United States Patent

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[54] RESPIRATOR WITH FLUID AMPLIFIERS WITH FLUID TIMER

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[73] Assignee: **General Medical Corporation**

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[52] **U.S. Cl.** **128/145.8**, 137/81.5

[51] **Int. Cl.** **A62b 7/04**

[58] **Field of Search** 128/DIG. 10, 145.5, 145.6, 128/145.7, 145.8; 137/81.5, 24.14, 86

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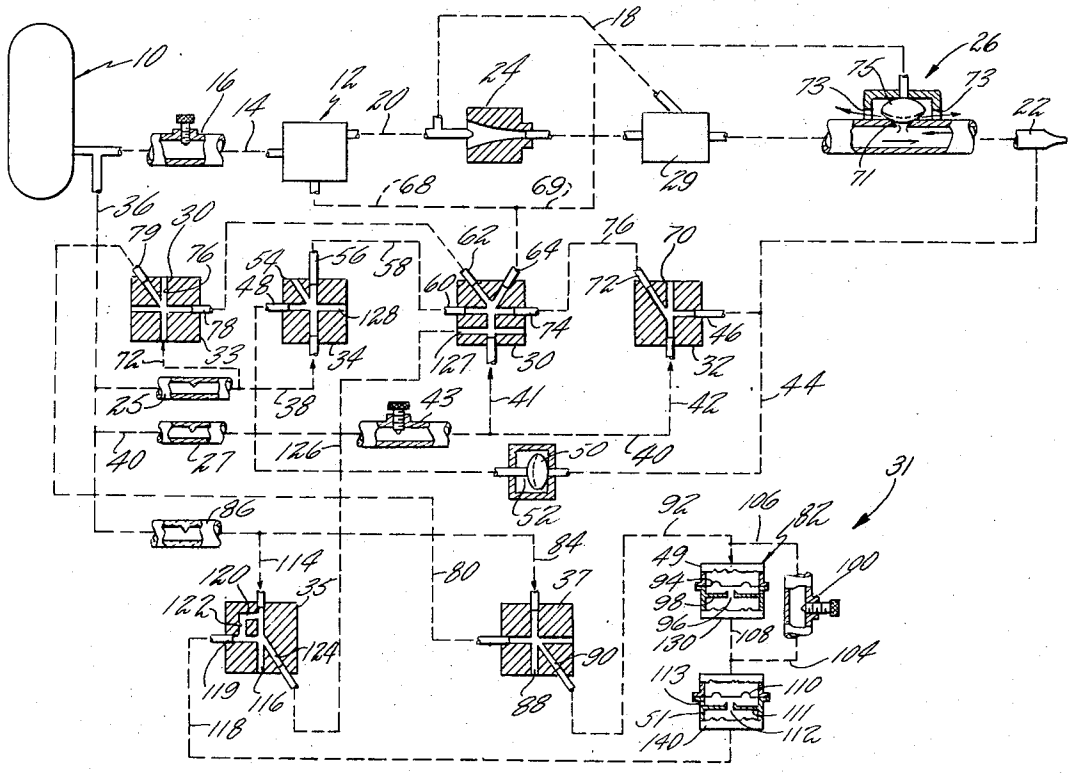
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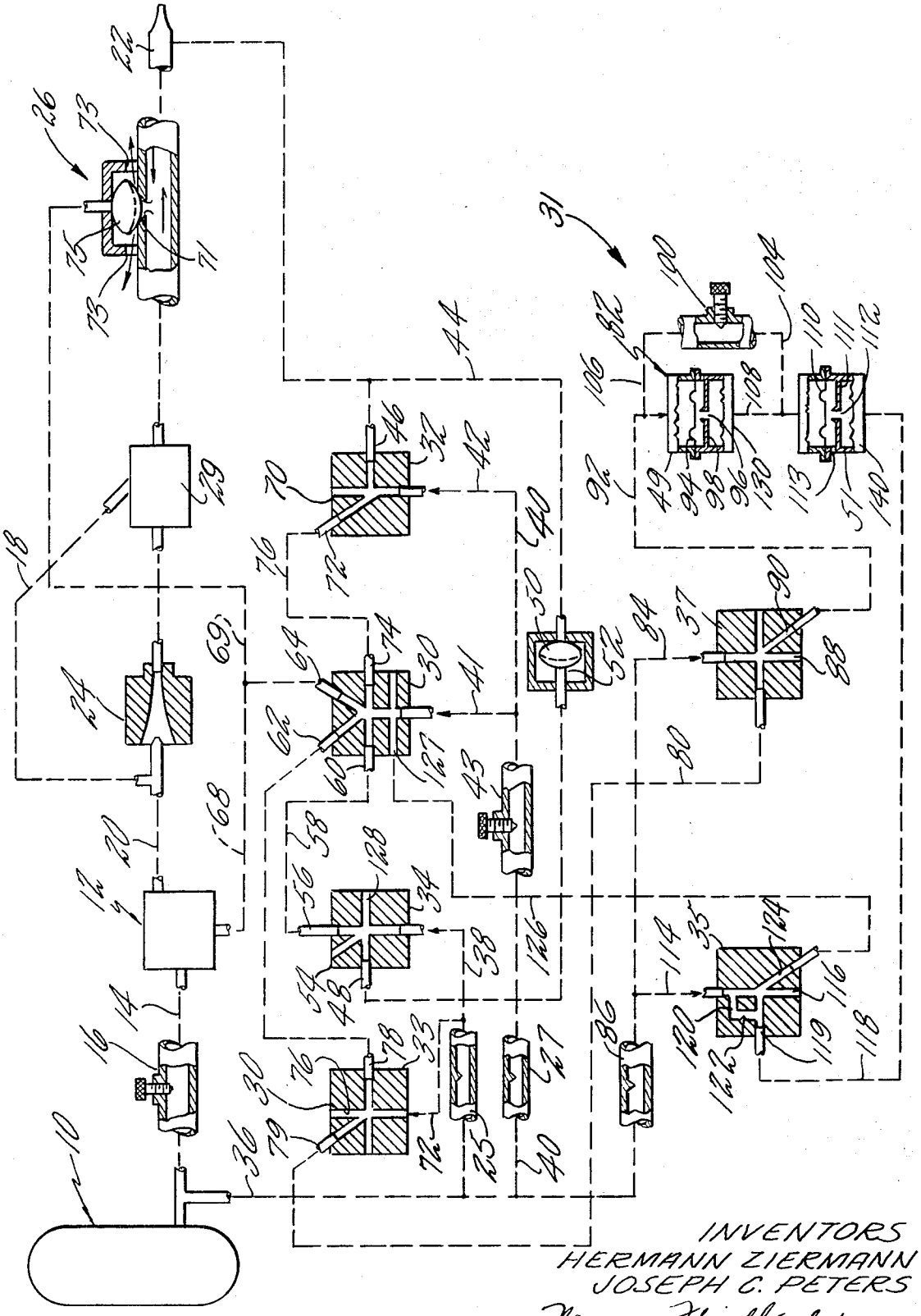
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[57] **ABSTRACT**

An on-off inhalation valve of a respirator for admitting fluid to the lungs of a patient is controlled by a flip-flop fluid amplifier driven by a fluid amplifier during the exhalation cycle and by another fluid amplifier during the inhalation cycle and including a fluid timer for controlling the length of time of the pause between exhalation and inhalation.

8 Claims, 1 Drawing Figure





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RESPIRATOR WITH FLUID AMPLIFIERS WITH FLUID TIMER

BACKGROUND OF THE INVENTION

This invention relates to a respirator utilizing fluid amplifier logic circuitry to control or assist respiration.

The above-mentioned patent application filed by Ziermann and Peters describes and claims a fluid amplifier controlled respiration system which utilizes a fluid amplifier to actuate a valve to open and close for intermittingly communicating a source of fluid, such as air and/or oxygen, to the lungs of the patient. This patent application discloses a respirator that utilizes separate fluid amplifiers for accomplishing the switching, namely, by providing an OR fluid amplifier for switching from inhalation to exhalation and an NOR fluid amplifier for switching from exhalation to inhalation. It is sometimes desirable or necessary to control the length of time of the pause between exhalation and inhalation and accordingly, this invention provides means coupled to one of the sensing fluid amplifiers for governing these exhalation characteristics. What is meant by exhalation time is the time lapse between expulsion and inhalation or the period between breaths.

SUMMARY OF INVENTION

A primary object of the present invention is to provide an improved fluid amplifier driven respirator.

In accordance with the present invention a timing means which controls the switching fluid amplifier is provided to control the length of exhalation time of the breathing cycle.

Other features and advantages will be apparent from the specification and claims and from the accompanying drawings which illustrate an embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE is a schematic illustration of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the sole FIGURE, the invention can best be understood by considering the invention as being made up of three circuits: (1) the flow circuit for leading air and/or oxygen to the lungs of the patient and discharging the air expelled from the lungs of the patient, (2) the fluidic logic circuitry for effectuating the switching from the inhalation and exhalation regimes of the breathing cycle, and (3) the timing circuit controlling the pause between exhaling and inhaling. As noted, air and/or oxygen from a source generally illustrated by reference numeral **10** is supplied to the normally closed on-off inhalation valve **12** through line **14**. A suitable flow control valve generally illustrated by reference numeral **16** for adjusting the flow may be used if desired. During the inhalation cycle, fluid entering inhalation valve **12**, previously actuated to the opened position, is ported to line **20** where it is directed to the mouthpiece **22** for admittance to the lungs of the patient. For a more detailed description of a suitable inhalation valve reference is hereby made to the commercially available valve identified as model 2010 manufactured by Northeast Fluidics, Inc. bearing the trade name Fluidamp. It is customary to include a suitable ejector **24** which serves to increase the volume of air delivered to the patient and since the ejector does not form a part of the invention, for the sake of convenience, the description thereof is omitted. Normally opened exhalation valve **26** previously actuated to its closed position i.e. closed to ambient) is disposed in line **20** between the ejector and the lungs of the patient. When in the exhalation cycle, inhalation valve **12** is positioned to the off position and exhalation valve **26** is automatically moved to the opened position for discharging the fluid exhumed from the lungs of the patient to ambient.

A nebulizer generally illustrated by numeral **29** may be utilized if necessary or desirable and is driven by the fluid evidenced in line **18** upstream of the ejector **24**. A suitable nebulizer may be of the type shown in U.S. Pat. No. 3,379,194 granted to H. Ziermann on Apr. 23, 1968. It is noted that the nebulizer in this instance will only operate when valve **12** is in the on position. Thus, it only operates during the inhalation cycle and is inherently inoperative during the exhalation cycle, assuring that no medication is lost when the patient is exhaling.

Referring next to the logic circuitry which serves to sense certain parameters for switching the inhalation and exhalation valves in a certain timed relationship for defining the exhalation to inhalation ratio. The logic circuitry can be considered as two systems, namely the one which comprises primary fluid amplifier generally illustrated by numeral **30**, exhalation control fluid amplifier **32**, inhalation control fluid amplifier **34**, and the other for timing the pause between exhalation and inhalation which comprises fluid amplifier **33**, back pressure switch **35**, fluid amplifier **37** and the timing mechanism generally illustrated by reference numeral **82**.

Preferably, fluid amplifier **30** is a flip-flop type where the flow from the power stream has no preference to either output channels and requires some means such as pressure or flow at the control ports to effectuate switching. Fluid amplifiers **32** and **34** are preferably of the OR and the NOR types, respectively. As is known, the OR and NOR types of fluid amplifiers are the types where the power stream attaches to one output channel and requires a positive signal for the OR and a negative signal for the NOR to switch output channels.

Looking first at the three fluid amplifiers for controlling the respiration cycle, the power stream is connected to source **10** by supply line **36** by way of branch lines **38**, **40**, **41** and **42**. Stepdown resistors **25** and **27** may be employed to lower the pressure where needed. Since pressure from the source is typically 50 pounds per square inch gage (psig), the restrictor **25** reduces pressure to say 2 psig and restrictor **27** reduces pressure to say 15 psig. These restrictors could be made variable as is obvious to one skilled in the art and the scope of the invention is not limited by the particular pressure reducing means utilized. As it may be desirable to control the level of the switching pressure, pressure control valve **43** preferably operating over a range of 3 to 13 psig is disposed just upstream of branch lines **41** and **42**. Sensing line **44** preferably connected to the mouthpiece of the respirator, although it may be located anywhere that is indicative of lung conditions, is connected to control port **46** of fluid amplifier **32** and indirectly to control port **48** of fluid amplifier **34**. As was mentioned above, the fluid amplifier **34** is a NOR type and switches at a negative or near negative pressure signal. This is effectuated by connecting a balloon type valve element **50** which opens and closes orifice **52**. It has been found that this device increases sensitivity particularly in the negative pressure regimes.

Looking at the operation of the logic circuitry, during the inhalation cycle when a small inspiration effort is made, the volume of air in line **44** is reduced to a negative pressure. This loss in pressure deflates valve element **50**, which normally closes off orifice **52**, causing a loss of pressure in control port **48** increasing the pressure drop across the splitter and hence diverting the output of fluid amplifier **34** from output channel **54** to output channel **56**. Since output channel **56** is connected to control port **60** of the flip-flop fluid amplifier **30** by line **58**, the flow from the power nozzle in line **41** is diverted from the output channel **62** to output channel **64**. This flow is then divided so that a portion is admitted to valve **12** through line **68** for effectuating the opening thereof and the other portion is admitted to exhalation valve **26** by line **69** inflating balloon **75** seating it against seat **71** and preventing escapement of air to ambient through bleed ports **73**. Hence, fluid from the main supply line will flow unrestricted to the mouthpiece.

Looking next at the exhalation cycle, when the patient is about to exhale, the pressure obviously has built up within the lungs which in turn is sensed and transmitted to the exhalation fluid amplifier **32** through control port **46** causing the power stream to be diverted from the output channel **70** to the output channel **72** where it is directed to the control port **74** of

the flip-flop amplifier 30 by way of line 76. This causes the output stream in the output channel 64 to divert to channel 62 so as to be transmitted to the timing logic circuitry. The loss of pressure in lines 64 and 68 will permit the normally closed inhalation valve 12 to close and the normally opened inhalation valve 26 to open; thus, the flow exhuming from the patient's lungs will pass through the exhalation valve and dumped into ambient.

As was mentioned above, the timing mechanism serves to control the length of time that it takes from the point of time the patient completes his exhalation to the time inhalation is repeated. Thus, the pause between breaths is determined by this timing mechanism. The signal transmitted to output channel 62 in this embodiment is amplified by the fluid amplifier 30 which receives the constant power supply through branch line 72 connected to branch line 38 downstream of fixed restrictor 25. Fluid amplifier 30 is a typical OR gate type and the flow from the power stream is normally attached to the output channel 76. The admittance of pressure into control port 78 serves to switch the power stream to output channel 79 where it is in turn admitted to the control port of fluid amplifier 37 by way of line 80. This serves to actuate the timing mechanism generally indicated by numeral 82 by diverting the power stream emanating from line 84 which is connected to line 36 through fixed restriction 86 from the output channel 88 to the output channel 90. Fluid amplifier 37, like fluid amplifier 33, is an OR type where the power stream attaches to the output channel 88 and dumped to ambient until the switching signal diverts the pressure stream to output channel 90. Line 92, connected to output channel 90 leads fluid into the timing element 49. Timing element 49 consists of a cylindrical container defining a pair of chambers separated by wall 98, extending across the inner diameter and a cooperating diaphragm 94 also extending thereacross and adapted to seal off orifice 96 formed in wall 98. Timing element 51 is similarly constructed and consists of diaphragm 110 cooperating with orifice 112 formed in wall 111 extending thereacross. Variable restrictor 100 is shunted across orifice 96 and interconnects the two volume chambers 49 and 51, via lines 104 and 106. When pressure is admitted into line 92, owing to the fact that there is less resistance to enter timing element 49 than variable restrictor 100, it will first enter the timing element 49. As soon as the pressure builds up behind diaphragm 94, it will move downwardly against orifice 96. At this point the flow in line 92 will then be diverted through variable restrictor 100 through line 106. The flow then will be admitted into timing elements 49 and 51 through line 108. When these elements are filled, the pressure acting on diaphragm 110 moves it against orifice 112 blocking off line 118 connected to back pressure switch 35. The back pressure switch 35 which is also a fluid amplifier, serves to switch the power stream in line 114 from output channel 116 to output channel 124. When orifice 112 is not blocked off, the power stream normally passing through output channel 116 also permits flow to pass through control port 119 through line 118, timing element 51, orifice 112 and bleed 113. Thus when orifice 112 is blocked off, a portion of the flow of back pressure switch 35 will enter passage 120 and through restrictor 122 from line 114, causing a pressure differential across the splitter of the fluid amplifier and causing the power stream to divert to output channel 124. The power stream is then transmitted back to the flip-flop fluid amplifier 30 by way of line 126 and control port 127. This serves to switch the fluid and power stream 41 from channel 62 to channel 64 for repeating the inhalation cycle. The length of time it takes for the switch 30 to receive a signal will be determined by the volume of chambers 130 and 140 in addition to the variable restriction 100 which is adjustable to change the delay time.

It should be understood that the invention is not limited to the particular embodiments shown and described herein, but that various changes and modifications may be made without departing from the spirit or scope of this novel concept as defined by the following claims.

We claim:

1. A fluidic controlled respirator for augmenting the breathing of a patient including a source of pressurized fluid to be injected into the lungs of the patient, a fluid line from said source to delivery means adapted to admit fluid to the patient, an inspiration valve and an expiration valve disposed in said fluid line and control means for synchronously opening and closing said inspiration valve and expiration valve for admitting fluid to and bleeding fluid from the patient, said means including a pure fluidic amplifier responding to the condition of the lungs for intermittingly opening and closing said inspiration valve and said expiration valve, timing means for timing the delay between exhalation and inhalation, said timing means including a back pressure pure fluid amplifier switch, said switch having an output channel fluidly connected to a control port of said fluidic amplifier, and said back pressure switch responding to a pressure signal generated by said timing means for effectuating switching of said pure fluidic amplifier for effectuating sequentially opening closing of said inhalation valve and said exhalation valve at a predetermined time interval.

2. A fluidic controlled respirator as claimed in claim 1 wherein said timing means includes a volume chamber and a restrictor, means for fluidly connecting said chamber and said restrictor in parallel relation so that fluid flows through said restrictor after said volume chamber fills, and said back pressure switch responsive to the condition when said fluid flows through said restrictor for actuating said control means.

3. A fluidic controlled respirator as claimed in claim 2 including an additional fluid amplifier having one of its output channels connected to said volume chamber and said restrictor.

4. A fluidic controlled respirator having a source of fluid, a fluid line interconnecting said source and delivery means for filling the lungs of a patient, a normally closed valve for blocking off the flow of the fluid and a normally opened valve for interconnecting the lungs to ambient disposed in said fluid line,

a. means for intermittently and synchronously opening said normally closed valve and closing said normally opened valve,

1. said means including a first fluid amplifier having an output channel for directing actuating pressure to said normally closed and normally opened valve for effectuating opening and closing thereof respectively,

2. a second fluid amplifier having an output channel connected to a control port of said first fluid amplifier,

3. a third fluid amplifier having an output channel connected to another control port of said first fluid amplifier,

4. means responsive to the breathing of said patient for controlling said second and third fluid amplifier whereby said first amplifier intermittently opens and closes said normally closed valve and said normally opened valve,

5. adjustable means for controlling the time delay between the expiration and inhalation of the breathing cycle,

6. a pair of spaced volume chambers and a variable restrictor fluidly shunting one of said volume chambers and discharging into said second chamber, and

7. pressure responsive means responsive to when said volume chambers fill with fluid for actuating said first fluid amplifier.

5. A fluidic controlled respirator as claimed in claim 4 including a fourth fluid amplifier having an output channel intermittently leading fluid to said volume chambers and said variable restrictor.

6. A fluidic controlled respirator as claimed in claim 4 wherein said pressure responsive means is a fluid amplifier and includes a control port connected to one of said volume chambers and an output channel connected to a control port of said first fluid amplifier.

7. A fluidic controlled respirator as claimed in claim 4 wherein said volume chamber includes a variable volume sec-

tion and a flexible member cooperating with an orifice for closure thereof when the volume reaches a predetermined value.

8. A fluidic controlled respirator as claimed in claim 5 including a fifth fluid amplifier having a control port connected to an output channel of said first fluid amplifier and an output channel connected to the control port of said fourth fluid amplifier.

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