

June 30, 1942.

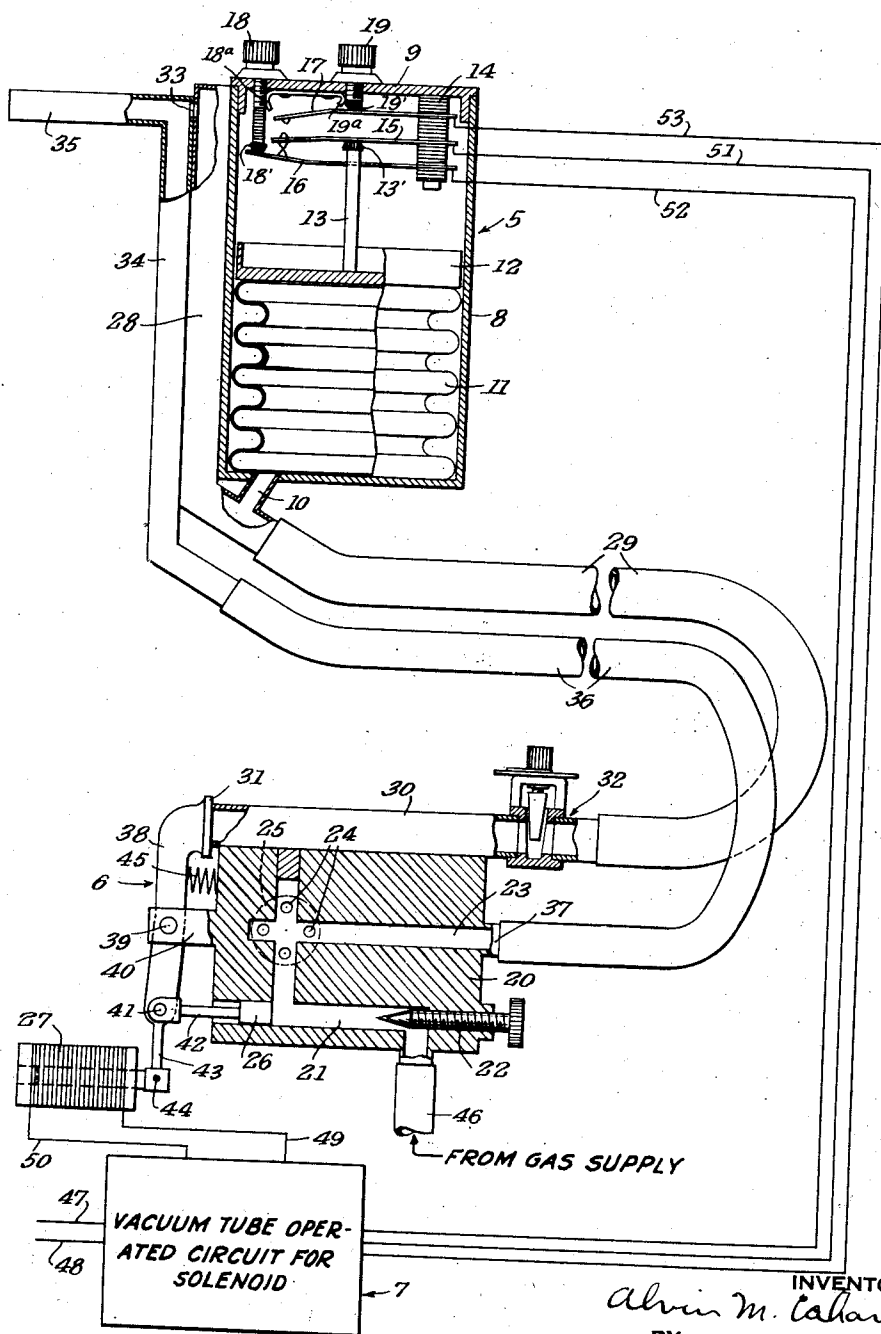
A. M. CAHAN
RESUSCITATING DEVICE

2,288,436

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2 Sheets-Sheet 1

Fig. 1



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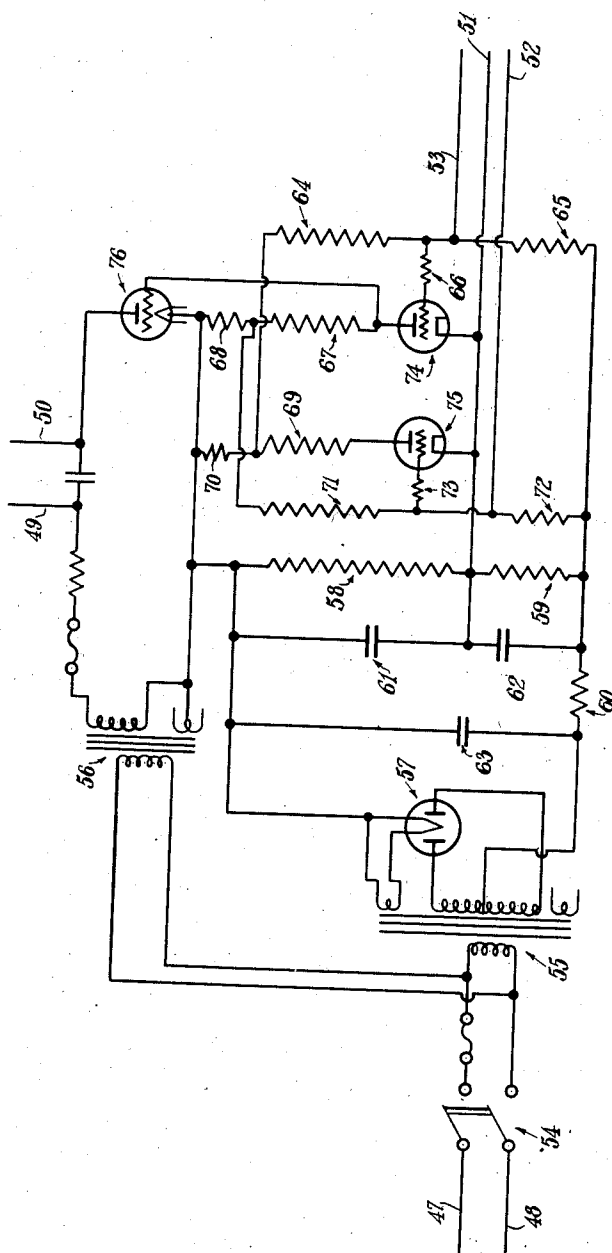
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RESUSCITATING DEVICE

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2 Sheets-Sheet 2



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RESUSCITATING DEVICE

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12 Claims. (Cl. 128—29)

My present invention relates to a resuscitating device and while not limited thereto is especially adapted for use with any patient in whom there is respiratory failure, such as occurs in fourth stage anaesthesia, gas poisoning, morphine poisoning, drowning, poliomyelitis, etc., or in whom the respiratory movements threaten not to take place before the life of the patient is endangered, as occurs in newborn infants delivered from narcotized or anaesthetized mothers. My invention is also adapted to delivering inhalation anaesthesia under positive pressure, as is desirable in certain open operations on the thorax, where the pleural cavity is exposed to the atmosphere, so that the lungs thus exposed would collapse if this were not prevented by positive pressure anaesthesia.

The fire hazard entailed in the use of such an apparatus in conjunction with volatile explosive anaesthetics has been eliminated by the use, instead of a system of mechanically operated electrical relays, which would spark, of a vacuum tube amplifier relay system, whereby the current passing across the electrical contacts is so small that no sparking can occur, and the machine can therefore be safely operated even in an atmosphere of cyclopropane and oxygen in their most explosive proportions. Besides, the controlling contacts are not in the stream of gas, but are in a chamber separate from the gas channels. This may, if desired, be hermetically sealed, although this precaution is unnecessary.

The present invention aims to provide a device of the general character indicated which is relatively simple in construction, easy and economical to fabricate and assemble, and admirably adapted for the performance of the critical functions which it is intended to carry out.

In the accompanying specification I shall describe and in the annexed drawings show an illustrative embodiment of the resuscitating device of the present invention. It is, however, to be clearly understood that I do not wish to be limited to the details shown inasmuch as changes therein may be made without the exercise of invention and within the scope of the claims hereto appended.

In the accompanying drawings

Figure 1 is a partially schematic, partially sectional view of a resuscitating device made in accordance with the principles of the present invention; and

Figure 2 is a schematic showing of the electrical hookup employed in the vacuum tube relay

utilized as part of the combination of elements making up the present invention.

Before describing my invention in detail, I deem it advisable briefly to refer to some of the disadvantages existing in devices hitherto employed for corresponding purposes so that the manner in which the present invention overcomes and eliminates the same may be more readily appreciated.

In positive pressure, and positive and negative pressure resuscitating devices now in use there is a tendency for the critical pressure that the lungs can withstand to be exceeded, so that I have observed at autopsies done on infants that have died after unsuccessful attempts at resuscitation extensive emphysema of the lungs, both on cross section, in the parenchyma of the lungs, and subpleurally. Some of the subpleural emphysematous blebs are occasionally seen to be ruptured. In several adults that have died after periods of respiratory failure, during which time they had been maintained by positive and negative pressure resuscitation methods, I have observed that not only is there marked pulmonary emphysema that does not occur otherwise in such patients, but in one case air had actually been forced into the mediastinal connective tissue, and had extended down along the paravertebral tissues. In the pulmonary veins of this same case was found considerable amounts of foam, shown by aerobic and anaerobic cultures not to be due to gas forming micro-organisms. The resuscitation devices used on these patients have been both manually and mechanically operated; each showing similar pathological results. By means of the present invention, the instrument may be set at the critical pressure, which will then not be exceeded during the resuscitating procedure. Other objects and advantages of the present invention will readily occur to those skilled in the art to which the present invention relates as the detailed description thereof progresses.

Referring now more in detail to the aforesaid illustrative embodiment of the present invention and with particular reference to the drawings illustrating the same, it might be stated that the device comprises, generally, three main operating units; a pressure-operated circuit-controlling device 5, a valve mechanism 6, and a vacuum tube relay device 7.

The pressure-operated circuit-controlling device 5 consists of a cylindrical housing 8 which is open at its upper end and provided with a cover plate 9 and which is further provided in the bottom wall thereof with a vent 10. En-

closed within the housing 8 is a pressure operated bellows 11, the lower end of which is sealed to the bottom of the cylinder, but is open to the vent 10 and the upper end of which is secured to a plate 12 from which there extends a rod 13, the upper end of which is covered by an insulating cap 13'. Secured to the cover plate 9 and depending from the underside thereof into the housing 8 is an insulating block 14, which supports an intermediate spring contact 15, which is bent so as to rest against the insulating cap 13' at the end of rod 13 at all times during the operation of the device, a lower spring contact 16 and an upper spring contact 17. In order to adjust the spacing between the three contacts 15, 16, and 17 I provide adjusting screws 18 and 19 respectively provided with insulating caps 18' and 19', the former operating upon the lower contact 16 to determine that point to which the pressure in the system must fall before the circuit between contacts 15 and 16 is made, and the latter operating upon the contact 17 to determine that point to which the pressure must rise in order to close the circuit between contacts 15 and 17. Thus the upper and lower limits of pressure desired for resuscitation may be selected by operating the machine against a properly adapted water manometer, and the machine may thus be standardized; screws 18 and 19 being provided with arrows, pointing to pressures engraved on a dial placed at the periphery of the screws (not shown). The screws 18, and 19 are stabilized by springs 18a and 19a, in order to cause the adjustment not to vary.

The valve mechanism 6 consists of a valve block 20 provided with an inlet passage 21 into which there is projected a needle valve 22 to control the rate of flow of a gas through the passage 21. The block 20 is also provided with an outlet passage 23 which, in effect, constitutes a continuation of the inlet passage 21. Intermediate the passages 21 and 23 I provide a plurality of vents 24 normally closed by a safety valve 25. For directly controlling the flow of gas from passage 21 to passage 23 I provide a sliding valve 26.

The vacuum tube relay device 7, in and of itself, is no part of the present invention. It is a unit that utilizes a well known electrical engineering circuit. For the purpose of describing its function in the present invention it is sufficient to say that the relay device 7 includes a plurality of vacuum tubes, the operation of one or more of which is designed to excite another tube and deliver to its grid a positive charge which sets up a current through the solenoid 27, the current operating the solenoid continuing to flow until such time as the vacuum tube which controls the same, has delivered thereto a negative charge, at which time the current through the solenoid is discontinued and the solenoid permitted to return to its normal position.

The three mechanisms are structurally connected with each other as follows:

Secured to the housing 8 of the circuit control device 5 is a tube 28, the upper end of which is sealed and the lower segment of which communicates with the vent 10 and also with a flexible hose 29, the latter in turn being connected with an exhaust tube 30. Included in tube 30 and adapted to control the open cross-section thereof for a purpose which will hereinafter be more fully set forth, is a manually operated gate valve 32.

Adjacent the closed upper end of the tube 28 I provide a passage 33 whereby the tube 28 connects with an inlet tube 34 provided at the upper

end thereof with a delivery tube extension 35. The lower end of the tube 34 is connected with a flexible hose 36 in turn communicating by means of a fitting 37 with the outlet passage 23 of the valve block 20.

The exhaust valve 31 is carried at one end of a rocker arm 38 pivoted at 39 to an extension 40 formed on the valve block 20. The other end of the arm 38 is pivotally connected at 41 to a link 42 attached to the sliding valve 26 and another link 43, an extension and part of the rocker arm 38, pivotally connected at 44 to the core of the solenoid 27. Intermediate the valve block 20 and the rocker arm 38 on the exhaust valve side thereof I provide a spring 45 which maintains the exhaust valve 31 in the open position, and the intake valve 26 in the closed position when the solenoid coil is not actuated by a current. The device is completed by a flexible hose 46 connecting the inlet passage 21 with a source of oxygen delivered from a cylinder of compressed oxygen via a standard reducing valve, or of an anaesthetic mixture delivered by any one of the standard closed system machines.

It has been found that the control unit 5 works just as well, and with less difficulty to the operator, and in a more simplified fashion, if the unit 5 be incorporated on the same base as the valve mechanism 6 and the vacuum tube relay circuit 7, modifying it, however, so that vent 10, connecting the interior of the bellows 11 with the gas supply, is connected as a direct perpendicular extension from the intake 23. The tubes 29 and 36 then are connected to a Y tube, (not shown), the third tube of this Y tube then delivering the gaseous mixture to the patient, and returning it to the machine. It should be noted that with this arrangement the intake tube 36 should be of larger diameter so as to decrease the pressure gradient to an inconsequential level at the maximum rate of flow of the gas.

The various mechanisms are electrically connected with each other as follows:

The numerals 47 and 48 designate the main supply line for a source of electrical current. These leads enter the vacuum tube relay 7. The relay is connected by conductors 49 and 50 to the solenoid 27 and the various circuits which control the supply of current to the solenoid 27 are completed by means of conductors 51, 52 and 53, the first of these conductors being connected with the intermediate contact 15, the second of these conductors being connected with the lower low pressure contact 16, and the last of these conductors being connected with the upper high pressure contact 17.

The elements of the relay 7 and their functions are as follows:

Current from the line 47—48 is controlled by a main switch 54, in turn connected to the primary of a transformer 55. Through parallel conductors current is also conveyed to the primary of another transformer 56. The secondary of the transformer 55 is tapped to supply current to the filament of a rectifier tube 57, the two plates of which are likewise supplied with current from the secondary of the transformer 55. Associated with the rectifier 57 is a filter, comprising the resistors 58, 59 and 60 and the condensers 61, 62 and 63, which, in turn, is electrically connected through resistors 64 to 73 inclusive, with two high-mu tubes 74 and 75. It will be noted that the electrical connections are such that the tubes 74 and 75 cannot both be conducting at the same time; only one or the

other can be so functioning at any given time. The tubes 74 and 75 are respectively connected with the upper and lower contacts 17 and 16 of the pressure operated circuit-control 5 by means of the conductors 53 and 52 and are also connected with the intermediate contact 15 of said control by means of the conductors.

The secondary of the transformer 56 supplies unrectified alternating current to another vacuum tube 76 and, through the conductors 49 and 50 to the solenoid 27.

Thus, when the contacts 15 and 16 are engaged, the tube 75 becomes conducting and the tube 74 does not conduct so that the tube 76 permits the passage of current to the solenoid 27. When there is engagement between the contacts 15 and 17, the tube 75 ceases to conduct and the tube 74 becomes conducting. The potential drop due to the anode current of this tube flowing through the resistors 67 and 68 provides a negative voltage between the grid and cathode of the tube 76 thus stopping the passage of current to the solenoid.

This completes the description of the afore-said illustrative embodiment of the device of the present invention and the mode of operation and use thereof may be briefly summarized as follows:

Assuming that the device is to be used for resuscitation, the hose 46 is connected with a source of oxygen, as described above. First the oxygen supply is turned on to deliver the desired flow per minute, which is gauged by the requirements of the patient-adult or infant. The current supplying the vacuum tube circuit is turned on. Since the pressure in the tube supplying the gas to the patient is atmospheric, contacts 15 and 16 are together, and when the vacuum tubes become heated and begin to function, the solenoid coil is activated, the core is drawn into the axis of the coil, thus opening valve 28, allowing the gas to flow along tube 36 toward the patient, and simultaneously closing valve 31, thus shutting off the exhalation valve. The tube 35 may then be connected with a tracheal airway already in place in the patient, or with a rigid face mask, fastened over the patient's nose and mouth in the standard manner used with closed system anaesthesia. The gas enters the patient's lungs and expands them up to the predetermined level at which time a back pressure is built up in the extension 35, which back pressure is communicated by way of the vent 33 to the outlet tube 28 which in turn conveys the built up pressure by way of vent 10 to the bellows 11. When this pressure rises above the predetermined minimal pressure (in actual trials this has been of the order of 1 and 2 millimeters of water pressure), the bellows 11 expands so as to move the plate 12, and with it the rod 13, upwardly in the cylinder 8, so as to break the contact between 16 and 15. However, notwithstanding the breaking of the circuit through the contacts 15 and 16, the relay 7, originally operated by reason of the engagement between the contacts 15 and 16, maintains the supply of current through the solenoid 27 to keep the valve 26 open and the valve 31 closed. However, as the pressure operating upon the bellows 11 increases, another critical point is reached and at the instant that this point is reached a new circuit is established by reason of the engagement between the intermediate contact 15 and the upper contact 17. This circuit through the relay 7, delivers a negative charge to the vacuum tube controlling the flow

of current through the solenoid 27 and this negative charge brings about cessation of current operating the solenoid 27 so that the spring 45 can then function to pivot the rocker arm 38 thereby closing the inlet valve 26 and opening the exhaust valve 31. This operation results in a reduction of pressure throughout the system with the result that the bellows 11 moves toward its collapsed position. The movement of the bellows must be gradual rather than sudden inasmuch as a sudden drop of the bellows results in vibrations which will move the contact 15 rapidly into and out of engagement with the contacts 16 and 17, thus interfering with the proper operation of the device. In order to prevent this sudden drop in pressure, the valve 32 must be adjusted so that rate of expiration of the patient, caused by the collapse of his naturally elastic lungs, just filled by the resuscitator will maintain intratracheal pressures within the exhalation tube, and thus within the control bellows 11. This will vary from adult to infant, and therefore the valve must be marked for three positions—corresponding to the tidal respiratory exchange from adult to infant. Thus, the valve 32 is capable of adjustment so that the cross section of its airway can be made to correspond with the cross section of the trachea of the patient being treated. Inasmuch as there is little variation in the cross sectional area of newborn infants (for practical purposes), children, and adults, a suitable scale may be constructed for the operation of this valve. In this way, the lungs of the patient will be allowed to collapse at their natural free rate. As soon as the pressure in the system as a whole begins to reduce from the upper critical limit, the contact 15 becomes disengaged from the contact 17, but this has no effect upon the circuits set up in the relay 7 to control the solenoid 27 inasmuch as again another "holding" tube in the circuit of the relay 7 continues to function under its negative charge until such time as the pressure in the system as a whole is reduced to the lower critical point, at which time contact is re-established between the contacts 15 and 16 and the "holding" tube of the relay 7 is again supplied with a positive charge. This results in a repetition of all of the operations just described and these operations are continued until such time as the patient being operated upon is able to breathe of his own volition. The device is then withdrawn from the patient.

This completes the description of the mode of operation and use of the device of the present invention. As stated above, instead of oxygen being supplied through the hose 46, the latter can be connected with a source of general anesthetic and the device used just as efficiently for this function in properly selected cases.

It will be noted from all of the foregoing that the resuscitating device of the present invention is simple in construction, easy and economical to fabricate and assemble and admirably adapted to perform the intended function reliably.

What I claim as my invention is:

1. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic

means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic inlet and outlet valve-operating means.

2. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, a solenoid for operating said inlet and outlet valves, and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits to control the functioning of said solenoid whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit.

3. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and bellows-operated means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic inlet and outlet valve-operating means.

4. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, a solenoid for operating said inlet and outlet valves, and bellows-operated means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits to control the functioning of said solenoid whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit.

5. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic in-

let and outlet valve-operating means, said means including a plurality of electrical contacts and a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts.

6. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic inlet and outlet valve-operating means, said means including a plurality of electrical contacts, a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts, and means to adjust the amounts of pressure necessary to consummate said electrical engagements.

7. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, a solenoid for operating said inlet and outlet valves, and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits to control the functioning of said solenoid whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit, said means including a plurality of electrical contacts, and a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts.

8. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, a solenoid for operating said inlet and outlet valves, and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits to control the functioning of said solenoid whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit, said means including a plurality of electrical contacts, a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts, and means to adjust the amounts of pressure necessary to consummate said electrical engagements.

9. In a device of the character described an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic means whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit.

10. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and bellows-operated means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic means whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit.

11. In a device of the character described, an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic

means for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic means whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit, said means including a plurality of electrical contacts, and a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts.

12. In a device of the character described an intake conduit for conveying a gas to a person's tracheal passage, an exhaust conduit communicating with said intake conduit and also with the atmosphere, inlet and outlet valves for said intake and exhaust conduits, electro-magnetic means, for operating said inlet and outlet valves, a vacuum tube operated trigger mechanism for controlling the operation of said electro-magnetic means and means, communicating with said exhaust conduit and responsive to predetermined upper and lower pressure limits within the entire system, for establishing a plurality of electrical circuits through said trigger mechanism to control the functioning of said electro-magnetic means whereby a flow of current thereto is initiated when the pressure reaches the lower limit and is maintained therein until the pressure reaches the upper limit, when said flow of current is discontinued and remains so until the pressure returns to the lower limit, said means including a plurality of electrical contacts, a bellows connected with one of said contacts and adapted to move the same into and out of electrical engagement with the remaining contacts, and means to adjust the amounts of pressure necessary to consummate said electrical engagements.

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