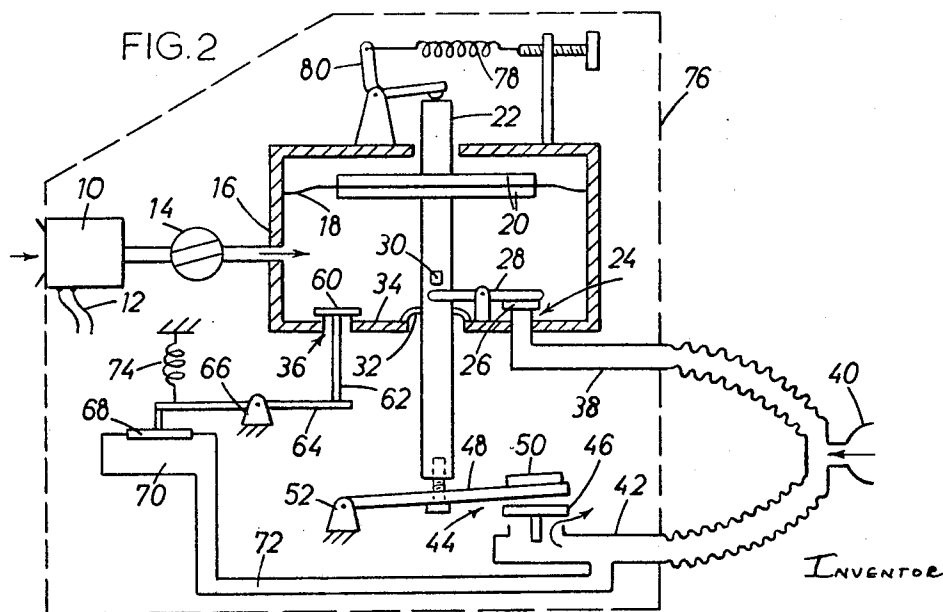
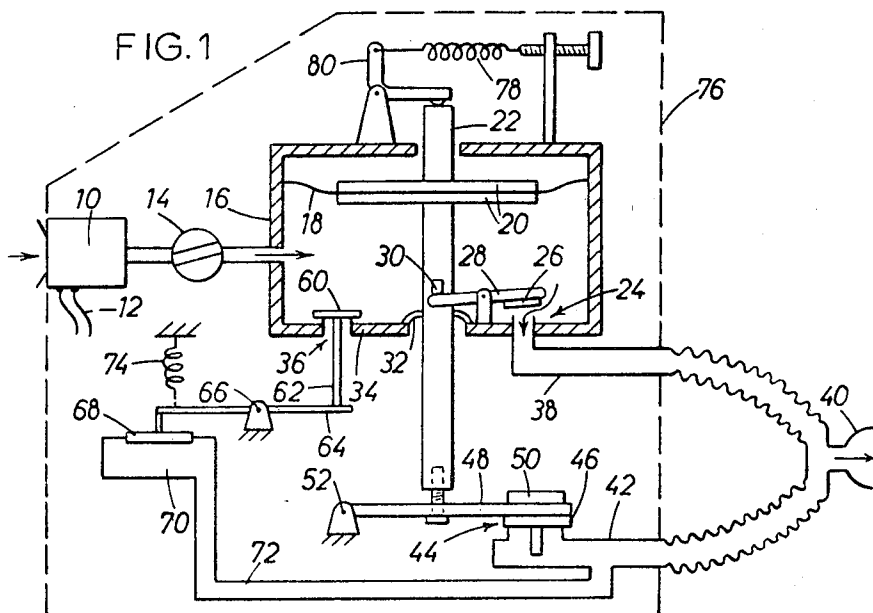


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PATIENT CONTROLLED RESPIRATORY APPARATUS

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PATIENT CONTROLLED RESPIRATORY APPARATUS

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ABSTRACT OF THE DISCLOSURE

A respiratory machine particularly for domestic use has a continuously-fed expansible-contractible chamber with a flexible diaphragm whose movements actuate an outlet valve through which the chamber contents pass to a user. A vent valve opened by an attempt to inhale by the user allows the chamber to contract thereby opening the outlet valve and supplying the user with his air or gas requirements.

This invention relates to a respiratory machine and particularly though not exclusively to a respiratory machine of such a character as regards size, complexity, and safety that it can be conveniently utilized in the home to assist the breathing of persons suffering from bronchial troubles, asthma, and the like.

According to the present invention, a respiratory machine adapted to supply a user according to his requirements when fed with gas comprises an expansible and contractible reservoir having an outlet valve which when open permits gas to pass to the user, means for opening the outlet valve in response to a predetermined contraction of the reservoir, a vent valve which when open permits escape of the contents of the reservoir and consequent contraction thereof, and means for opening the vent valve in response to a sub-atmospheric pressure applied by the user to the machine.

The reservoir of the machine is preferably continuously fed with gas (e.g. atmospheric air) through a flow control valve by a turbine pump. The turbine pump is preferably of the type which can be electrically driven from an electricity supply. The reservoir may be a cylindrical chamber having a rubber or like resilient diaphragm as one of its end walls, and a valve actuating mechanism may be mechanically connected to the diaphragm. Such a mechanism may include a lever connected to a rod or the like secured to the valve member of the outlet valve, the arrangement being such that a predetermined contraction of the reservoir effects pivoting of the lever to open the outlet valve. The vent valve may be a valve having a simple plate-like valve member and the arrangement may be such that the vent valve is kept closed by pressure within the reservoir but is opened by a pressure-responsive operating mechanism. Such an operating mechanism may include a chamber closed by a flexible diaphragm and connected to the exhalation side of a user's face mask.

The outlet valve actuating mechanism may co-operate with an operating mechanism adapted to closing an exhalation valve connected to the face mask in response to contraction of the reservoir, and such an operating mechanism may be arranged so that the outlet valve shuts just before the exhalation valve opens.

The invention will now be more particularly described with reference to the accompanying drawings, which show an illustrative embodiment of a machine according to the invention, and in which:

FIG. 1 shows the machine in its first steady state with the outlet valve open, the vent valve shut, and the gas supplied by the turbine pump passing directly through to the face mask; and

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FIG. 2 shows the machine in its second steady state with the outlet valve shut, the vent valve shut, the exhalation valve open, and the user breathing out freely.

The illustrated machine includes a turbine pump 10, of the type which can be driven by an electric power supply fed along leads 12 from the mains, and which can deliver a flow of about 50 litres per minutes at a pressure of about 50 centimetres of water. The output from the turbine pump 10 is fed through a flow control valve 14 to a cylindrical chamber 16, whose upper wall is formed by a resilient diaphragm 18. This diaphragm 18 may be strengthened over the major part of its area by being clamped between a pair of disc-shaped plates 20. These plates are secured to a rod 22. Alternatively the diaphragm 18 may be bonded to a rigid plate.

The chamber 16 is provided with an outlet valve generally indicated at 24, and this valve has a valve member 26 which is actuated by a valve actuating mechanism including a lever 28 and a projection 30 secured to rod 22. The rod 22 passes through a seal 32 in the lower wall 34 of chamber 16, and a vent valve generally indicated at 36 is also provided in this lower wall.

A pipe 38 connects the outlet valve 24 to one branch of a flexible rubber hose serving to connect a face mask 40 with the pipe 38. Another branch of the rubber hose connects the face mask 40 to a pipe 42 which leads to an exhalation valve generally indicated at 44. The exhalation valve 44 is closed by a valve member 46 engageable by a valve operating mechanism comprising a lever 48 and weight 50, the lever being pivotably mounted on a fixed support 52 within the machine.

Returning now to the vent valve 36, this has a plate-like valve member 60 connected to a stem 62, and is actuated by means of a lever 64 pivoted at 66, as will be hereinafter described. The lever 64 is connected to a diaphragm 68 which closes one wall of a chamber 70. The chamber 70 is connected by a pipe 72 to the exhalation pipe 42. A tension spring 74, connected between lever 64 and a fixed point on the machine, is arranged to exert a force on lever 64 such that it remains just out of contact with valve stem 62 until a sub-atmospheric pressure of about 1 cm. of water or less exists in chamber 70. A screw adjustment or other conventional mechanism can be arranged to adjust the force exerted by spring 74 for the initial setting up of the machine. Upon say 1 cm. of water sub-atmospheric pressure existing in chamber 70, the lever 64 is pivoted counterclockwise against spring 74, thereby opening vent valve 36. The reason for this arrangement will be understood when the operation of the whole machine is described.

The machine is housed in an external casing diagrammatically indicated by the dotted line 76, and the face mask 40 with its two branch pipes can if desired be disconnected from the casing 76.

The operation of the machine can now be described.

Once the machine is switched on, and electrical power supplied through leads 12 to the turbine pump 10, this pump runs continuously, delivering air into chamber 16. As will be seen, the design of this machine is such that it can operate for long periods in either one of two steady states, the first steady state being illustrated in FIG. 1. In this state, the outlet valve 24 is open, and the air supplied by pump 10 to reservoir 16 leaves the reservoir 16 through outlet valve 24 and passes to the face mask 40 and thence to the user. When the user has inhaled sufficiently, he commences to breath out, and the pressure exerted by the user breathing out is exerted on the exhalation valve 44 tending to lift its valve member 46, and also tends to increase the pressure within the reservoir 16, tending to lift diaphragm 18. Consequently, the rod 22, fixedly secured to diaphragm 18, tends to lift, and stud 30 is thus moved upwardly away from lever 28,

allowing valve member 26 to fall and close outlet valve 24. The machine is then in the second steady state illustrated in FIG. 2. In this state, outlet valve 24 and vent valve 36 are closed, and the pump 10 supplies air to reservoir 16 which is closed, thereby lifting diaphragm 18 and rod 22 against the force of a spring 78 acting through a bell crank lever 80. The exhalation valve 44 is now open, and the user exhales freely through the face mask 40 and valve 44. An adjustment means, for example an adjusting screw, may be provided to vary the force exerted by the spring 78.

If now the user wishes to breathe in, and attempts to draw breath in, a slight sub-atmospheric pressure is generated within pipe 42, and therefore also in pipe 72 and chamber 70. The negative pressure in chamber 70 causes diaphragm 68 to be drawn downwardly, thereby opening vent valve 36 as previously described. This permits the gas in reservoir 16 to escape, and with the consequent rapid fall in pressure in reservoir 16, diaphragm 18 moves downwardly, this movement being assisted by spring 78. Towards the end of the movement, projection 30 engages lever 28, pivoting it counterclockwise and opening outlet valve 24. Once the user is supplied through outlet valve 24, the sub-atmospheric pressure no longer exists in chamber 70, and consequently spring 74 is able to pivot lever 64 clockwise, allowing vent valve 36 to close. The machine is then again in the first stable state illustrated in FIG. 1 and air or gas as the case may be passes freely to the face mask via outlet valve 24.

It will be appreciated that if desired the machine can be employed to administer an anaesthetic gas merely by connecting the inlet of pump 10 to a supply of the appropriate nature.

In a practical embodiment, the type of turbine pump 10 used is such that it generates a pressure of 50 cms. water maximum. This means that the pressure on the top of valve member 60 is never greater than 50 cms. water. The ratio of the area of diaphragm 68 to the area of the top of valve member 60 is roughly 100:1, so that a sub-atmospheric pressure of 1/2 cm. water will overcome this pressure.

Valve 44 is a non-return valve which operates in both cycles so that when the weight 50 is lifted up by the lever 48, the non-return valve remains closed until the user exhales. The reason for this is so that the patient can breathe out through the non-return valve, but when he generates a sub-atmospheric pressure it is transferred to chamber 70, as valve 44 is then closed.

Modifications can be made within the scope of the invention, for example, other forms of mechanical linkage could be used as the actuating mechanism for opening the outlet valve in the manner described, and equally other mechanisms will occur to those skilled in the art as possible substitutes for the exhalation valve operating mechanism and the vent valve pressure responsive actuating means.

I claim:

1. A respiratory machine adapted to supply a user according to his requirements when fed with gas comprising:

- (a) an expansible and contractible reservoir in the form of a chamber having one wall constituted by a flexible diaphragm;

- (b) a strengthening disc mounted on the said diaphragm;
- (c) a rod secured to the said disc;
- (d) a projection extending laterally from the rod;
- (e) an outlet valve mounted in a wall of the said chamber;
- (f) means connecting the outlet valve to a user's face mask or the like so that when the outlet valve is open gas can pass from the interior of the chamber to the user;
- (g) an actuating mechanism for the outlet valve including a pivotable lever adapted to engage the said projection whereby axial movement of the rod in one direction consequent upon contraction of the said reservoir opens the outlet valve;
- (h) a vent valve for the chamber which when open permits escape of the contents of the reservoir through the said vent valve;
- (i) a diaphragm-actuated mechanism operatively connected to the vent valve for opening the same in response to a sub-atmospheric pressure applied by the user to the machine and sensed by the diaphragm of the said mechanism; and
- (j) a source of breathable gas in fluid communication with said chamber.

2. A machine according to claim 1 including a pivoted and spring-biased lever operatively connected with the diaphragm of the said mechanism in which the spring biasing of the said lever is such that the said vent valve is opened in response to a pressure of about 1 cm. of water below atmospheric.

3. A machine according to claim 1 including an exhalation valve for the user connected to the said means connecting the outlet valve to a user's face mask or the like and an exhalation valve operating mechanism adapted to cooperate with the outlet valve actuating mechanism so that the outlet valve shuts just before the exhalation valve opens.

4. A machine according to claim 1 including a spring or the like arranged to bias the diaphragm in a direction tending to reduce the volume of the reservoir.

5. A machine according to claim 4 including adjusting means adapted to vary the force exerted by the spring or the like.

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