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M. SAKLAD ET AL
HIGH ALTITUDE RESPIRATION

2,830,579

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2 Sheets-Sheet 1

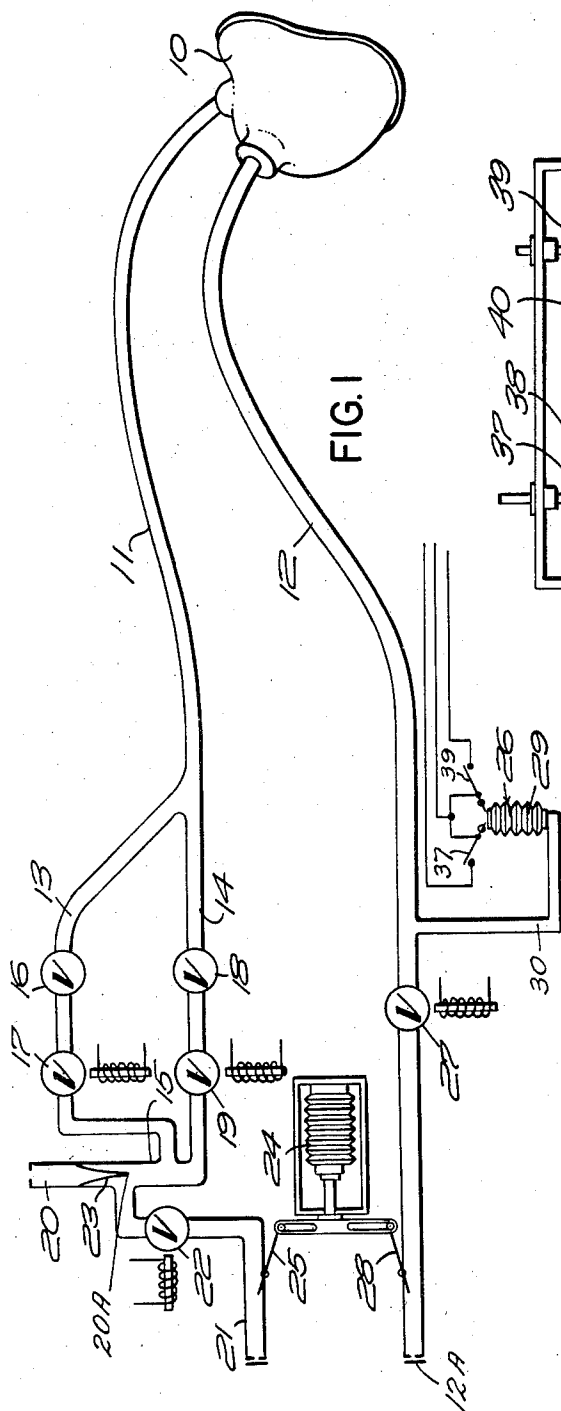


FIG. 1

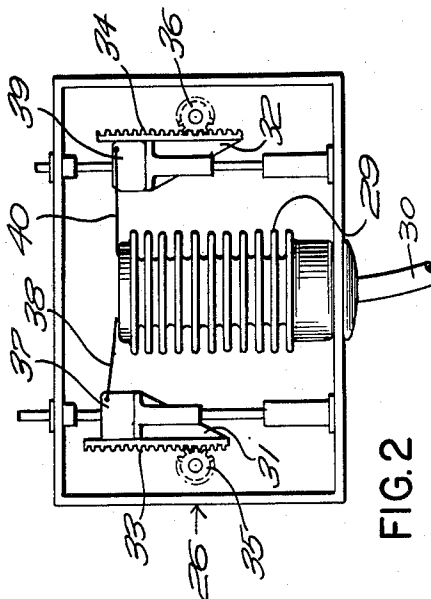


FIG. 2

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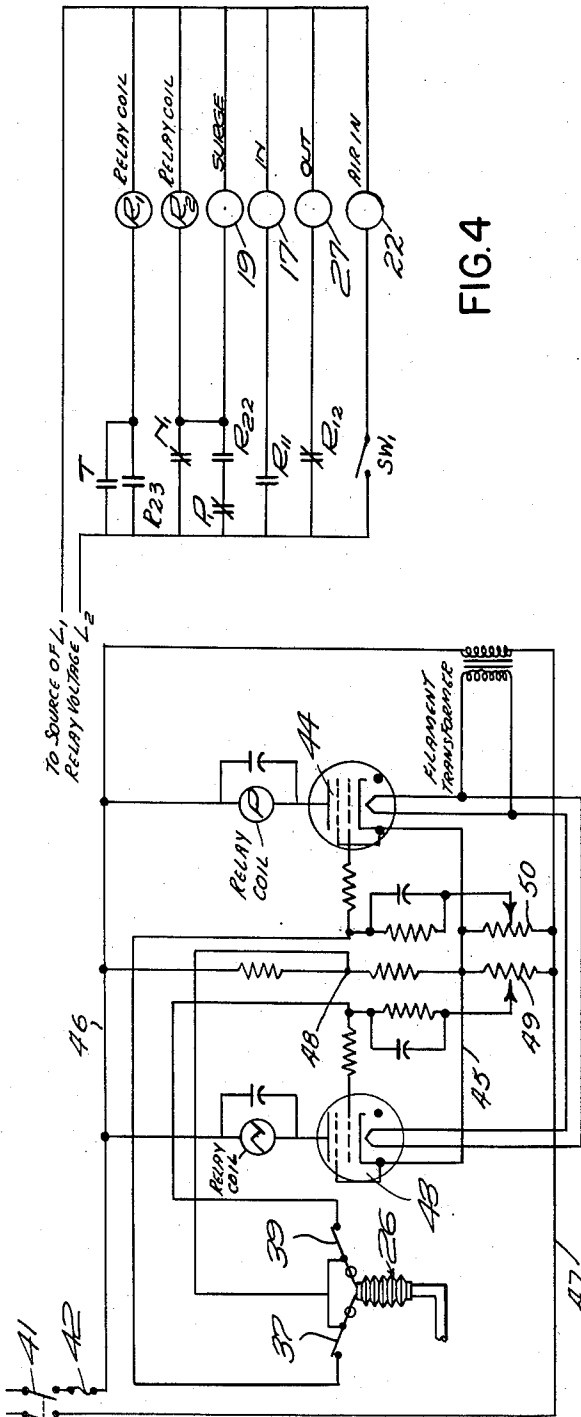


FIG. 3

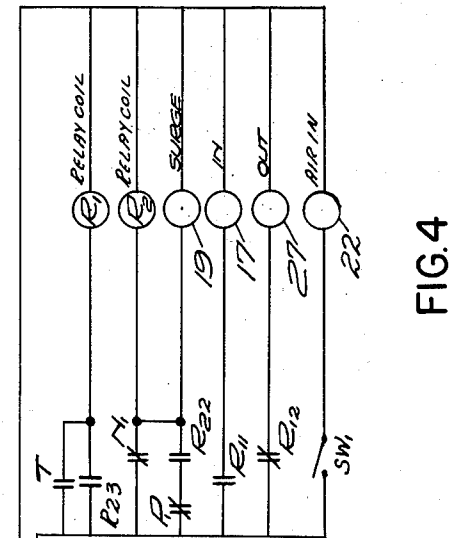


FIG. 4

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HIGH ALTITUDE RESPIRATION

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3 Claims. (Cl. 128—29)

The present invention relates to a respiratory apparatus, and more particularly to an electronically controlled device for high altitude respiration.

The present invention is a continuation in part of our co-pending application entitled "Electronically Controlled Respiratory Apparatus," filed Oct. 21, 1952, Ser. No. 319,634.

The principal object of the present invention is to provide an electronically controlled device for high altitude respiration sensitive to the needs of aircraft personnel, as to oxygen requirement and pressure needs on either or both phases of respiration.

Another object of the present invention is to provide a high altitude respiratory device which can also function to produce controlled or artificial respiration, the need for which is automatically sensed by the apparatus.

Our co-pending application hereinabove referred to describes an electronically controlled device for producing controlled or assisted respiration. The present apparatus is similar in operation but it is specifically designed for high altitude respiration where it is necessary that the percentage of oxygen vary as to the altitude, and the degree of positive pressure during the expiratory phase also vary automatically with the altitude.

With the above and other objects in view, our invention consists of a novel arrangement of parts more fully described in the detailed description following, in conjunction with the accompanying drawings, and more particularly designed in the appended claims.

In the drawings:

Fig. 1 is a plan view, partially diagrammatic of an apparatus embodying our invention.

Fig. 2 is a side elevation of the pressure-sensing mechanism.

Fig. 3 is a circuit diagram of the pressure control.

Fig. 4 is a diagram of the relay control circuit.

It has been found desirable to provide an apparatus which will deliver oxygen to an aviator in accordance with the needs; as to percentage of oxygen at varying altitudes, pressure required to inflate the lungs and positive pressure during exhalation. The present invention is sensitive to such demands and will deliver the necessary percentage and volume of oxygen. In addition, the present invention can also be made to cycle for the aviator where he is no longer able to breathe for himself, thus serving as an artificial respirator. There are no electronic devices now employed for such purposes. The device of the present invention can also be used for supplying air or oxygen to passengers at high altitude.

Essentially the present invention is similar to that described in our co-pending application for controlled and assisted respiration. Referring more in detail to the drawings, Fig. 1 shows a mask 10 which may be of any desired conventional construction in use by aviators. The mask 10 is provided with an inlet line 11 for supplying a mixture of air and oxygen, or oxygen alone, and an exhaust line 12. The inlet line 11 is fed by two branches 13 and 14 which join again at 15. The main branch 13 is

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preset by a hand control valve 16 and controlled by a solenoid valve 17. The flow through the auxiliary branch 14 is also preset by a hand control valve 18 and controlled by a solenoid valve 19.

Oxygen is provided from a conventional pressure cylinder (not shown) through the pipe 20 which communicates with the junction 15. Air is pulled into the system through the inlet 21, controlled by a solenoid valve 22. A Venturi section 23 is positioned at the junction of the air inlet tube 21 and the oxygen tube 20 so that the flow of oxygen will aspirate the air into the system by virtue of the negative pressure created at the throat 20A thereof. An aneroid device 24 operates a valve 25 which also controls the amount of air entering the system.

The exhaust line 12 is provided with a pressure-sensing mechanism 26 connected thereto by duct 30 and a solenoid control valve 27. The rate of exhaust flow is regulated by a valve 28 which is also operable by the aneroid 24, the end of the exhaust duct 12 having an "Acushnet" valve 12A to prevent reverse flow.

While any type of pressure-sensing mechanism 26 may be used, we have illustrated a bellows type device shown in detail in Fig. 2. In this device a conventional bellows 29 is connected to the exhaust line 12 through pipe 30, the bellows moving vertically with the pressure. Vertically slidably mounted on each side of the bellows 29 are a pair of plates 31 and 32 having rack teeth 33 and 34 along their side edges. Gears 35 and 36 are turned to adjust the vertical position of the plates 31 and 32. Mounted on plate 31 is a micro-switch 37 having an arm 38 resting on top of the bellows 29. Mounted on the plate 32 is a second micro-switch 39 having an arm 40 also resting on the top of the bellows 29. The micro-switches are so arranged that the switch 37 is sensitive to the negative pressure and is operable on the downward movement of the bellows 29 while the switch 39 is sensitive to the positive pressure and operable on the upward movement of the bellows 29.

The electronic circuit for effecting control of the apparatus as shown in Figure 1 is illustrated in Figures 3 and 4. Figure 3 illustrates an electronic switching mechanism which is particularly adapted to operate relays N and P which are responsive to the operation of switches 39 and 37, respectively. Briefly, the circuit consists of a source of alternating current which is supplied through switch 41 and appears across lines 46 and 47. Connected between these lines is a voltage divider network which is tapped as at 48 to provide a source of potential to one contact of the pressure sensing mechanism 26. Two thyatron switch tubes 43 and 44 have their cathodes connected together by a line 45 which serves as a reference potential. Connected between the reference potential line 45 and input line 47 are a pair of potentiometers 49 and 50, the taps of which are connected, respectively, through suitable networks to the grids of tubes 43 and 44, respectively. The grids of tubes 43 and 44 are also connected, respectively, to one contact of switches 39 and 37, respectively. The plate of tube 43 is connected through the operating coil of relay N to line 46, while the plate of tube 44 is connected through the operating coil of relay P to line 46. It will be appreciated that with neither switches 37 nor 39 closed, tubes 43 and 44 are rendered non-conductive by virtue of the fact that the grids are maintained at a voltage negative to the cathode, which is also sufficiently negative to be below the critical firing voltage. Should either switch 37 or 39 close, however, a positive voltage will be applied to the respective grid from the tap 48 of the voltage divider network, thus making the grids more positive with respect to the cathode and firing the tube, which will cause current flow therein, and operate the relay connected in the plate circuit thereof.

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Referring to Figure 4, we have shown therein a schematic view that includes the contacts N_1 and P_1 of the relays N and P of Figure 3 as well as the operating coils of valve 17, 19, 22, and 27, it being understood to those skilled in the art that lines L_1 and L_2 indicate a source of relay voltage.

In order to correlate how these various relays and the switching circuit of Figure 3 control the mechanism of Figure 1, the operation of the device will now be described.

Let us assume that the pilot is operating a respirator on an assisted basis. By inhaling, he creates a negative pressure that will be sensed by mechanism 26, which will close switch 39. This will fire tube 43, energizing relay N and closing contacts N_1 . This will operate relay R_2 thereby closing contact R_{22} and leaving open contact R_{23} . Contact P_1 of relay P is a normally closed contact, and thus it will be seen that a self-holding circuit is established through relay R_2 which will open valve 19 and keep it open until another condition is reached.

After a predetermined time elapse, the pilot will exhale, which tendency will be sensed by mechanism 26 that will close switch 37, thus firing tube 44 and operating relay P. This will open contact P_1 , which will drop out, relay R_2 opening contact R_{22} and closing contact R_{23} . It will be understood that relay N has already dropped out due to the extinguishment of tube 43 on the negative half cycle of the applied voltage as well as the opening of switch 39. The closing of contact R_{23} will operate relay R_1 , closing contact R_{12} and leaving open contact R_{11} . It will be noted that relay R_1 will be automatically held in by contact R_{23} until relay N operates again. It will also be noted by the above description that there are in effect two supply valves open on the input circuit, namely, valves 17 and 19. A supply of air into the system may be nicely controlled by the operation of solenoid valve 22 which is under the control of an external switch SW_1 .

This device, while described as being particularly adapted for assisted breathing, may also be utilized to provide controlled breathing through the operation of a contact T, as shown in Figure 4. Contact T may be operated from any source, such as a timing relay or other timing circuit. For instance, the timing circuit as disclosed in our copending application referred to above may be utilized. Briefly, it will be appreciated that when contact T closes, this will operate relay R_1 which will then operate alternately valves 17 and 27 by first closing contact R_{11} and then opening said contact and closing con-

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tact R_{12} . It will also be appreciated that when such an operation is taking place, the pressure sensitive mechanism 26 may or may not be disconnected and will thus, if connected, additionally control the limits to which positive and negative pressure will be exerted.

We claim:

1. A high altitude respiratory apparatus comprising a source of supply of oxygen, a breathing device, an inlet line from said source of supply to said breathing device, an exhaust line from said breathing device, a shut-off valve in each of said lines, a flow control valve in said air and said exhaust lines, means sensitive to inspiratory and expiratory pressures, said means actuating said shut-off valves to open the inlet line on inspiration and open the outlet line upon expiration, and atmospheric pressure sensitive means for controlling said flow control valves.

2. A high altitude respiratory apparatus comprising a source of supply of oxygen, a breathing device, an inlet line from said source of supply to said breathing device, an exhaust line from said breathing device, a solenoid operated shut-off valve in each of said lines, switches in circuit with the solenoids, a flow control valve in said air and said exhaust lines, a source of electricity, means sensitive to inspiratory and expiratory pressures, said means actuating switches in circuit with the solenoid valves and said source of electricity to open the inlet line upon inspiration and open the outlet line upon expiration, and atmospheric pressure sensitive means for controlling said flow control valves.

3. A high altitude respiratory apparatus comprising a source of supply of oxygen, a breathing device, an inlet line from said source of supply to a breathing device, an air inlet line connected to said oxygen inlet line, an auxiliary inlet line from said source of supply to said breathing device, an exhaust line from said breathing device, a source of electricity, a solenoid operated shut-off valve in each of said lines, a flow control valve in said air and said exhaust lines, means sensitive to inspiratory and expiratory pressures, said means actuating switches in circuit with the solenoid valves and said source of electricity to open the inlet line upon inspiration and open the outlet line upon expiration, and atmospheric pressure sensitive means for controlling said flow control valves.

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