

[54] MEDICAL RESPIRATORS

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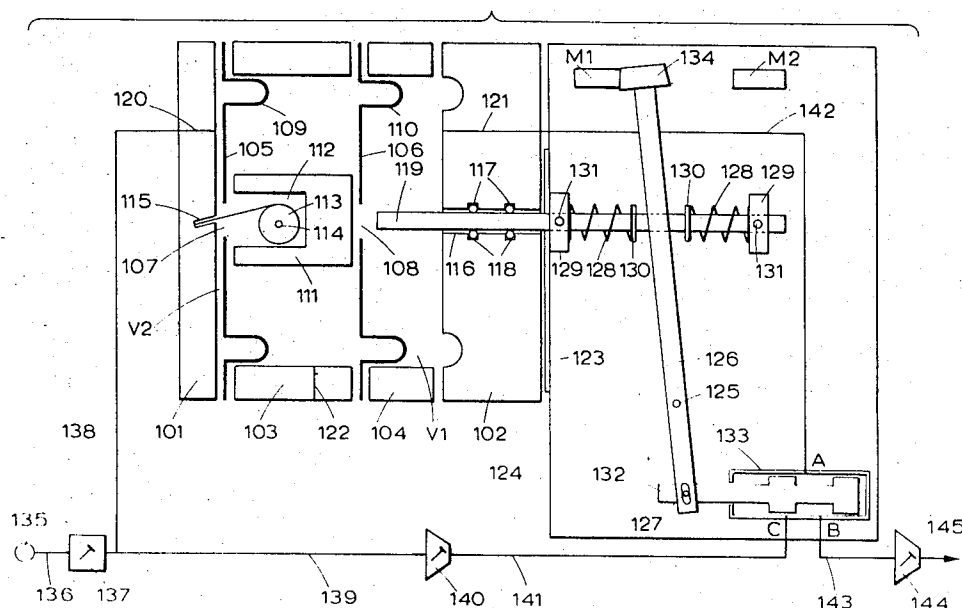
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[57]

ABSTRACT

A medical respirator having switching means to control flow of patient gas from a pressure source through a control means into a variable volume during an expiration period of the respirator and from the variable volume to the patient through restrictive means during an inspiration period. The gas container is divided into two volumes by a movable member, the first volume being variable and the ratio of volumes varying with the position of the movable member. Gas for the patient is expelled from the first volume during part of the inspiration period by decrease of the capacity of the first volume as a result of the movement of the movable member caused by the pressure of the patient gas in the second volume.

1 Claim, 2 Drawing Figures



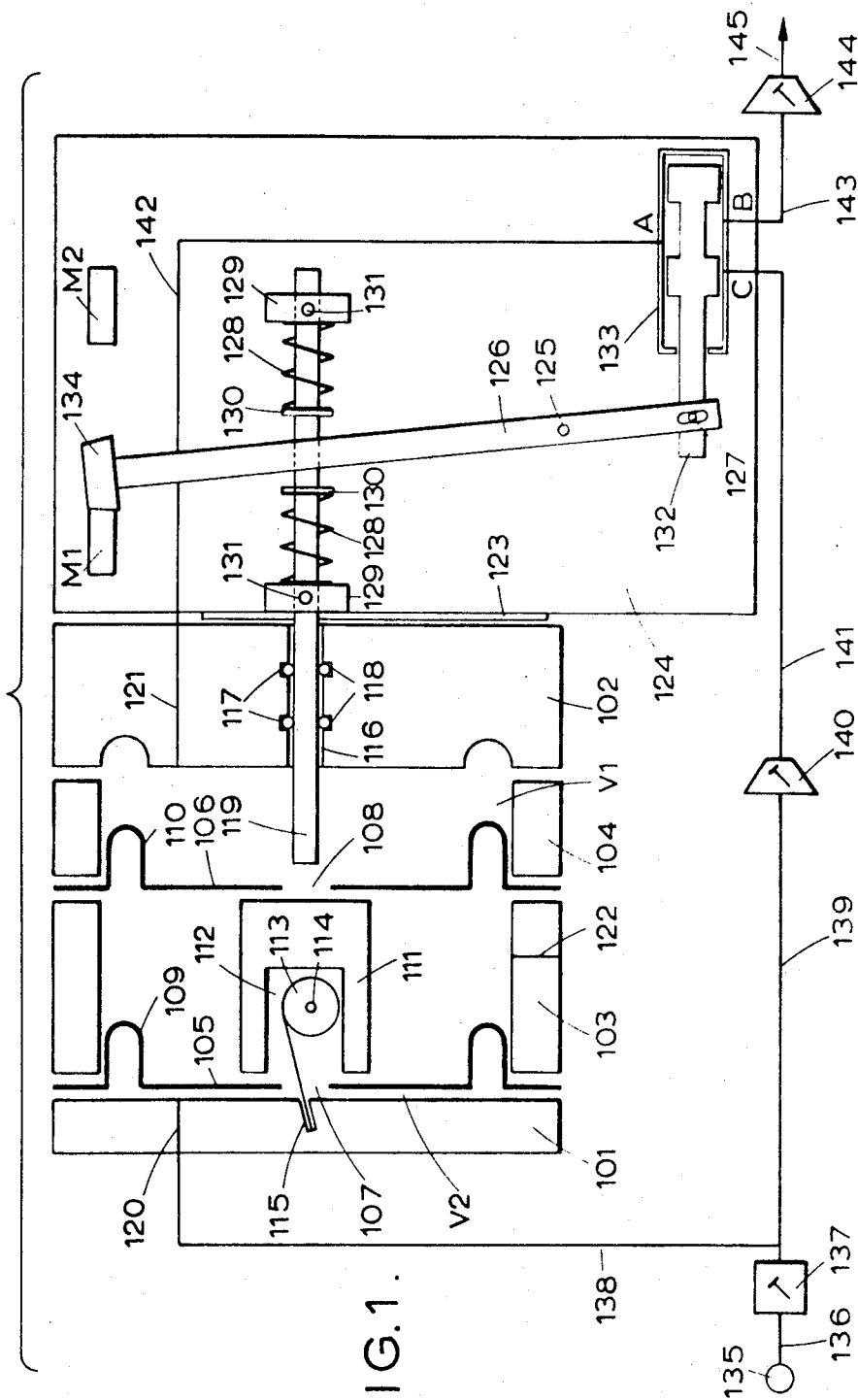


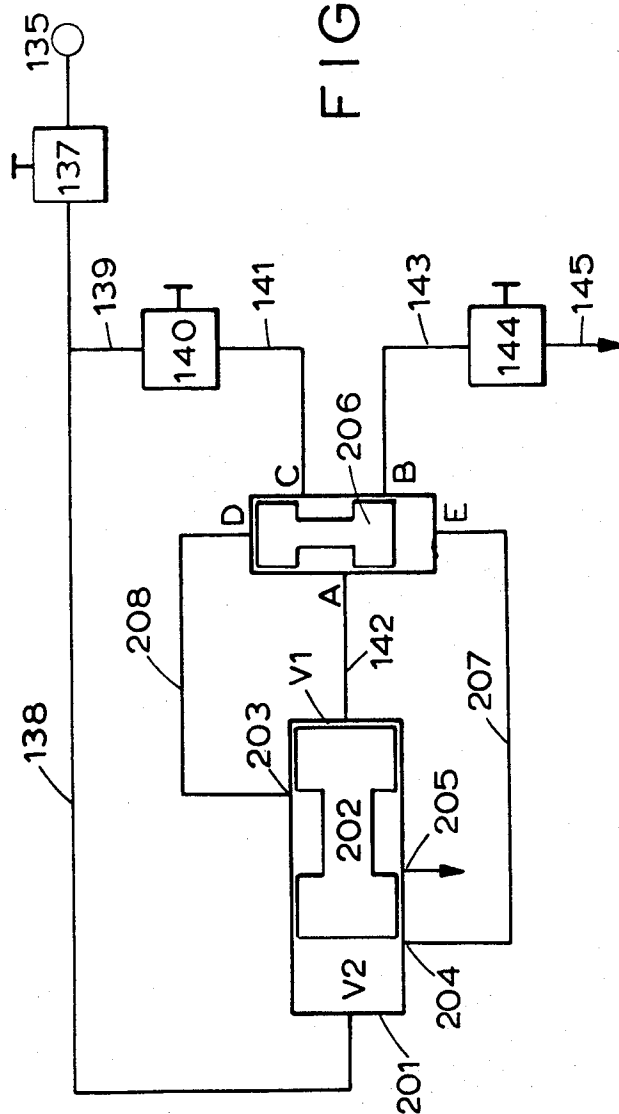
FIG. 1.

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FIG. 2



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MEDICAL RESPIRATORS

This invention relates to medical respirators of the type referred to in our co-pending U.S. application Ser. No. 31,515 in which there is shown a medical respirator including switching means to control flow of patient gas from a pressure source via pressure or flow controlling means into a variable volume during an expiration period of the respirator and from the variable volume to the patient through restrictive means during an inspiration period. A patient gas container is divided into first and second volumes by a movable member, the first volume constituting the said variable volume, the ratio of the volumes varying with the position of the movable member. Gas for the patient is expelled from the first volume during at least part of the inspiration period by decrease of the capacity of the first volume caused by movement of the movable member within the container under the influence of patient gas pressure in the second volume.

Such a respirator utilises patient gas at higher than atmospheric pressure to expel previously stored gas from a first volume to a patient during an inspiratory period, the gas at pressure being applied to the second volume separated from the first by movable means, such as a piston, linked diaphragms, or bellows, which move during the expulsion to reduce the capacity of the first volume to a minimum. A restriction in the gas passage between the first volume and a patient determines, in conjunction with the pressures of gas stored and gas applied to the second volume, the flow of gas to the patient. Where the two pressures have a fixed relationship, e.g. are substantially equal, adjustment of the size of the restriction may be calibrated in terms of time, such calibration being maintained when, to alter the tidal volume, alteration is made to the pressure of gas stored. During an expiratory period at least part of the gas formerly in the second volume is transferred to the first volume, the movable means moving in the reverse direction and reducing the capacity of the second volume to a minimum.

It is an object of the present invention to utilise such movement and gas flow for timing of the periods of a respiratory cycle.

In accordance with one aspect of the present invention there is provided a medical respirator of the type shown in U.S. application Ser. No. 31,515 in which the movable member operates switching means for switching the flow of gas to and from the first volume.

In accordance with a further aspect of the present invention, an adjustable means is provided for adjustably restricting the flow of gas from the first volume to the patient.

According to yet a further aspect of the present invention, a further adjustable means is provided for adjustably restricting the flow of gas into the first volume.

The various features and advantages of the present invention will be apparent from the following description of an exemplary embodiment thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an exploded view showing a medical respirator according to the invention employing mechanical coupling between the moving member and the switching means, and

FIG. 2 shows an alternative form of respirator in which the switching member is operated by gas pressure in the two volumes.

In the drawing which includes a container with linked diaphragms as the movable member, parts of the container being shown exploded to improve clarity, end walls 101 and 102 are, when assembled by screws (not shown) passing therethrough, separated by two tubular members 103 and 104. Two rigid diaphragms 105 and 106, having respective central apertures 107 and 108 and annular flexible portions 109 and 110, have the peripheries of the latter secured respectively between end plate 101 and member 103 and between members 103 and 104. A distance piece 111, of similar length to member 103, is secured to both diaphragms and seals both diaphragm apertures 107 and 108. A recess 112 in distance piece 111 contains a spiral retractile spring 113, providing substantially constant tension, mounted on the distance piece 111 by means such as pivot pin 114 permitting rotation of the spring spool. The end of spring 113 is secured by means not shown, in a slot 115 in end wall 101.

End wall 102 is pierced by a hole 116 having sections 117 of increased diameter, the sections locating means, such as O rings 118, which provide a gas seal for a rod 119 passing through hole 116 and secured to distance piece 111. Two volumes V2 and V1 are thus partially defined by the end walls and diaphragms, which volumes have respective entry ports indicated by lines 120 and 121. An entry port, indicated by line 122, in member 103, enables the space between the diaphragms to be maintained at any desired pressure.

A plate 124 is secured by screws, not shown, to the external face of end wall 102 by means of a flange 123 and carries a rod 125 acting as a pivot for a bar 126 which is slotted in two places to allow passage of rod 119 and a pin 127 therethrough. Two spring operating assemblies, each comprising a spring 128 having its respective ends connected to a collar 129 and to a washer 130, are secured to rod 119 by a set screw 131 in each collar.

An extension 132 of the spool of a three-port change-over gas valve 133 mounted by means not shown on plate 124, carries pin 127, so that movement of bar 126 about its pivot 125 establishes, in a first position as shown, a passage between ports A and B of the valve 133, and in a second position, a passage between ports A and C. Secured on the end of bar 126 remote from pin 127 is a pole piece 134 of magnetic material. Adjustably movable on plate 124 by means not shown are two permanent bar magnets M1 and M2, pole piece 134 being shaped so that in its two extreme positions the respective face thereof is parallel to and abutting an end pole face of one or other of magnets M1 and M2.

Inspiratory gas at pressure is applied to port 135 and thence via a gas pipe line 136 to a pressure regulator 137. Gas, at a pressure determined by the setting of regulator 137, flows into volume V2 via pipe line 138 and entry port 120. It is also present in line 139, a variable restricting means 140 and a pipe line 141 being serially connected between regulator 137 and port C of valve 133. In the shown inspiratory position port C is closed and volume V2 will increase; so expelling the contents of volume V1 via port 121 and pipe line 142 connecting port 121 to port A of valve 133. After passing through the valve the contents emerge from port B and pass via pipe line 143 and variable restricting means 144 to pipe line 145 feeding gas to a patient. Irrespective of the pressure set by regulator 137 the time for the complete discharge of volume V1, at which

point its capacity is substantially zero, will be constant for any particular setting of variable restriction 144.

As volume V1 is reduced rod 119 is moved to the right from its shown position carrying the left hand spring operating assembly into contact with bar 126 and then compressing its spring 128 due to bar 126 being held in position by magnetic attraction between pole piece 134 and magnet M1. At the position when volume V1 is reduced to an operating minimum the arrangement of springs and magnet is such that the magnetic attraction of magnet M1 is overcome, and the compressed spring 128 rapidly drives bar 126 into its alternative position; magnetic attraction from magnet M2 assisting in the latter part of the operation and retaining bar 126 in its new position, thus providing a "snap action" effect such that pole piece 134 is prevented from remaining at a position intermediate pole pieces M1 and M2. The spool of valve 133 thus has a snap-action, being rapidly moved to establish a passage between its ports A and C and at the same time close port B.

The above spool movement terminates the inspiratory period and starts the expiratory period during which the force exerted by spring 113 draws the diaphragm assembly to the left, thus reducing volume V2 and increasing volume V1. Gas within volume V2 is thereby transferred to volume V1 via lines 138, 139, variable restricting means 140, and lines 141 and 142, additional gas for volume V1 being supplied from pressure regulator 137 if required. All gas flowing into volume V1 passes through the restricting means 140, not identical with restricting means 144 due to the limited difference in pressure applied, which may therefore be adjusted to control the duration of the expiratory period, which period is terminated in turn by returning bar 126 to the shown position by means of movement of the diaphragm and rod 119 assembly, the snap-action operation of valve 133 now being provided by the other, right hand, spring operating assembly.

The respiratory cycle is thus repeated, with period times solely determined by the resistance to flow of the two restricting means, until such time as gas at pressure is prevented, by switch means not shown, from reaching either the regulator 137 or one of volumes V1 or V2.

The invention is not limited to the construction shown in the drawing. For example, snap-action of the switching to prevent a possible stalled condition (with both ports C and B masked from port A of valve 133) may be achieved by known spring toggle means. Similarly, rod 119 may pass through volume V2, though with such a construction there is a conflict of position with spring 113. Such conflict may be overcome by utilizing metal bellows within a container to obtain the two volumes or adopting the two diameter piston or diaphragm arrangements illustrated in our co-pending application Ser. No. 31,515.

As an alternative to mechanical coupling between the gas container and the switching mechanism, the latter may conveniently be controlled by means of gas pressure derived from the two volumes V1 and V2 under control of the movable member acting as a switch. Such a method is shown in FIG. 2 by way of example. Components which are common to both FIGS. 1 and 2 bear the same reference in each Figure.

Referring now to FIG. 2, a gas container 201 enclosing the two volumes V1 and V2 includes a slidable pis-

ton, or spool, 202 having a central portion of reduced diameter. Piston 202 is free to move in either direction in the container, but is so constrained by spring means, such as assembly 113, 114, 115 of FIG. 1, that with equal forces acting on its opposing faces it moves to the left to decrease volume V2 to a minimum. Alternatively, the right hand face of piston 202 may have a larger area than the left hand face such that, with equal pressures in the two volumes, the force on the right hand face exceeds that on the left and the piston moves to the left.

Container 201 is provided with ports 203, 204 and 205 connected respectively to ports D and E of spool valve 133 and to atmosphere. In the position shown, piston 202 connects port 203 to port 205 and port 204 connects with volume V2; these conditions representing the beginning of an expiration period. Spool 206 of valve 133 has moved to its uppermost position as shown in the Figure by virtue of the gas pressure in volume V2 applied via port 204, pipeline 207 and port E. Movement of the spool was affected due to the pressure at port being higher than that at port D which is vented to atmospheric pressure via pipeline 208 and ports 203 and 205.

Inspiratory gas, at the pressure determined by pressure regulator 137, is now fed to volume V1 via pipelines 138, 139, an adjustable expiration period flow control 140, pipeline 141, ports C and A of valve 133 and pipeline 142. With substantially equal pressures in the two volumes, V1 and V2, piston 202 moves to the left as previously explained and immediately blocks port 204. Spool 206 of valve 133 remains in the position shown until the end of the expiration period; the setting of adjustable flow control 140 determining the rate at which patient gas flows into volume V1 and, hence, the duration of the expiration period.

When volume V1 has reached its maximum, signifying the end of the expiration period, piston 202 connects port 204 to port 205 and port 203 is opened to volume V1. Spool 206 is moved into its lower position by the pressure in volume V1 via ports 203 and D; port E being vented to atmosphere via pipeline 207, port 204 and port 205. In valve 133, port C is now blocked and a passage is established between ports A and B. Inspiratory gas in volume V1 now flows via pipeline 142, ports A and B, pipeline 143, adjustable inspiration period flow control 144 and pipeline 145 to the patient.

The pressure in volume V2 from regulator 137 now moves piston 202 towards the position shown at a rate dependent upon the setting of flow control 144, the latter thus determining the duration of the inspiration period. Spool 206 of valve 133 remains in the lower position until piston 202 reaches the position shown in the Figure, when port 204 is opened to volume V2 and the pressure thereof is applied via pipeline 207 and port E to move spool 206 into its upper position so terminating an inspiration period and commencing an expiration period.

What we claim is:

1. A medical respirator comprising a gas container, a movable member within said container being responsive to pressure acting thereon, first and second volumes formed within said container being separated by said movable member, said first volume being variable with the position of said movable member, first connection means connected to said first volume for conveying inspiratory gas therefrom to a patient during an in-

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spiratory period of the respirator, a change-over switch connected to said first connection means for passing inspiratory gas to a conduit leading to the patient from the first connection means when the change-over switch is in the inspiratory position, restricting means within said conduit for controlling the flow of inspiratory gas to the patient, second connection means connected to said second volume, a source of respiratory gas connected to said second connection for supplying inspiratory gas to said second volume during an inspiratory period so that said movable member will be displaced as a result of the pressure in said second volume acting on said member, said first volume being decreased by movement of said member so as to expel inspiratory gas to the patient, means for regulating the pressure of the inspiratory gas connected between said source of gas and said second connection, third connection means connected between said second volume and said change-over switch for conveying inspiratory gas from said second volume to said first volume when said switch is changed-over to an expiratory position, and means connected to said change-over switch responsive to the relative position of said movable mem-

ber for causing said switch to change-over between inspiratory and expiratory positions so that said movable member controls the operation of said change-over switch, said change-over switch being a spool valve having a piston movable between inspiratory and expiratory positions, said means for causing said switch to change-over between inspiratory and expiratory positions comprising a mechanical linkage coupled between the piston of said spool valve and said movable member so that said piston will be caused to move between inspiratory and expiratory positions in response to movement of said movable member, and a snap-action mechanism arranged with said mechanical linkage for causing rapid switching action of said piston between inspiratory and expiratory positions, said snap-action mechanism comprising spring means acting on said linkage for causing rapid movement thereof, a pair of magnets representing the expiratory and inspiratory positions, and a pole piece connected to said linkage for cooperating with one or the other of said magnets so that said linkage is either in the inspiratory or expiratory position.

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