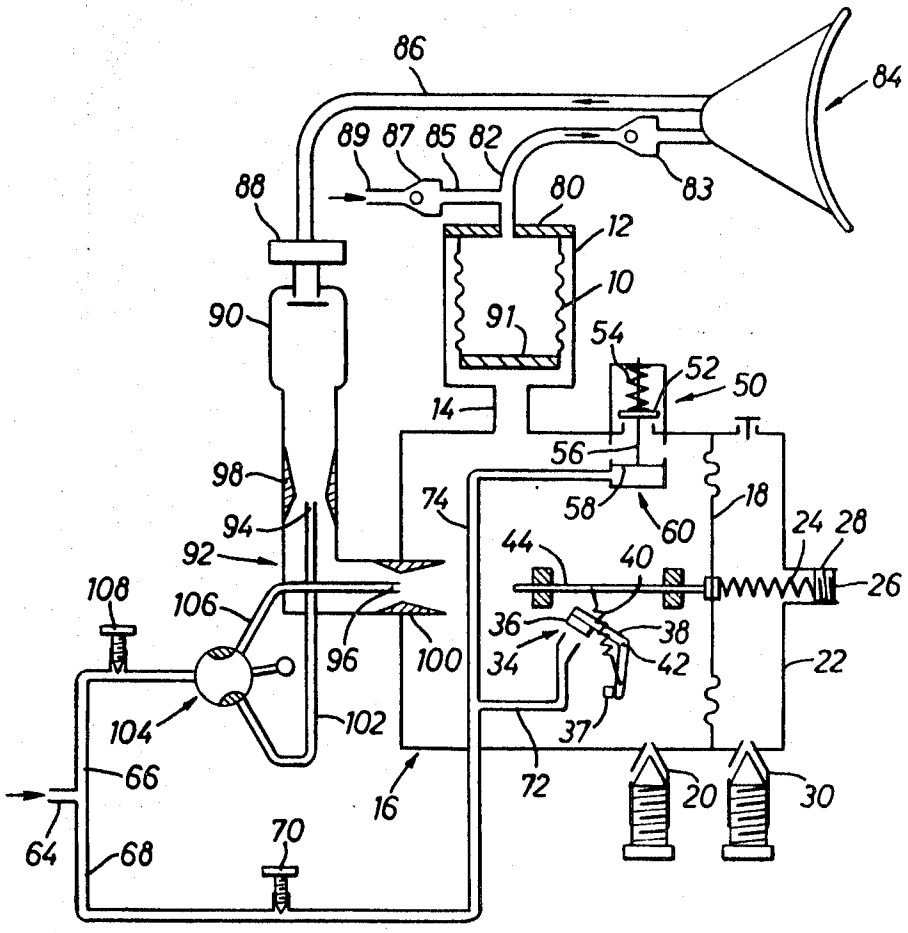
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VENTILATING MACHINE

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VENTILATING MACHINE

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ABSTRACT OF THE DISCLOSURE

A ventilation machine particularly for surgical use allows a full facility for adjustment of inhalation and exhalation duration and pressure. The machine is actuated by an over-centre toggle mechanism responsive to the volume of a control chamber. The latter is connected to a chamber containing a bag from which gas is forced to the user.

This invention relates to a ventilation machine, and in particular to a ventilation machine for use in hospital operating theatres for supplying air, gas or air-gas mixtures to a user who will normally be a patient undergoing surgery. In this specification, the term 'gas" will be used to include air alone, oxygen alone, and air-gas mixtures or mixtures of oxygen with another gas or gases for example an anaesthetic gas.

It is an object of the invention to provide a ventilation machine driven by gas pressure and requiring no other external power.

It is another object of the invention to provide such a machine which is of reliable design which will require a minimum of maintenance.

It is a further object of the invention to provide such a machine in which the patient or other user can be assisted to exhale by suction, or can be required to exhale against a positive pressure.

It is yet another object of the invention to provide a simple volume-cycled machine facilitating the making of a large number of adjustments by the anaesthetist, for example, inspiratory and expiratory pressure, and duration of inhalation and exhalation phases.

According to the present invention in its general aspect, there is provided a ventilation machine comprising a variable volume chamber adapted to be connected to a face mask for a user and to be contracted to force gas to the user by pressure of gas within a variable volume control chamber, an over-centre toggle mechanism responsive to the control chamber volume and arranged to actuate a first valve which can allow gas into the control chamber and a second valve which can be actuated to allow exit of gas from the control chamber.

The second valve may be actuated in response to closure of the first valve.

Advantageously, a bleed orifice in the control chamber is provided to allow slow escape of gas from the control chamber. This, as will be seen, permits alteration of the duration of the inspiration phase. For this purpose, the bleed orifice is of adjustable size.

The over-centre toggle mechanism may be connected to a flexible diaphragm partially bounding the variable volume control chamber. A further chamber may be located on the opposite side of the flexible diaphragm from the over-centre toggle mechanism, and the said further chamber may have a bleed orifice therefrom. The pressure applied within this further chamber has a biasing effect on the flexible diaphragm, and by adjusting the pressure in the further chamber, it is possible to permit selection of the duration of the user's expiratory phase.

The flexible diaphragm is preferably biassed inwardly relative to the control chamber by a spring. The spring may be adjustably mounted so that the force exerted by it on the flexible diaphragm can be varied. This allows adjustment of the inspiratory pressure.

The invention will be better understood from the following particular description of an illustrative embodiment thereof, given with reference to the accompanying drawing, which is a diagrammatic representation of one embodiment of apparatus according to the invention.

The illustrated ventilation machine comprises a variable volume chamber **10** constituted by a bellows located within a glass jar **12**, the interior of the jar being connected by a pipe **14** to a variable volume control chamber **16**. This chamber is bounded on one side by a flexible diaphragm **18**. The control chamber **16** has a bleed orifice **20** therefrom constituted by a needle valve, and the casing of control chamber **16** is contiguous with the casing of a further chamber **22**. This chamber **22** is also bounded by the diaphragm **18**. A compression spring **24** is located between the flexible diaphragm **18** and an adjustable mounting **26**. The adjustable mounting **26** may for example comprise an abutment located within a threaded tubular part **28** of the wall of the chamber **22**, in such a way that the abutment can be screwed inwardly or outwardly by an externally-applied tool. The chamber **22** has a bleed orifice **30** therefrom, also constituted by an adjustable needle valve.

The control chamber **16** has a first, or gas entry, valve **34** having a valve member **36**. The valve member **36** is mounted on pivoted lever **38** which in conjunction with a spring **40** constitutes an over-centre toggle mechanism. The spring is connected to a rod **44** secured to the flexible diaphragm **18** and the lever **38** is pivoted at **42**.

The control chamber **16** has a second, or gas exit, valve **50** in the wall thereof, the said valve having a valve member **52** and being biassed to a closed condition by a compression spring **54**. Its valve member **52** is secured to a rod **56** whose other end is secured to a diaphragm **58** bounding a small cylindrical closed volume **60**.

The ventilation machine includes a gas supply tube **64** which branches into sections **66** and **68**. Section **66** leads to a double-Venturi arrangement which will be shortly described, and section **68** leads via a needle valve **70** (which is used to adjust the flow rate) to a first branch **72** leading to the first valve **34** and a second branch **74** leading to the interior of the cylindrical volume **60**. Thus when the valve **34** is open gas is supplied from a pump, not shown, but connected to tube **64**, to the interior of the control chamber **16**. When the valve **34** is closed gas is supplied to the interior of the cylindrical volume **60**.

The roof **80** of the glass jar **12** is rigid and serves to mount the bellows **10**, and has an orifice therein by which the interior of the bellows **10** is connected via a tube **82** to a face mask, diagrammatically indicated at **84**, for the user. The bellows **10** is normally held expanded by the weight of a plate **91** forming its bottom wall. The face mask **84** is also connected, via a tube **86**, to a bacterial filter **88**, which may be dispensed with if desired, and then to an expiratory valve **90**. This valve is a non-return valve and allows expiration of air through tube **86** but does not allow inspiration of air through that tube. In a similar way, the tube **82** contains a non-return valve **83** assuring that the user can inhale the contents of the bellows **10** but cannot exhale into the bellows **10**. A tube **85** is connected to the tube **82** and contains a non-return valve **87**. The end **89** of the tube is open to the atmosphere. This arrangement allows air to enter the bellows **10** when they expand. This expansion occurs due to the weight of the plate **91** when the pressure is removed from the interior of the glass jar **12**.

Exhalation is assisted by the double-Venturi system generally indicated at **92**. This system includes two nozzles, **94**, and **96**, directed at right angles to one another and each extending into a surrounding tube narrowed as indicated at **98** and **100** respectively to provide a Venturi effect. The nozzle **94** is supplied via pipe **192** from an expiration pressure adjusting tap **104**, and the nozzle **96** is supplied from the same tap via a tube **106**. The tap **104** is supplied from branch section **66** via a flow-regulating needle valve **108**. In normal use, the setting of needle valve **108** is such that the flow through the valve **70** provides sufficient pressure in the line **74** to overcome the spring **54** when the valve **34** is closed. The normal setting of the valve **70** is of course consistent with the foregoing requirement and with the requirement that the maximum flow rate through needle valve **70** is less than the flow rate through the valve **34** when open. This ensuures that when the valve **34** is open, pressure in the control chamber cannot build up, so that the spring **54** holds the valve **50** closed.

With this arrangement it will be seen that if the valve **104** is altered so that gas is solely supplied along tube **106**, then the expiratory pressure applied to the patient will be at its minimum value. In fact a suction will be so applied. Likewise, if the tap **104** is turned so that all the air supplied along branch section **66** is fed through tube **102**, and none through tube **106**, the suction effect applied to the face mask will be minimal and in exhaling, the user will have to overcome a positive pressure opposing such exhalation.

The operation of the apparatus will now be described.

Starting for the sake of example during the inspiratory phase, the first valve **34** is open (as shown in the drawing) with the valve member **36** being urged against a suitable stop **37** by the tension spring **40**. Gas is being supplied (a) from the pump via tubes **64**, **68** and **72** and (b) from the nozzles **94** and **96** to the interior of the control chamber **16** and thence to the interior of the chamber **12**. It will be understood that non-return valve **90** is closed. The bellows **10** is therefore compressed, and the gas therein is expelled via tube **82** and **83** to be inhaled by the user. While this occurs, the gas exit valve **50** is closed and pressure gradually builds up within the control chamber **16** at a rate determined by the rate of leaking of gas through bleed orifice **20** out of the chamber **16**. The build-up of pressure can be made slower by opening the adjustable orifice **20**. As the pressure increases in control chamber **16**, the flexible diaphragm is distended and therefore moves in a direction to the right as seen in the diagrammatic drawing against the spring **24** and against the pressure within the further chamber **22**. This draws the rod **44** to the right, to a position where it trips the over-centre toggle mechanism **36**, **38**, **40**, **42** thereby pivoting the lever **38** in an anti-clockwise direction and closing the valve member **36** to the body of the valve **34**, thereby closing the gas entry valve **34**. The gas supplied along tube **68** then flows via tube **74** to the cylindrical chamber **60**, distends the diaphragm **58**, and lifts the valve member **52** to open gas exit valve **50**. Gas then quickly escapes from the interior of the control chamber **16** through the valve **50**, and with the reduction in pressure within chambers **12** and **16** the bellows are free to assume their expanded condition. An arrangement, not shown, is provided to ensure that in so doing the bellows **10** fill with air or from atmosphere with oxygen or other gas as may be required by the medical or surgical staff in charge of the machine. The shutting of valve **34** marks the end of the inspiratory phase, and the expiratory phase commences. During this phase, air is sucked from the user via tube **86**, filter **88**, expiratory valve **90**, through the action of the Venturi system **92**. For convenience, though this is not an inherent feature of the invention, the exhaled gas is passed into the interior of control chamber **16** as illustrated.

With the reduction in pressure within the control chamber **16**, the diaphragm **18** moves under the action of the spring **24** and pressure within further chamber **22** in a direction to the left, until the rod **44** is thereby moved a distance such that the over-centre toggle mechanism **36**, **38**, **40**, **42** is again triggered. When this occurs, the first valve **34** is opened and the inspiratory phase again commences. It will be seen that the sequence of events described above will occur repeatedly.

By adjusting the spring abutment **26** the inspiratory pressure may be adjusted, and by adjusting the bleed orifice **30** the rate at which the diaphragm **18** moves to the right can be altered, thereby adjusting the duration of the expiratory phase. By adjusting the bleed orifice **20**, the rate at which pressure builds up within the control chamber **16** can be selected, thereby allowing alteration of the duration of the inspiratory phase. By suitable adjustment of the tap **104**, the expiratory suction or pressure applied to the user can be varied.

Among the advantages of the machine described herein are that it can be operated with a relatively simple pump supplying compressed air or gas at a pressure of only about 2–3 lbs. per square inch, and that the simplicity of the cycling mechanism is conducive to durability and easy maintenance.

The specific embodiments described and illustrated herein is of course exemplary and not limitative and modifications will occur to one skilled in the art.

I claim:

1. A ventilation machine comprising:

(a) a first variable volume chamber having a moveable wall;

(b) a second variable volume chamber in communication with said first variable volume chamber, associated in such a manner that changes in the pressure of said first variable volume chamber produce corresponding changes in the volume of said second variable volume chamber;

(c) a face mask connected to said second variable chamber by means of which a user can breathe;

(d) A tube connected at one end to said face mask and at the other end to said first variable volume chamber, said tube having a pair of narrowed portions in the interior thereof;

(e) A pair of nozzles disposed within the tube, each nozzle cooperating with a narrowed portion to provide a venture effect, said nozzles oriented in different directions in the tube so that one of the nozzles provides suction tending to draw gas from the face mask and the other provides suction tending to draw gas from the interior of said first variable volume chamber, said nozzles arranged to allow adjustment of the expiratory pressure applied to the user;;

(f) means for connecting said nozzles to a pressurized gas source;

(g) an over center multi-position toggle mechanism responsive to pressure variations in said first chamber;

(h) a first valve connected to the toggle mechanism opening and closing in response to the movement of the toggle mechanism for controlling the entry of gas into said first variable volume chamber;

(i) means for connecting said valve to a pressurized gas source; and

(j) an exit valve in the first variable volume chamber responsive to pressure in said first chamber.

2. A machine as claimed in claim **1**, wherein the exit valve in said first chamber is biased in a closed position and opens in response to the closing of said first valve.

3. A machine as in claim **1**, wherein said first chamber has a bleed orifice.

4. A machine according to claim **3**, wherein said bleed orifice is adjustable in order to vary the duration of the users inhalation phase.

5. A machine as in claim **1**, wherein the moveable wall in said first variable volume chamber partly defines a

third variable volume chamber having an adjustable bleed orifice in order to provide a selected rate of reduction of pressure in said third chamber to permit selection of the duration of the users expiratory phase.

6. A machine according to claim 5, wherein the moveable wall is a flexible diaphragm including a spring means biasing the diaphragm inwardly relative to the first variable volume control chamber.

7. A machine according to claim 6, wherein said spring means includes means for adjusting the force of the spring.

8. A machine according to claim 1, wherein the nozzles are directed in perpendicular directions.

9. A machine according to claim 5, wherein said over center multi-position toggle mechanism is connected to and operated by the movement of the moveable wall in said first variable volume chamber.

References Cited

UNITED STATES PATENTS

2,766,753 10/1956 Koch et al. ---------- 128—145.8

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J. B. MITCHELL, Assistant Examiner

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,621,842 Dated November 23, 1971

Inventor(s) ROGER E. W. MANLEY

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 7, correct to read -- Claims priority,

application Great Britain, July 5, 1968, --

Signed and sealed this 6th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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