VOLUME CYCLED MEDICAL VENTILATORS

Filed Oct. 13, 1964
VOLUME CYCLED MEDICAL VENTILATORS
Filed Oct. 13, 1964, Ser. No. 403,666
Priority application filed in United Kingdom, Oct. 15, 1963, 40,548/63
4 Claims. (Cl. 137—624.14)

ABSTRACT OF THE DISCLOSURE
A volume cycled medical ventilator includes a bellows for supplying gas to a patient during an inhalation period through a changeover valve in a first position and a valve controlling mechanism for moving the valve to a second position to allow the patient to exhale to atmosphere in a expiration period. The valve controlling mechanism is moveable by a lever connected to the bellows to effect a change between the inhalation and exhalation periods when the volume of gas in the bellows reaches maximum or minimum limits. The valve controlling mechanism includes magnetic means for holding the valve in the first or second position against the bias of springs until the change in volume of the bellows increases the spring pressure enough to overcome the magnetic means. Consider the specification for further details and features of the invention.

This invention relates to medical ventilators used to supply air, oxygen or anaesthetic gases to a patient in the application of artificial respiration or for anaesthetic in anesthesia. Modern ventilators control the supply of gas to the patient during inspiration periods, and permit or encourage the emptying of the patient's lungs during an ensuing expiration period. It is customary to provide means for controlling the rhythm of the machine, and this may be determined by sensing the volume or pressure of the gas, or by timing the duration of the two periods in each cycle. When used with a gas supply giving a constant rate of flow, the time, pressure and volume are related, but the ventilator is said to be time-cycled if it normally supplies gas for a pre-determined period; pressure-cycled if it supplies gas until a pre-determined pressure is achieved, and volume-cycled if it measures a pre-determined volume of gas to be delivered to the patient in each cycle. The motive energy for the cycling means may be derived from an external source, such as an electrical power supply, an additional supply of gas under pressure, or they may be activated entirely by the gas supply for the patient, either by permitting a certain wastage of gas to operate a change-over mechanism, or by storing energy during one period by compressing a spring, for example, and utilizing the stored energy to motivate the second period of each cycle, to give a completely self energised machine.

The advantage of simplicity and portability has led to several proposals for self energised volume-cycled ventilators, in which gas is fed to a bellows during an expiration period whilst the gas is emptying from the patient's lungs via an outlet valve to atmosphere, and upon the bellows expanding to a pre-determined size, a change-over mechanism is actuated upon the bellows to close the outlet valve and open an inlet valve to permit gas from the bellows to be fed to the patient, the bellows being urged to contract by a spring, or the like. Upon the bellows contracting to a second pre-determined size the change-over mechanism is again operated by the bellows, to terminate the inspiration period and commence a new cycle. Attempts to provide volume-cycled ventilators of this type have taken various forms, but no machine has met with universal acceptance, because it has proved difficult to supply a change-over mechanism capable of simple operation yet giving adequate sensitivity and accuracy, and furthermore, in some conditions met with in normal practice, these machines have been known to stall, that is to say, the rhythmic cycling has ceased. One object of the present invention is to provide a self energised volume-cycled ventilator that is simple to operate, yet at the same time accurate and reliable in use.

The present invention is a volume cycled medical ventilator including a bellows to which gas is fed during the expiration period when gas already in the lungs of a patient is being exhausted therefrom, and a change over mechanism operated upon the bellows expanding by a pre-determined amount due to the gas flowing into the bellows, the operation of said change over mechanism opening a valve to initiate the inspiration period and allowing the gas in the bellows to flow out during the inspiration period under the action of spring means or the like acting on the bellows until the bellows is contracted to a position at which the change over mechanism is again operated to close the valve in the outlet from the bellows and allow the next expiration period to commence during which the gas fed to the bellows again expands the bellows. One feature of the present invention is a self energised volume-cycled medical ventilator employing a valve for the control of gas flow from a bellows, in which spring means or the like are adapted to urge said valve towards the closed position and a magnetic circuit including a portion movable with said valve is provided to hold said valve in the open position against the pressure of said spring means when the air gap in said magnetic circuit is less than a pre-determined size, and means associated with the expansion and contraction of the bellows of said ventilator, mechanically to move said valve and movable portion to a position at which the air gap exceeds said pre-determined size whereupon said spring urges said valve to the closed position.

According to a further feature of the present invention a self energised volume-cycled medical ventilator employs a change-over mechanism for the control of gas flow between a bellows of said ventilator and a patient, and between the patient and an outlet to atmosphere, an inlet valve and an outlet valve linked to move together in which said inlet is held in the open position by a magnetic circuit until an air gap, introduced into said magnetic circuit by the contraction of the bellows of said ventilator, exceeds a predetermined size, whereupon spring means or the like urge said inlet valve closed and said outlet valve open, said outlet valve then being held open by a further magnetic circuit until an air gap is introduced in said further circuit by the expansion of said bellows.

According to yet another feature of the present invention a bellows operated volume-cycled ventilator employs a pressure relief valve connected in the gas circuit at a point between the inlet valve and the outlet valve, and controlling a further outlet to atmosphere, said relief valve being urged to the closed position by spring means, or the like, and a magnetic circuit associated with said valve and including a portion moving with said valve, said magnetic circuit being adapted to hold said valve open when the air gap in said magnetic circuit is reduced below a predetermined size by the pressure in said gas circuit, and means associated with the contraction of the bellows of said ventilator to introduce an air gap in said magnetic circuit greater than said pre-determined size, whereupon said spring means urge said relief valve to the closed position.

In an arrangement such as the above a gas operated
3. The resonator is connected in the gas circuit controlled by the pressure relief valve such that the resonator is excited by the passage of gas to atmosphere through the pressure relief valve giving audible warning of the pressure relief being in the open position.

The above and other features of the invention will be more readily understood by a perusal of the following description having reference to the accompanying drawing which is a diagrammatic representation of a ventilation system in accordance with the present invention.

The apparatus comprises a bellows 1 which is connected to a supply attached to an input port 2. The gas supply may include means for providing a constant flow of gas, and the input to the bellows may be controlled by a valve adapted to prevent over-expansion of the bellows.

The bellows is connected to a lever in the form of a movable plate 3, which is hinged to rotate at pivot 4, so that as the bellows is expanded by the incoming gas, both plates rotate in a clockwise direction due to the weight of the plate 3. An outlet 5 from the bellows, which leads to a valve assembly 6, and all of the subsequent gas circuit with the exception of a variable constriction 10 (hereinafter described), is of a sufficiently large diameter to allow a substantial rate of gas flow. The valve assembly 6 comprises two valves, 6A and 6B, coupled by a rod 6D. The inlet valve 6A is shown in the closed position, and the outlet valve 6B is shown open, the valves being separated by a gas tight seal 6C. In the position shown, incoming gas from the supply 2 has caused the bellows to expand, and a patient using the machine is free to breathe out via a connection 7 and an outlet 8 to atmosphere. As will be explained later, expansion of the bellows to a predetermined volume causes a change in the mechanism 9 for moving the valve assembly 6 to an alternative position, in which the valve 6B prevents gas passing from the patients lungs to atmosphere, and valve 6A opens to permit gas from the bellows to pass via the variable constriction 10 and a connection 11 to the patient. For any given volume of gas, the duration of the expiration period is determined by the rate of flow from the supply, but as the pressure of gas increases, the duration of the inspiration period is determined by the setting of the variable constriction 10. To prevent the machine from stalling in certain adverse clinical conditions, a pressure-relief valve 12 is connected to the connection 11. A valve-plunger 13 prevents the escape of gas to atmosphere via outlet 14 during normal working, but as the pressure of gas increases, the valve 13 rises the plunger 13 and its associated magnetic member 15 is forced to move against a spring 16 towards a magnet 17, and at a predetermined pressure level the plunger will reach a position in which the air-gap in the magnetic circuit is small enough to permit the magnet 17 to overcome the spring 16 and so pull the plunger 13 to the open position and hold it there. A reduction in the volume of the bellows as gas passes to atmosphere via outlet 14 causes the plate 3 to descend, and at the end of the inspiration period a pin 18 attached to the plate strikes a member 19 attached to the plunger 13, causing the magnetic member to move away from the magnet 17. Spring 16 closes the valve thus blocking outlet 14. The magnet 17 is adjustable mounted in the valve 12, and the point of engagement of members 18 and 19 may be adjusted to give precise operation.

The mechanism 9 for changing the position of valve assembly 6 utilizes a lever 20, pivotally mounted at 21 and linked to the valve rod 6D at 22. Attached to the lever 20 are two magnetic members 23, 24. Two permanent magnets 25, 26 are mounted on the supporting framework to contact the members 23, 24. In the expiration position, as shown, member 23 is held by magnet 25, so holding the inlet valve 6A closed, the power of the magnet being sufficient to overcome the pressure of a spring 27 on a rod 28 slidably mounted in the lever 20. The expanding bellows moves the plate 3 until the rod 28 contacts the edge 30 upon the rod 28 with sufficient force to compress spring 27 and to move the magnetic member 23 away from the magnet 25, whereupon the spring 27 forces the lever 20 to rotate until magnetic member 24 engages with magnet 26 which holds the lever in position with outlet valve 6B linked to an inspiration period. Means may be provided to adjust the position of magnets 25, 26, on the supporting framework (not shown).

The inspiration period is terminated when contraction of the bellows has permitted the plate 3 to move to a position in which a rod 31 slidably mounted in the lever 20 is engaged by a disc 32, fixed on the plate 3, with sufficient force to compress a spring 33 and to move the magnetic member 24 away from the magnet 26, whereupon the spring 33 will move the lever 9 back to the expiration position.

Control of the volume of gas delivered in each cycle is provided by adjustment of the wedge 30, having a pivot 34 adjustably positioned on the supporting framework (not shown). Movement of the pivot 34 towards a point 35 will reduce the volume of gas delivered as the movement of plate 3 requires to engage rod 31 will be reduced, whilst movement of the pivot 34 in the other direction, towards a point 36 will increase volume of gas delivered. This adjusting movement may be provided in a number of ways, e.g. by a chain passing over a rotary drive shaft. This would permit the control to be obtained by rotation of a conventional pointer knob on the front panel of the machine, and has been found to be more desirable than a slide adjustment. The wedge 30 can also be used to provide for setting the machine to function with a manual control bag, as is often required in anaesthesia, by arranging that in the extreme position, in the region of point 35, the wedge 30 applies holding pressure upon rod 28, so that no movement of the plate 3 occurs and the inlet valve 6A remains open.

The ventilator described may be used with closed circuit breathing techniques, and negative pressure can be obtained by attaching suction means to outlet 8 to provide a negative phase. One-way valves, and safety valves may be fitted, and auxiliary items may be incorporated, for example a pressure gauge may be connected to the connection 11, and a volumeter may be attached at outlet 8.

Choice of the spring pressures and magnets, provides a precise and reliable operation, and facilitates the production of machines having constant and readily controllable characteristics. Various modifications can be made without departing from the scope of the invention, for example a single magnetic member could be used in place of the two members 23, 24. Furthermore a permanent magnet could be made to move with respect to a stationary magnetic member, or both the moving and stationary portions of a magnetic circuit could be formed by permanent magnets.

We claim:

1. A volume cycled respirator comprising a bellows operatively connected with a lever, an inlet port connecting the interior of the bellows with a continuous pressure gas supply, an outlet duct for said bellows communicating with a valve chamber, in said chamber a valve which in a first position blocks an outlet duct from a patient while permitting the gas in the bellows to pass through the chamber to an inlet duct to the patient, whereas in a second and alternative position said valve permits the said outlet duct to have free access to atmosphere while block-
ing the passage of gas through the chamber to the inlet duct, a valve controlling mechanism which at the end of the inspiratory period is operated by said lever to move said valve from said first position to said second position and comprising means which, on the volume of gas in said bellows having reached a predetermined upper magnitude, cause said lever to operate the valve control mechanism to return the valve to the first said position and comprising spring means adapted to urge said valve towards the second position and a magnetic circuit including a portion movable with said valve and adapted to hold said valve in the first position against the pressure of said spring means when the spring pressure is less than a predetermined magnitude, and means associated with the contraction of the bellows of said ventilator, mechanically to increase said spring pressure to a magnitude greater than said predetermined magnitude whereupon said spring breaks the magnetic circuit and urges said valve to the second position.

2. A volume cycled respirator as claimed in claim 1 further comprising a second spring means for urging the valve toward the first position and a second magnetic circuit including a portion movable with said valve and adapted to hold said valve in the second position against the pressure of said second spring means when the second spring pressure is less than a predetermined magnitude and means associated with the expansion of said bellows mechanically to increase said second spring pressure to a magnitude greater than said predetermined magnitude whereupon said second spring breaks the second magnetic circuit and urges the valve to the first position.

3. A volume cycled respirator as claimed in claim 2 further comprising a pressure relief valve connected to the inlet duct to the patient, and controlling a further outlet to atmosphere, said relief valve being urged to the closed position by third spring means, and a third magnetic circuit associated with the pressure relief valve and including a portion movable with the relief valve, said third magnetic circuit being adapted to hold said relief valve open when the air gap in the third magnetic circuit is reduced below a predetermined size by the rise of pressure in said inlet duct, and means associated with the contraction of the bellows to introduce an air gap in said third magnetic circuit greater than said predetermined size, whereupon said third spring means urge relief valve to the closed position.

4. A volume cycled respirator as claimed in claim 2 in which the said means associated with the expansion of the bellows to increase the second spring pressure includes abutment means between said lever and said second spring means adapted to compress the second spring means when the bellows is expanded, said abutment means including a wedge member movable to adjust the expansion of the bellows necessary to cause the second spring means to move the valve to the first position.

References Cited

UNITED STATES PATENTS
1,044,031 11/1912 Drager
2,071,215 2/1937 Petersen
2,273,790 2/1942 Raymond
2,575,086 11/1951 Atchison
2,870,763 1/1959 Stanton

FOREIGN PATENTS
250,763 10/1962 Australia.

WILLIAM F. O'DEA, Primary Examiner.
R. GERARD, Assistant Examiner.