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[54] **SAMPLING MEANS FOR EXHALED AIR**
5 Claims, 3 Drawing Figs.

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[51] Int. Cl. **A61b 10/00**

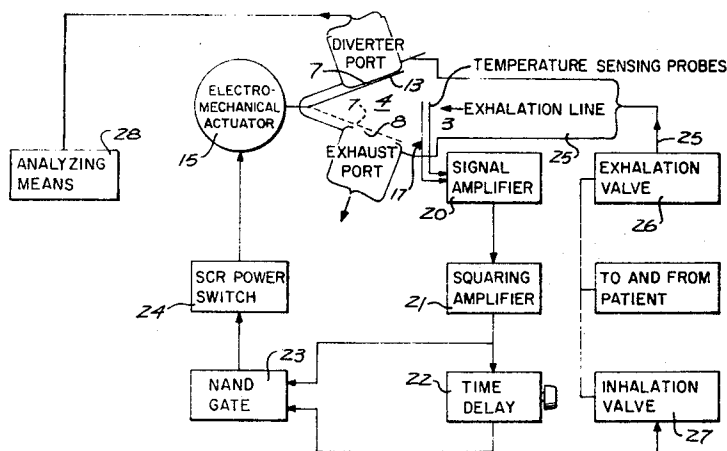
[50] Field of Search 128/2, 2.08,
2.07; 23/254; 73/421.5, 23; 137/119, 101.21, 118

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ABSTRACT: A valve and control therefor for separating the end tidal air or alveolar gas from air exhaled from a human or animal, wherein a valve, having two ports, is inserted in the exhalation line forming part of a breathing apparatus, the first port discharging to atmosphere, the second port discharging into a collection receptacle or analytical device; and wherein a control, including a temperature sensor, is located ahead of the valve to sense movement of exhaled air, is electrically connected to a variable time delay means operable to close the first port and open the second port after a preselected portion of the exhaled air has passed so a desired portion of the end tidal air may be collected or analyzed.



PATENTED OCT 19 1971

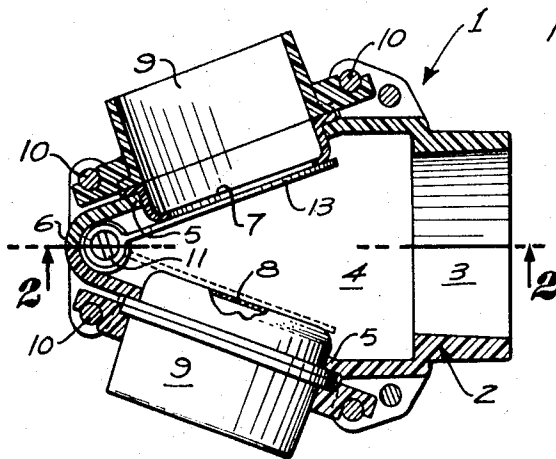


FIG. 1

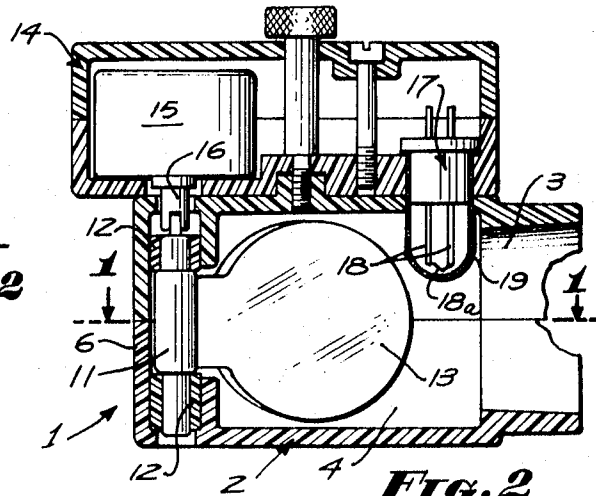


FIG. 2

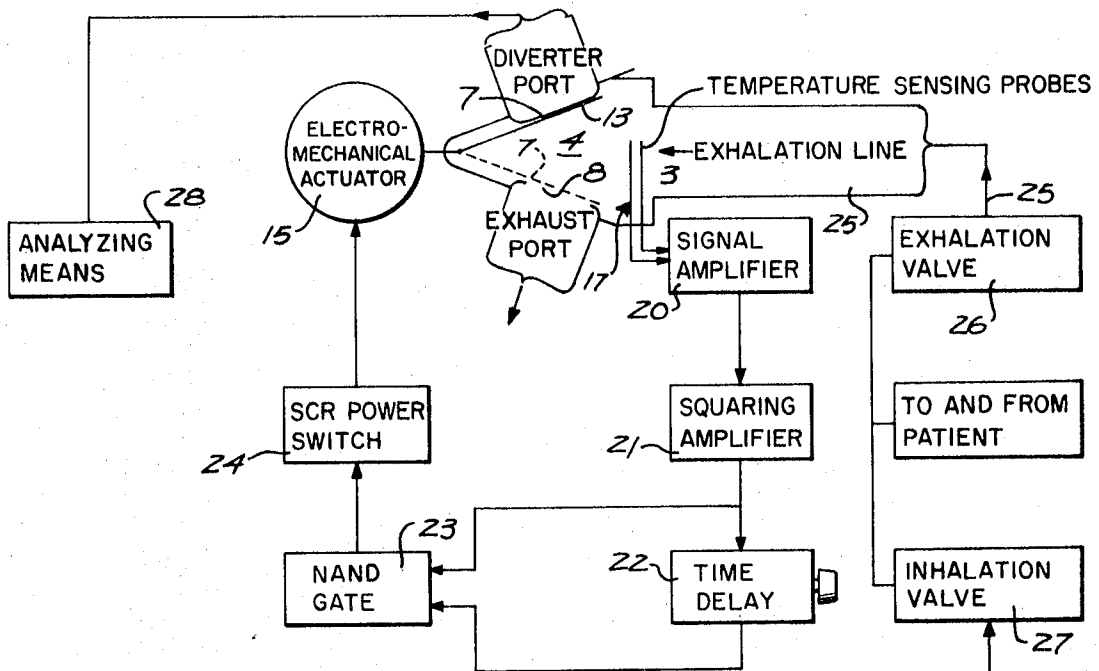


FIG. 3

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SAMPLING MEANS FOR EXHALED AIR

BACKGROUND OF THE INVENTION

It is desirable for diagnostic purposes to analyze the air-gas mixture exhaled by humans and animals. In a single exhalation cycle, the first portion of such mixture exhaled by a mammal consists principally of ambient air in passageways between the point of exhalation and the main airways of the lung. The first portion merges into the second portion of the exhaled mixture which consists of the residual ambient air and alveolar gas; that is, the gas contained in the cells of the lung. The last portion of the exhaled mixture consists principally of the alveolar gas, and is also known as end tidal air. This last portion of the exhaled mixture which is of primary interest in human and animal physiology for diagnostic and analytical purposes.

SUMMARY OF THE INVENTION

The present invention is directed to means for sampling air exhaled from a mammal and is summarized in the following objects:

First, to provide a sampling means for exhaled air wherein a valve permits discharge of a preselected portion of exhaled air and is then operated to divert a selected terminal portion for analysis.

Second, to provide a sampling means for exhaled air, as indicated in the preceding object, wherein a sensor exposed to the exhaled air initiates a variable time delay which operates the diverted valve after a selected interval calculated to divert a predetermined terminal portion of the exhaled air.

Third, to provide a sampling means for exhaled air wherein the sensor is a self-heating resistance device, adapted, when cooled by the exhaled air, to initiate the time delay, and when heated, during the inhalation cycle, to disarm the time delay in preparation for the next inhalation cycle.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of the diverted valve used in the sampling means for exhaled air, the view being taken through 1—1 of FIG. 2.

FIG. 2 is a sectional view of the diverter valve, taken through 2—2 of FIG. 1.

FIG. 3 is a block diagrammatical view indicating the electrical components of the sampling means as well as apparatus with which the sampling means is used.

The sampling means for exhaled air includes a diverter valve 1, having a valve body 2 which may comprise a pair of complementary components, and forming an inlet 3. The inlet communicates with a valve chamber 4, having converging walls 5 and an apex end 6.

One of the walls 5 is provided with an opening which receives a seal ring having inturned flanges forming a diverter port 7, and the other wall is provided with a similar opening which receives a similar seal ring forming an exhaust port 8. The seal rings project into the valve chamber and are held in place by suitable retainer fittings 9, attached by screws 10.

The apex end 6 of the valve chamber receives a pivot shaft 11, the ends of which are journaled in bearings 12. The pivot shaft 11 supports a gate valve 13, in the form of a flat disk. Oscillation of the pivot shaft moves the gate valve 13 between the diverted port 7 and exhaust port 8.

Mounted on top of the valve body 2 is a control housing 14 which may be formed of complementary components, and contains a rotary solenoid 15, having a drive shaft 16, suitably engageable with the upper end of the pivot shaft 11.

Mounted in the control housing 14 is a temperature sensor 17; for example, a Thermistor. The temperature sensor includes a pair of supports 18, which extend into the valve chamber 4 adjacent the inlet 3 and are joined by a sensing element 18a in the form of a resistor. A screen cage 19 may be provided around the supports and sensing elements.

The output of the sensor is capacitor coupled to a signal amplifier 20. The signal amplifier is a DC coupled amplifier which operates at very high gain. This causes the output of the

amplifier to swing between positive and negative saturation, producing a low quality square wave whose period is equal to the swings of the input signal. This square wave is fed into a squaring amplifier 21, which increases the rise time of the square wave to a point that it can be used to trigger a time delay 22 which may be a monostable multivibrator. The multivibrator is arranged so that it may be varied over a range of 0.1 second to approximately 10 seconds. The output of the monostable multivibrator or time delay, in conjunction with the output of the squaring amplifier 21, is fed to the input of a two input NAND-gate 23. The NAND gate produces a signal at its output only if the following two conditions are satisfied:

1. The output of the squaring amplifier 21 is still at negative saturation.
2. The time delay has finished its time period and returned to its original state.

When the preceding two conditions have been met, a silicon controlled rectifier power switch 24 is caused to turn on. The output of the switch is filtered DC which is applied to the rotary solenoid 15.

The inlet 3 of the diverter valve is connected to an exhalation line 25, which is connected to the patient through a breathing apparatus which includes an exhalation valve 26 connected to the exhalation line 25, and an inhalation valve 27. The two valves, 26 and 27, operate alternately as the patient inhales and exhales so that there is intermittent flow of air in the exhalation line.

The diverter port communicates with a conventional analyzing means 28, capable of identifying the composition of gases received from the diverter valve.

Operation of the sampling means for exhaled air is as follows:

Air exhaled from the patient enters the inlet port 3 and impinges on the temperature sensor element 18a. The temperature sensor element is supplied with sufficient current to maintain a normal temperature above 100° F. so that the incoming air cools the sensor element by convection, thus changing its resistance. This resistance change is utilized to arm the control circuit comprising the signal amplifier, squaring amplifier, time delay, NAND gate and power switch, and also to start the time delay circuit within the time delay mechanism. After a predetermined interval has elapsed, determined by the setting of the time delay, the solenoid 15 is operated to close the exhaust port 8 and open the diverted port 7. By proper adjustment of the time delay, only the last portion of the exhaled gas is diverted. It is this last portion of the exhaled gas that is the end tidal or alveolar gas which is of primary interest.

When the exhalation cycle is completed, the temperature sensor 17 returns to its normal temperature terminating operation of the control circuit so that the time delay may return to its initial condition. This operation takes place during the interval that the patient is inhaling; that is during the inhalation cycle, the diverter port is closed and the exhaust port opened so that the apparatus is ready for the next exhalation cycle.

The present embodiment of this invention is to be considered in all respects as illustrative and not restrictive.

I claim:

1. A sampling means for diverting the end tidal portion of air exhaled by a patient and conveyed through an exhalation air line, and sampling means comprising:

a diverter valve having an inlet arranged for connection to such line, an exhaust port, an outlet diverter port and means including a valve member normally in position closing said diverter port and movable to a position opening said diverter port and closing said exhaust port;

valve-operating means including an electromagnet means connected to said valve member and effective when energized to move said member to said position opening said diverted port;

means including temperature-sensitive electrical resistor means disposed in said inlet and means for electrically heating said resistor means to a temperature above that of

such exhaled air and said resistor means disposed to be cooled to a lower temperature by exhaled air incident to passage of exhaled air into said inlet whereby to produce an electric signal incident to being so cooled;

and signal translating means connected to said resistor means for reception of signals therefrom and including an adjustable time delay means for adjustably delaying translation of received signals, said signal translating means connected to said electromagnet means for energizing the latter for operating said valve to cause said valve member to open said diverter port and close the exhaust port at a selected time during passage of exhaled air into said inlet, whereby to divert through said diverter port only the end tidal portion of the exhaled air.

2. A sampling means as defined in claim 1, including: means in said signal translating means to cause said time delay to reset after completion of the exhalation, to permit sequential diversion of like portions of exhaled air.

3. A sampling means as defined in claim 1 wherein:

said temperature-sensitive resistor is a thermistor device and is heated by electric current and is cooled by exhaled air to produce an initiating signal for said time delay.

4. A sampling means as defined in claim 3 wherein:

said time delay is a variable period monostable multivibrator;

and said signal translating means comprises an amplifier interposed between said thermistor and the time delay.

5. A sampling means as defined in claim 4 wherein:

said signal translating means includes a two input NAND gate connected to receive signals from said amplifier and from said time delay to produce a signal for operating said electromagnet means only upon coincidence of a signal from said amplifier and a signal from said time delay indicating completion of a determined time delay period.

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