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CONTROL SYSTEM FOR BREATHING APPARATUS

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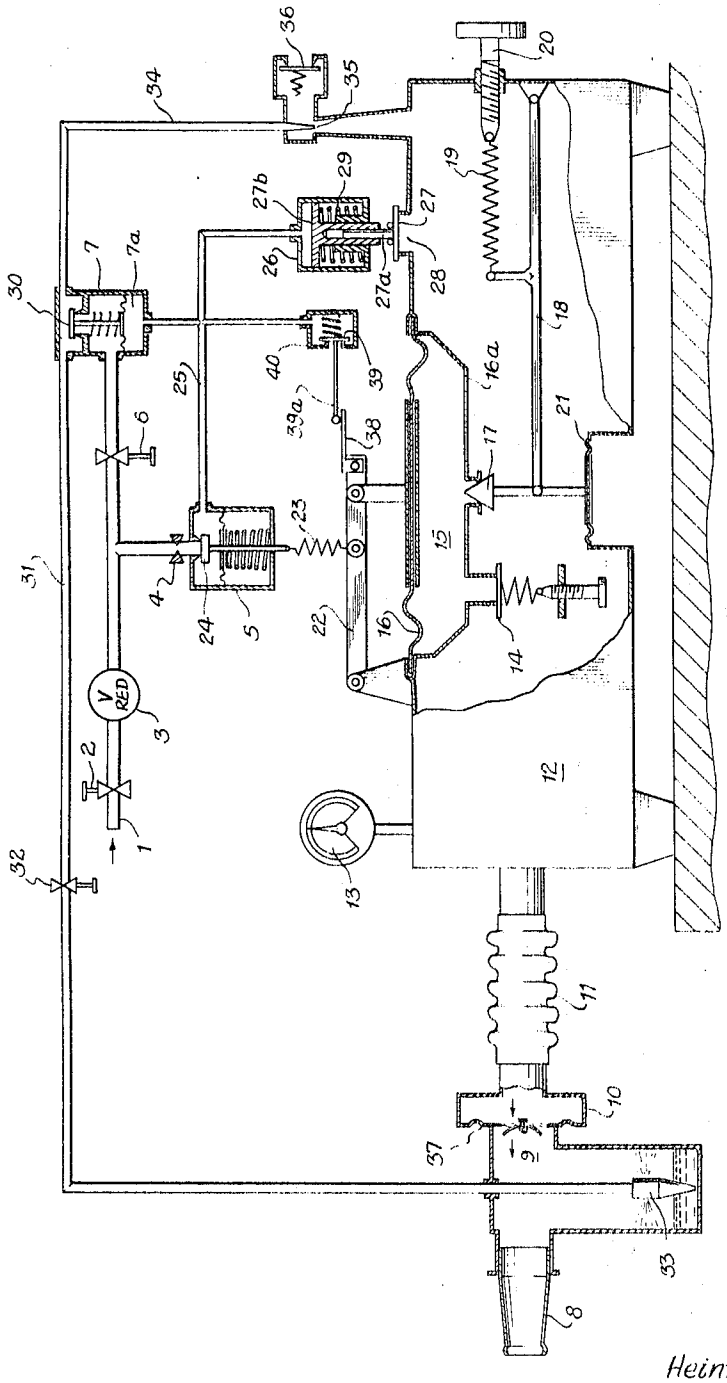


Fig. 1

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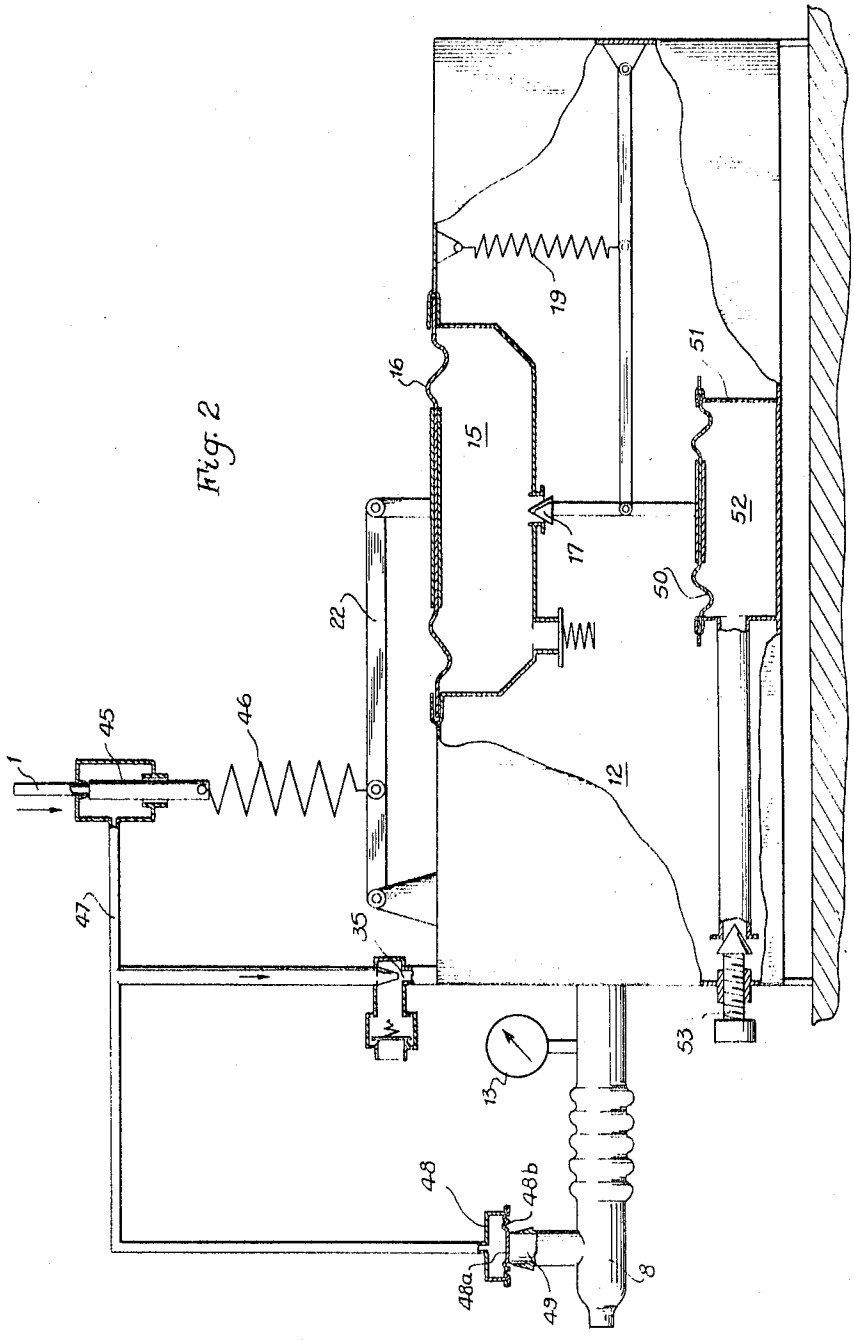
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CONTROL SYSTEM FOR BREATHING APPARATUS

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Fig. 2



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CONTROL SYSTEM FOR BREATHING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A control system for breathing apparatus wherein the slight less than atmospheric pressure produced by a patient when changing from exhaling to inhaling acts on a sensitive diaphragm to produce the flow of inhaling gas through the breathing apparatus to the patient.

An artificial respiration apparatus is known in which the nutrient gas is forced through a tube leading to the patient's lungs in response to the pressure in the lungs or in the respiratory tract. In such an apparatus, a lung control membrane is provided which is exposed to the pressure either in the exhale air tube and/or in the inhaling gas supply tube. This control membrane is connected with a mechanism which supplies the flow of nutrient gas to the patient's lungs when the patient produces a less than atmospheric pressure during inhaling. The gas flows to the patient for such a length of time until a predetermined inhaling pressure is achieved, and at this point, the control membrane shuts off the flow of gas and switches the apparatus to the exhaling phase. The exhaling phase has been assisted by the drawing out of the inhaled air.

Other apparatuses exist where the exhaling phase is accomplished without forcefully withdrawing the exhaled air because the air is exhaled by the lung muscles alone and expelled into the atmosphere. After the exhaling phase is finished, the patient's lung muscles again produce a less than atmospheric pressure at the beginning of the inhaling phase which acts on the control membrance so that the above-described process is repeated. In such apparatus, the control membrane is subjected to relatively high differences in pressures existing from the less than atmospheric pressure at the beginning of the inhaling phase to the greater than atmospheric pressure at the end of the inhaling phase. Consequently, the control membrane has to be constructed to respond to the large pressure range and/or provided with springs or the like. Such produces certain constructional disadvantages since the control membrane in the beginning of the inhaling phase and with the very slight less than atmospheric pressure produced by the patient does not produce sufficient controlling force for the reversal of the flow of gas in the breathing apparatus.

The object of this invention is to produce a breathing apparatus in which the changeover from inhaling to exhaling takes place in response to a very slight less than atmospheric pressure by the patient and without the need of any kind of electrical aids. In this invention, the flow of gas through the breathing apparatus is controlled by means of a diaphragm having one side subject to the pressure of the gas line leading to the patient's lungs. This diaphragm is separated from the gas line by a wall in which is a first check valve openable into the gas line by a pressure increase between the diaphragm and the wall and a second valve openable into the gas line upon an increase in pressure in the gas line. Thus, in this invention, the control diaphragm is not subjected

to considerable variations in pressure so that a very sensitive diaphragm can be used. This, in turn, has the advantage that the diaphragm is capable of producing sufficient forces to change over the gas flow from exhaling to inhaling even with the slightest less than atmospheric pressure produced by the patient.

As soon as a less than atmospheric pressure is produced by the patient, the first check valve is opened to provide communication between the gas line and the space between the wall and the diaphragm. The diaphragm under this less than atmospheric pressure produces the controlling force. As soon as an excess pressure occurs in the gas line due to inhaling, the first check valve closes so that the diaphragm becomes protected against a rise in pressure in the gas line. The second valve in the wall opens only when a predetermined greater than atmospheric pressure occurs in the gas line so that the diaphragm is not subject to pressure in the opposite direction and thus closes the gas supply line. Greater than atmospheric pressure escapes from the gas line, but the second valve immediately closes so that the membrane is no longer subject to the now existing greater than atmospheric pressure.

Additional devices are provided such as a membrane valve between the gas line and the breathing tube leading to the patient and a check valve that opens at greater than atmospheric pressure in the gas line so that gas flows to the patient and which closes, during greater than atmospheric pressure, an opening leading to the atmosphere and which communicates with the patient's lungs and whereby the opening is closed when the membrane is in its normal position. This device assists in the changeover from the inhaling to the exhaling phase.

In a further feature of the invention, the apparatus is constructed so that the gas line has an atmospheric check valve leading from the gas line to the atmosphere, which valve is closed by the pressure of the inhale nutrient gas during the inhaling phase. Thus the changeover from inhaling to exhaling is accomplished by the pressure of the supply of the nutrient gas.

In order to further lessen the forces on the control diaphragm and in order to further increase the sensitivity of the apparatus according to a further feature of the invention, the diaphragm is connected with a valve which closes by the pressure of the gas supply and is also connected to other valves actuated by the pressure of the gas supply for operating drive mean such as an injector or a relief valve opening to the atmosphere. The force of the control diaphragm in this construction is used only for the control of a gas valve which, in turn, controls the supply of compressed gas to the valves so that the forces to operate these other valves are supplied by the pressure of the compressed gas.

The means by which the objectives of the invention are obtained are described more fully with reference to the accompanying schematic drawings in which:

FIGURE 1 is a cross-sectional view through the breathing apparatus; and

FIGURE 2 is a similar view of a modified form of apparatus.

As shown in FIGURE 1, pipe 1 is connected to a source of compressed gas such as oxygen. Gas entering pipe 1 passes through shut off valve 2 and pressure reducer 3 in which the gas is reduced to a constant working pressure of about 1.5 atmospheres. The gas blowing out of reducer 3 goes through a throttle 4 into a closure valve 5 and also flows through a shut off valve 6 to a gas relay valve 7. Valves 5 and 7 are closed during the exhaling phase.

The patient is connected by way of fitting 8 to a breathing tube which communicates with the atomizer cham-

ber 9. Chamber 9 communicates through an inhale check valve 10 and bellows tube 11 with the chamber 12 forming a part of the gas line. The gas pressure in chamber 12 is measured by the gauge 13.

Chamber 12 contains a first check valve 14 which is openable into chamber 12 to effect communication with a diaphragm chamber 15, which on one side is closed by the flexible diaphragm 16 and the other side by a wall 16*a* extending into chamber 12. Mounted in this wall is a second valve 17 which also, when open, establishes communication between chambers 12 and 15, and this valve is actuated by a control lever 18. Lever 18 is joined by a spring 19 to an adjusting screw 20. The valve 17 is also connected to a flexible membrane 21 which controls the opening and closing of the valve.

When a patient inhales through the fitting 8, a slightly less than atmospheric pressure occurs as the inhaling impulse and this slight negative pressure appears in chamber 12 and through open valve 14 in chamber 15. On the other hand, valve 12 is held closed, as shown in FIGURE 1, by lever 18 and spring 19. The slight negative or less than atmospheric pressure in chamber 15 causes the diaphragm to move downwardly into chamber 15. Lever 22 joined to diaphragm 16 is moved downwardly so that tension is applied to spring 23 which is joined to valve 24 and moves the valve downwardly lifting the valve off the valve seat due to valve 5. Gas, such as oxygen, can now enter pressure line 25 and into the several parts associated therewith.

Connected to gas pressure line 25 is a control mechanism 26 for the atmospheric check valve 27 which normally controls the port 28 in chamber 12. Valve 27 closes by gravity due to the weight of the valve head and the valve stem 27*a*. The latter slides in a movable piston 27*b* which is urged upwardly by the pressure of spring 29 and can be driven downwardly by the gas pressure in line 25 to close valve 27. Thus valve 27 can be opened by overcoming its weight as long as there is no gas pressure in line 25. Gas pressure in line 25 closes valve port 28.

Also connected to gas pressure line 25 is the relay valve 7 containing gas pressure chamber 7*a*. When gas pressure exists in chamber 7*a*, the valve 30 is open and gas flows from reducer 3 through the valve into line 31 through shut off valve 32 into the atomizer nozzle 33 located at atomizer 9. Gas pressure also flows through line 34 to the injector 35 which causes a reduction of pressure to open check valve 36 and admit air from the atmosphere into chamber 12 to produce a mixture of air and oxygen.

Finally, lever 22 carries an extension arm 38 which engages the valve head 39 through valve stem 39*a* so that the valve can be tilted from its valve seat 40.

Because of the rising pressure in chamber 12 due to the mixture of oxygen and air flowing passed injector 35, the inhaled gas flows out of chamber 12 through tube 11, valve 10, atomizer 9 where it is mixed with vapor formed by nozzle 33, and into fitting 8 to the breathing tube leading to the lungs of the patient. During inhaling, valve 10 closes the exhale opening leading to the atmosphere. The rising pressure in chamber 12 together with the pressure in the lungs of the patient cannot affect the diaphragm 16 during the inhaling since communication between chambers 12 and 15 is closed off by first check valve 14 and second valve 17. However, the rising pressure in chamber 12 acts on membrane 21 until the pressure in chamber 12 overcomes the atmospheric pressure outwardly of chamber 10 and the force of spring 19 on lever 18 so that valve 17 eventually opens. Diaphragm 16, at this moment, and because of the opening of chamber 15, moves upwardly so that the valve 24 is closed by the movement of lever 22 and the pressure of spring 23. At the same time, valve 39 is tilted and unseated from seat 40 by means of the extension arm 38. This causes the release of the gas pressure in line 25 and a closing of valve 30 and a release of the gas pressure on piston 27*b*. Now the gas pressure in chamber 12 can escape into the atmosphere by the opening of valve port 28 as valve 27 is lifted by the gas pressure in chamber 12. When relay valve 7 is closed, the atomizer nozzle 33 and the injector 35 are shut off. The pressure in chamber 12 then sinks spontaneously. The valve 10 opens which also opens the exhaled air path 37 so that the exhaled air can pass into the atmosphere.

The exhale phase is thus finished and after a pause, the patient in his turn and through the slight inhale impulse brings the apparatus to a position to repeat the above cycle.

The modification of FIGURE 2 differs from FIGURE 1 as being a simplification of the apparatus since the control valve 5 and the valves 7 and 26 are omitted.

The compressed gas from the gas source passes through valve 45 which is connected directly to the lever 22 joined to the diaphragm 16 by the spring 46.

The gas line 47 is branched off to the injector 35 and the gas line leads to a check valve 48 openable into the atmosphere and which valve is seatable on the pipe 49 connected to the breathing tube fitting 8.

Gas, such as oxygen, when valve 45 is open, flows through injector 35 into chamber 12, and at the same time, the valve head 48*a* of valve 48 closes pipe 49. The valve head can be contained in a flexible membrane 48*b*.

Valve 48 opens when valve 45 is closed so that the patient can exhale freely through pipe 49 into the atmosphere.

FIGURE 2 further differs from FIGURE 1 in that the second valve 17 is joined to a membrane 50 which forms one wall of a housing 51 mounted within chamber 12. The chamber 52 in housing 51 communicates with the interior of chamber 12 by way of adjustable valve 53.

Valve 17 is again urged into closing position by a spring 19. When a pressure above a certain pressure is created in chamber 12, the valve 17 is opened by the pressure on membrane 50. The opening pressure can be adjusted by the setting of valve 53. This is shown in the following example. It is assumed that a greater than atmospheric pressure of, for example, 20 cm. WS must occur in chamber 12 in order to open valve 17 by the downward pressure on membrane 50. The increase in the opening pressure is obtained in that pressure is permitted to flow by way of valve 53 during the inhale phase from chamber 12 into chamber 52 until at that point a pressure of +30 cm. WS is reached.

This pressure can be read on gauge 13. If valve 53 is then closed, then the pressure in chamber 12 rises for another 20 cm. until valve 17 opens. Valve 53, with this method of adjustment, can only be temporarily opened during the first inhaling phase. The pressure in chamber 52 remains unchanged during the entire time in which the breathing of the patient is assisted by the apparatus.

Having now described the means by which the objects of the invention are obtained.

I claim:

1. A control device for a breathing apparatus in which a compressed gas source is furnished to a breathing tube leading to a patient comprising a gas line connectable between the gas source and the breathing tube, a flexible diaphragm separated from a wall in common with said gas line, first check valve means in said wall and openable into said gas line by a pressure increase between said diaphragm and said wall, second valve means in said wall openable into said gas line upon an increase in pressure in said gas line, means for adjusting the opening pressure of said first check valve means, means for adjusting the opening pressure of said second valve means, and control membrane means subject to the pressure in said gas line and connected to said second valve means for influencing the opening pressure thereof.

2. A device as in claim 1, further comprising spring

means joined to said second valve means for influencing the opening pressure thereof.

3. A device as in claim 2, said means for adjusting the opening pressure of said second valve means including set screw means for adjusting the tension in said spring means.

4. A device as in claim 3, said control membrane means being enclosed within said gas line, and throttle valve means between said gas line and said membrane means for communicating the pressure in said gas line to said membrane means.

5. A device as in claim 3, atmospheric valve means in said gas line openable to the atmosphere and closable by the pressure of the compressed gas source upon a pressure drop in said gas line as gas is inhaled by the patient.

6. A device as in claim 5, said atmospheric valve means comprising a valve head seatable on a valve seat in said gas line by its own weight, piston means subject to the pressure of the compressed gas source for urging the valve head toward the valve seat, and spring means

for urging the piston means away from said valve head.

7. A device as in claim 6, further comprising closure valve means connected between said compressed gas source, and said flexible diaphragm, pipe line means joining said closure valve means to said atmospheric valve means for actuating said piston means, and atomizer and injector valve means connected between said gas source and said gas line for supplying gas to said gas line.

8. A device as in claim 7, further comprising throttle means joined between said closure valve means and said compressed gas source.

References Cited

UNITED STATES PATENTS

2,766,753	10/1956	Koch et al.	128—145.8
Re. 25,871	10/1965	Andreasen	128—145.8
3,304,939	2/1967	Manley	128—145.7
3,385,295	5/1968	Beasley	128—145.8

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