July 7, 1959 G. D. BLACK 2,893,381

VALVE MEANS

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FIG. 1.

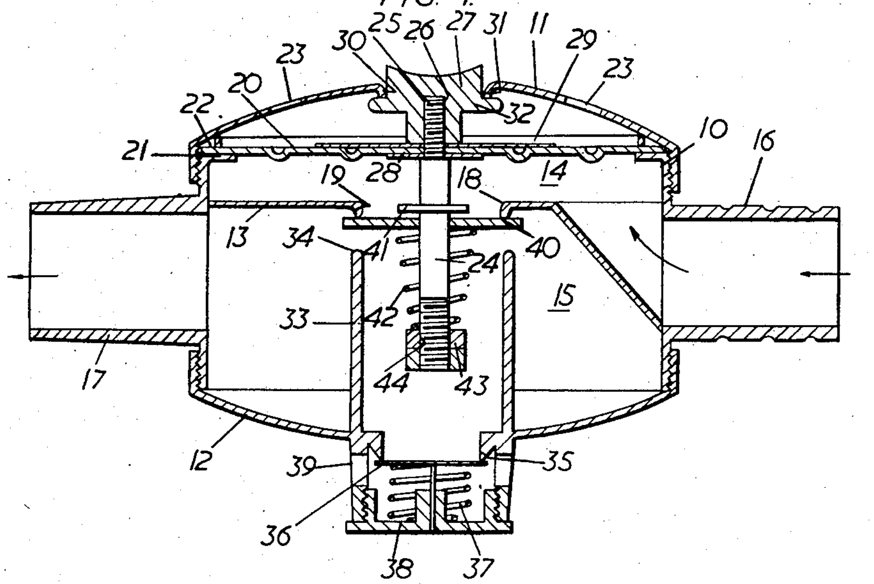
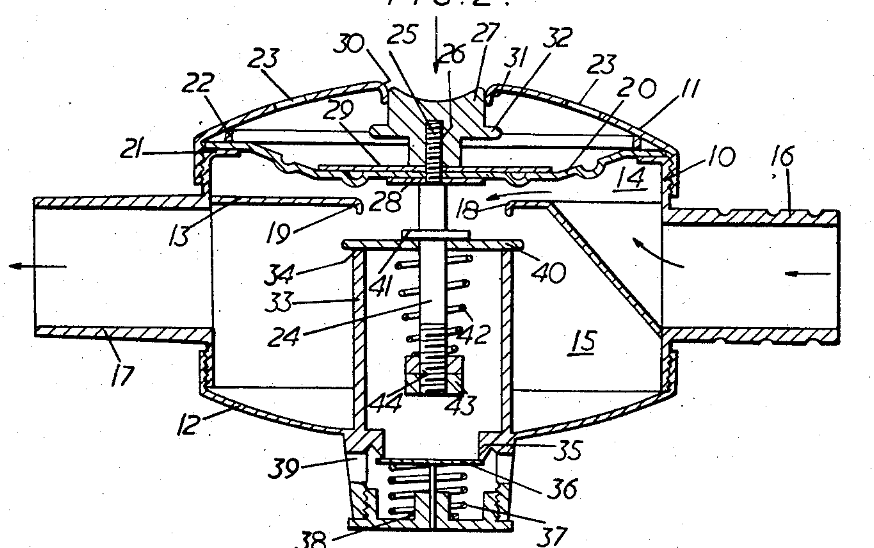


FIG. 2.



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VALVE MEANS

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FIG. 3.

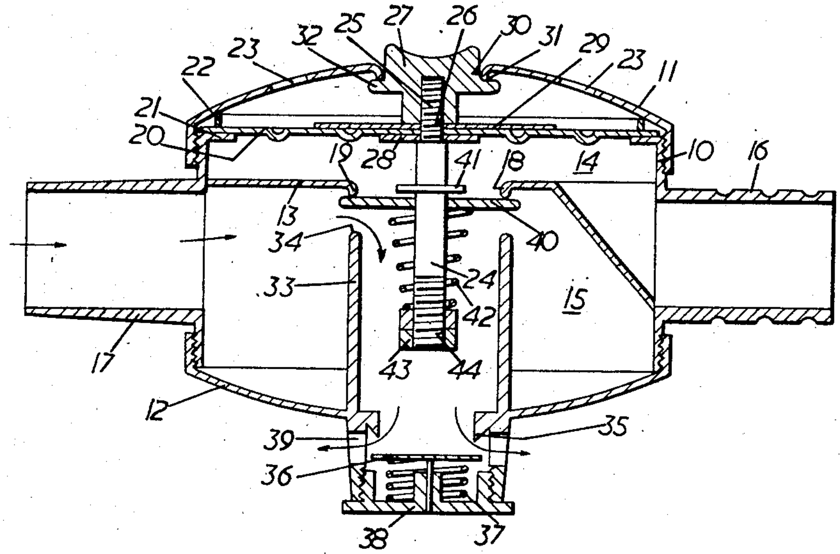
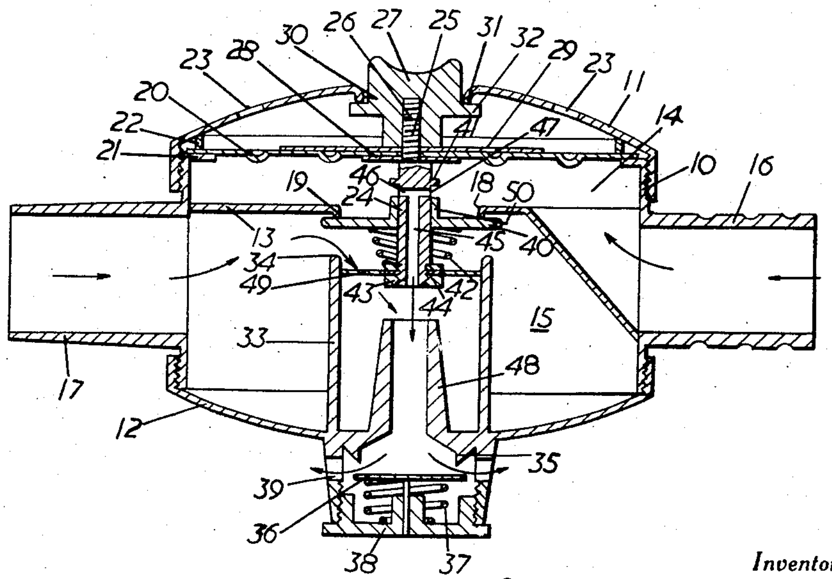


FIG. 4.



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VALVE MEANS

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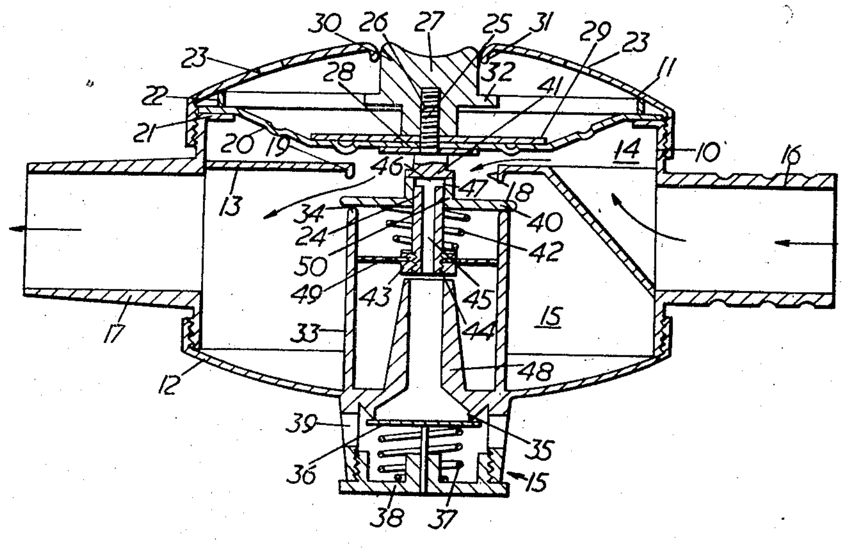
FIG. 5.



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VALVE MEANS

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7 Claims. (Cl. 128—29)

This invention relates to valve means for controlling the flow of inhalant gas to a patient in anaesthesia or artificial respiration.

In such treatments, the particular method of administering the inhalant gas to the patient will depend on whether or not the patient is capable of breathing spontaneously. When the patient is capable of spontaneous breathing it is desirable to supply the inhalant gas in accordance with the patient's demands, whilst when the patient cannot breathe unaided, it is usual to supply the inhalant gas under a positive pressure to the patient during an inspiratory phase and to shut off the gas supply and permit the lungs to exhaust to atmosphere during the expiratory phase. The duration of each phase may be controlled automatically, either in accordance with a predetermined time sequence or in accordance with the pressure in the patient's lungs, or it may be controlled manually, for example, by removing the face-mask from the patient's face during the expiratory period.

Machines are known which are capable of providing a flow of inhalant gas either continuously at a positive pressure, or according to the demand of the patient, and it is an object of the present invention to provide valve means which can be used with such machines under either positive pressure or demand conditions.

According to the present invention, valve means for controlling the flow of inhalant gas to a patient comprises an inlet chamber having an inlet port adapted to be connected to means for supplying inhalant gas either continuously at a positive pressure or according to the patient's demand, an outlet chamber having an outlet port adapted to be connected to a face mask or other means for supplying inhalant gas to the patient and a vent communicating with the atmosphere through a non-return valve, said chambers intercommunicating through a valve port, a pressure-responsive member exposed on one side to the pressure in the inlet chamber and on the other to atmospheric pressure, a valve member carried by the pressure-responsive member and adapted alternatively to close the valve port or the vent, and manually operable means for moving the valve member in a direction to open the valve port and close the vent, the arrangement being such that under positive pressure conditions, the valve member is held in the position in which the valve port is closed and the vent open by the pressure of the inhalant gas in the inlet chamber acting on the pressure-responsive member and is moved to the position in which the valve port is open and the vent closed by operation of the manual means during each inspiratory phase, and under demand conditions, the valve member is moved to open the valve port and close the vent under the influence of a negative pressure acting on the pressure-responsive member and is moved to close the valve port and open the vent under the influence of a positive pressure acting on the pressure-responsive member.

Means may also be provided to permit the valve member to open the valve port in response to inspiratory effort under positive pressure conditions when manual pressure is not applied to open the valve port, should the patient become capable of spontaneous breathing and attempt to inhale. For example, the valve member may be arranged to float on a valve stem attached to the pressure responsive member and passing through the valve port, the valve being biased against a shoulder on the stem by a light spring. Any attempt by the patient to inhale will then produce a negative pressure in the outlet chamber and cause the valve member to move along the valve stem against the spring to open the valve port, thus permitting inhalant gas to reach the patient.

Means may also be provided to produce a slight negative pressure in the outlet chamber during the expiratory cycle under positive pressure conditions, in order to assist in emptying the lungs of the patient, for example, by passing the gas under pressure from the inlet chamber through a jet and venturi arrangement.

If desired, the valve means may be arranged to provide an oxygen/air mixture on the demand setting of the resuscitator, by providing an air inlet port in the wall of the outlet chamber. This port is adapted to be closed, for example, by a sliding member, when positive pressure conditions are used.

The invention will now be more particularly described with reference to the accompanying drawings, in which:

Figure 1 is a sectional elevation of valve means according to the invention for use in the administration of oxygen to a patient, the moving parts of the valve means being shown in the positions assumed under positive pressure conditions before breathing commences;

Figure 2 is a view similar to that of Figure 1, showing the moving parts in the positions assumed during the inspiratory phase of the breathing cycle;

Figure 3 is a view similar to that of Figures 1 and 2, showing the moving parts in the positions assumed during the expiratory phase of the breathing cycle;

Figure 4 is a sectional elevation of a modified form of the valve means of Figures 1, 2 and 3, the moving parts being shown in the positions assumed during the expiratory phase of the breathing cycle under positive pressure conditions.

Figure 5 is a view similar to that of Figure 4, the moving parts being shown in the positions assumed during the inspiratory phase of the breathing cycle under positive pressure conditions.

In all the figures, like parts are denoted by the same reference numeral.

Referring to Figures 1 to 3, the valve means comprises a substantially cylindrical casing **10** closed in gas-tight manner at its upper and lower ends by outwardly dished end caps **11** and **12** respectively. The casing **10** is divided radially by a partition **13** into an inlet chamber **14** and an outlet chamber **15**. The casing **10** is provided with an inlet port **16** opening into the inlet chamber **14** and adapted to be connected to a resuscitator of a type which is capable of delivering a continuous flow of oxygen under a positive pressure or alternatively of delivering oxygen on the demand principle, that is to say with gas flow only during an inspiratory effort by the patient. The casing **10** is also provided with an outlet port **17** opening into the outlet chamber **15** and adapted to be connected to a face mask. In the drawings, the inlet port **16** and the outlet port **17** have been shown as mounted co-axially on the casing **10**. The radial positions of these ports on the casing may, however, be varied to suit any particular manufacturing or operating conditions.

The partition **13** is provided with a central valve port **18** which affords, communication between the inlet chamber 14 and the outlet chamber 15. The valve port 18 is provided with an annular seating 19 on its outlet chamber side.

The wall of the inlet chamber 14 opposite to the partition 13 is formed by a flexible diaphragm 20 clamped at its periphery in fluid-tight manner between an internal flange 21 on the upper end of the casing 10 and a clamping ring 22 held in place by the end cap 11. The end cap 11 is pierced by holes 23 so that the outer side of the diaphragm 20 is subjected to atmospheric pressure.

The diaphragm 20 carries a co-axial valve stem 24 which projects through the valve port 18 as hereinafter described. This valve stem 24 is mounted on the diaphragm 20 by means of a threaded extension 25 of smaller diameter than the stem which projects through a central hole in the diaphragm 20 and is screwed into a threaded recess 26 in a manually operable knob 27. Washers 28 and 29 are provided between the diaphragm 20 and the shoulder formed between the stem 24 and the extension 25 and between the diaphragm 20 and the knob 27 respectively to prevent leakage of gas past the diaphragm 20.

The knob 27 is arranged to project through a central aperture 30 in the end cap 11 so that it can be depressed by finger or thumb to move the diaphragm 20 towards the partition 13. The aperture 30 is provided with an inwardly directed flange 31 which abuts against a shoulder 32 on the knob 27 and acts as a stop for the knob 27 to prevent excessive outward movement of the diaphragm 20.

The outlet chamber 15 is arranged to communicate with the outer atmosphere through a vent formed by a tubular member 33 passing through and co-axial with the end cap 12. The tubular member 33 extends inwardly towards the partition 13, the inner end of the tubular member forming a valve seat 34 spaced a short distance from the partition 13. The interior of the tubular member 33 is arranged to communicate with the atmosphere through a non-return valve constituted by an annular valve seat 35 formed on the inside of the tubular member 33 and a valve member 36 urged into contact with the seat 35 by a biassing spring 37 bearing at one end against the valve member 36 and at the other against a plug 38 screwed into the outer end of the tubular member 33. Gas passing the non-return valve escapes to atmosphere through holes 39 in that part of the wall of the tubular member projecting beyond the end cap 12.

As stated above, the valve stem 24 projects through the valve port 18 into the outlet chamber 15. The stem 24 terminates well within the tubular member 33. On the valve stem 24 between the valve seat 19 on the valve port 18 and the valve seat 34 on the tubular member 33, is slidably mounted a valve disc 40, the diameter of which is such that the disc can engage either the valve seat 19 or the valve seat 34 to close the valve port 18 or the vent respectively. The valve disc is biassed towards a shoulder 41 formed on the stem 24 at a point such that the shoulder 41 lies approximately within the valve port 18 when the knob 27 is in contact with its stop 31, by a light spring 42 surrounding the valve stem and bearing at one end against the valve disc 40 and at the other against a nut 43 mounted on a terminal threaded portion 44 of the valve stem 24. The compression of the spring 42 is adjusted by rotation of the nut 43 to give sufficient pressure between the valve disc 40 and the seat 19 to seal the valve port 18 against the gas pressure in the inlet chamber 14 when the resuscitator is set to deliver oxygen under a positive pressure.

In operation, the inlet port 16 is connected to the delivery tube of the resuscitator and the outlet port 17 to a face mask. If the patient is incapable of spontaneous breathing, the resuscitator is set to produce a continuous flow of oxygen under a positive pressure. The pressure of the gas within the inlet chamber 14 acting upon the diaphragm 20 moves it in an outward direction until further movement of the diaphragm 20 is prevented by abutment of the knob 27 against the flange 31. This movement of the diaphragm 20 brings the valve disc 40 into sealing engagement with the valve seat 19 to close the valve port and so cut off the supply of gas to the outlet port 17. (Figure 1.)

The face mask is then applied to the patient and the knob 27 is manually depressed to move the diaphragm 20 inwardly until the valve disc 40 is brought into sealing engagement with the valve seat 34 to close the vent, thus allowing oxygen to flow from the inlet chamber 14 through the valve port 18 to the outlet chamber 15 and thence to the patient and at the same time cutting off any flow of gas through the vent. (Figure 2.)

After a time delay sufficient for the lungs of the patient to have become inflated, the knob 27 is released, allowing the diaphragm 20 to move outwardly under the influence of the gas pressure in the inlet chamber, until the valve disc 40 again closes the valve port 18. At the same time the vent is opened permitting exhaled gas to pass through the tubular member 33, past the non-return valve 36 and out through the holes 39 to atmosphere. (Figure 3.)

This cycle is repeated at rhythmical intervals until resuscitation is complete and the patient is able to breathe spontaneously.

At this point the resuscitator is reset to the demand or intermittent flow position and the operator ceases to apply pressure to the knob 27. Since there is now no positive pressure in the inlet chamber 14, the diaphragm 20 tends to take up a neutral position in which the valve disc 40 is between the seats 19 and 34 but not in engagement with either, so that both the valve port 18 and the vent are open. When the patient inhales, a negative pressure is produced in the outlet and inlet chambers and the diaphragm 20 is sucked inwardly moving the valve disc 40 into sealing engagement with the seat 34 to close the vent and to open the valve port 18 fully, as shown in Figure 2. Gas from the machine can then flow directly to the patient. When the patient exhales, a positive pressure is set up in the inlet and outlet chambers, and the diaphragm 20 is moved outwardly thereby, thus moving the valve disc 40 into sealing engagement with the seat 19 to close the valve port 18, thus stopping the flow of gas to the patient, and to open the vent for the passage of the exhaled breath to atmosphere, as shown in Figure 3.

If when the resuscitator is set to provide a continuous flow of gas under a positive pressure, the patient becomes capable of spontaneous breathing and tries to inhale when the knob 27 is not depressed and the valve port 18 is closed, the slight negative pressure produced in the outlet chamber 15 by the patient's effort to inhale is sufficient to cause the valve disc 40 to slide on the valve stem 24 against the biassing spring 42, thus breaking its sealing engagement with the valve seat 19 and opening the valve port 18 to permit gas to flow to the patient.

Referring now to Figures 4 and 5, these illustrate a modification of the valve means of Figures 1, 2 and 3, in which a light negative pressure is created in the outlet chamber 15 during the expiratory phase of positive pressure breathing to assist in emptying the lungs of the patient.

In this modification, the end of the valve stem 24 within the tubular member 33 is bored at 45 to form a nozzle, the bore 45 terminating in a cross-bore 46 opening at the surface of the stem 24 through orifices 47 between the shoulder 41 and the nut 43 which are within the inlet chamber 14 when the valve disc 40 is in sealing engagement with the seat 19 to close the valve port 18. The nozzle formed by the bore 45 is arranged to co-operate with a venturi tube 48 forming an upward extension of the non-return valve seat 35 and terminating within the tubular member 33. The bore 45 is kept in axial alignment with the venturi tube 48 by means of a perforated plate 49 mounted on the stem 24 by means of the nut 43 and adapted to slide within the tubular member 33. The valve disc 40 is provided with an upstanding collar 50 surrounding the stem 24 and adapted to obturate the orifices 47 when the valve disc 40 abuts against the shoulder 41. In this modification, the shoulder 41 is located at a point on the stem 24 such that the orifices 47 are not obturated by the collar 50 when the valve disc 40 is in sealing engagement with the seat 19 to close the valve port 18.

In operation, under positive pressure conditions, during the expiratory phase of the breathing cycle when the valve port 18 is closed as hereinbefore described, the gas under pressure in the inlet chamber 14 enters the bore 45 through the orifices 47 and the cross-bore 46 and issues thence as a jet into the venturi tube 48 before passing to atmosphere through the non-return valve. The action of the jet and venturi creates a slight negative pressure in the outlet chamber 15 and increases the exhalatory flow. (Figure 4.)

During the inspiratory phase of the breathing cycle, the valve disc 40 is moved along the valve stem 24 by the biasing spring 42 until the collar 50 abuts against the shoulder 41 and thereby obturates the orifices 47. Wastage of gasd uring this phase of the cycle is thus prevented. (Figure 5.)

I claim:

1. For controlling the flow of an inhalant gas to a face mask from means for supplying inhalant gas, alternatively continuously under at a positive pressure and according to the demand of a patient, valve means comprising a casing, a partition mounted within said casing to define with the walls thereof an inlet chamber and an outlet chamber, an inlet port in the wall of said inlet chamber arranged to be connected to said inhalant gas supply means, an outlet port in the wall of said outlet chamber arranged to be connected to said face mask, a vent in said outlet chamber communicating with the atmosphere through a non-return valve, a valve port in said partition affording communication between said inlet and said outlet chambers, a pressure responsive member mounted within said inlet chamber and exposed on one side to the pressure within said inlet chamber and on the other to atmospheric pressure, a valve member carried by said pressure responsive member and movable between a position closing said valve port and a position closing said vent, and manually-operable means for moving said valve member in a direction to open said valve port and close said vent, whereby under positive pressure conditions, said valve

member is held in the position in which said valve port is closed and said vent is open by the pressure of the inhalant gas in said inlet chamber acting on said pressure-responsive member and is moved to the position in which said valve port is open and said vent is closed by operation of said manually-operable means during each inspiratory phase, and under demand conditions, on inhalation said valve member is moved to open said valve port and close said vent under the influence of a negative pressure acting on said pressure-responsive member and on exhalation said valve member is moved to close said valve port and open said vent under the influence of a positive pressure acting on said pressure-responsive member.

2. Valve means according to claim 1 wherein means are provided to permit said valve member to open said valve port in response to inspiratory effort by the patient during the expiratory phase of the breathing cycle under positive pressure conditions.

3. Valve means according to claim 2 wherein said means for permitting said valve member to open said valve port comprises a valve stem carried by said pressure responsive member on which said valve member is arranged to float, and a light spring arranged to bias said valve member in the direction to close said valve port.

4. Valve means according to claim 1 wherein means are provided for producing a slight negative pressure in said outlet chamber during the expiratory phase of the breathing cycle under positive pressure conditions, whereby emptying of the lungs of the patient is assisted.

5. Valve means according to claim 4 wherein said means for producing a slight negative pressure in said outlet chamber comprises a venturi and a nozzle co-operating therewith adapted to pass a jet of inhalant gas under pressure to said venturi during the expiratory phase of the breathing cycle under positive pressure conditions.

6. Valve means according to claim 1 wherein means are provided for admixing atmospheric air with said inhalant gas under demand conditions.

7. Valve means according to claim 6 wherein said means for admixing atmospheric air with said inhalant gas comprises an air inlet port in the wall of said outlet chamber communicating with the atmosphere and adapted to be closed when such admixture of air with the inhalant gas mixture is not required.

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