to increase the pressure to a desired value in said chamber, the remaining aneroid set to begin distending at higher altitudes to act in concert with said first aneroid and resilient means to operate said diaphragm to further increase the pressure in said chamber.

BRADFORD B. HOLMES.

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