June 29, 1965 R. K. WILSON 3,191,595

ELECTRICALLY CONTROLLED RESUSCITATOR APPARATUS

Filed Nov. 16, 1959 2 Sheets-Sheet 1

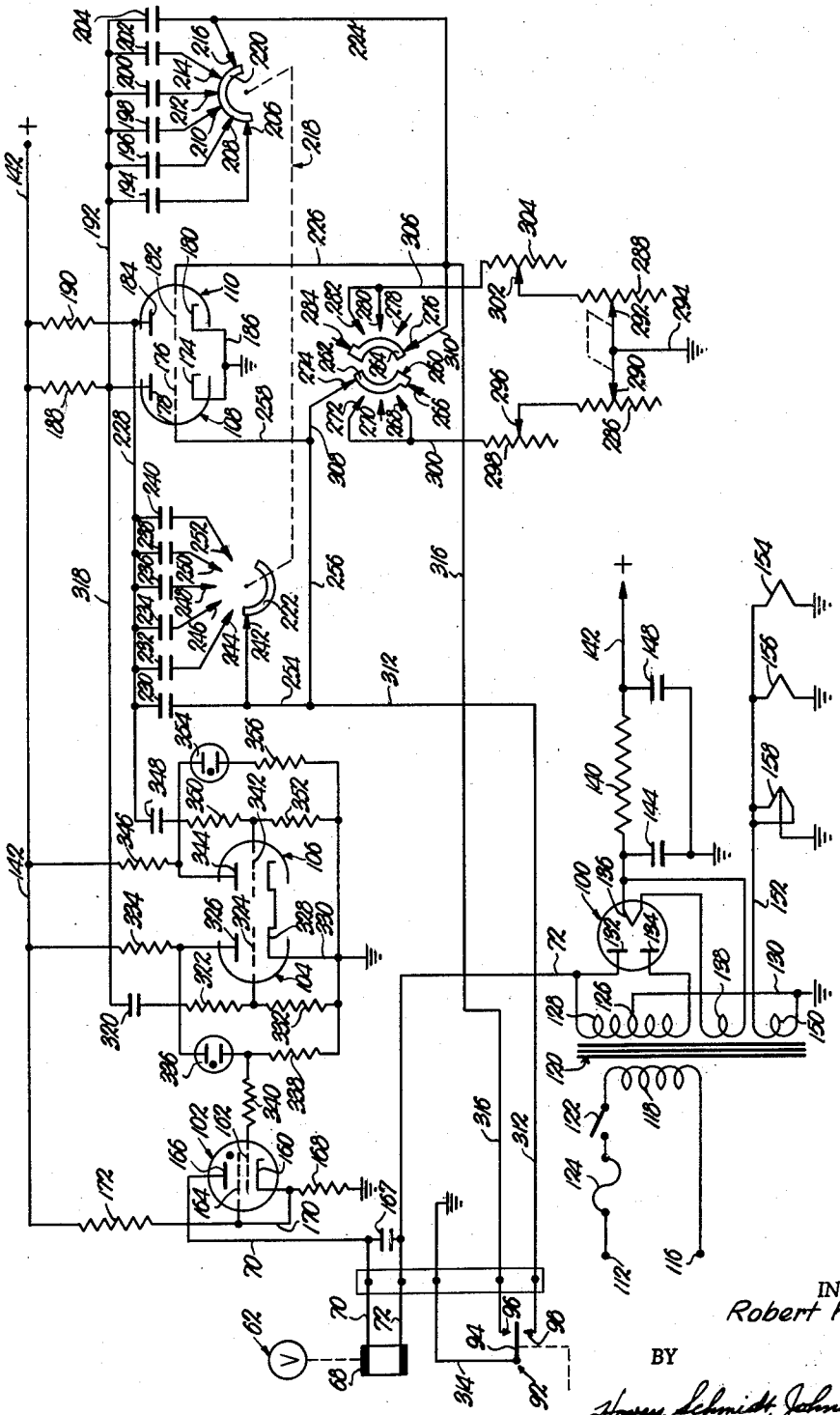


Fig. 1.

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ELECTRICALLY CONTROLLED RESUSCITATOR APPARATUS

Filed Nov. 16, 1959 2 Sheets-Sheet 2

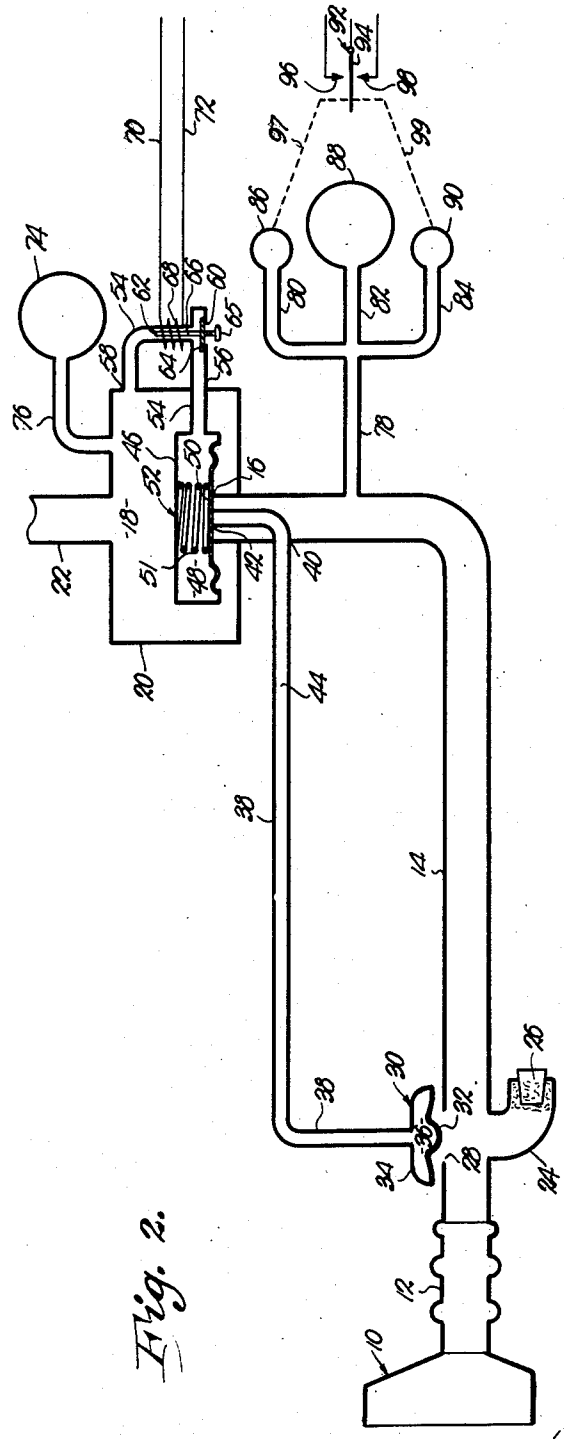


Fig. 2.

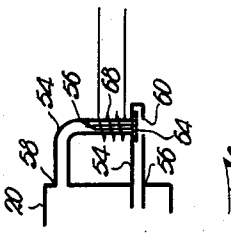


Fig. 5.

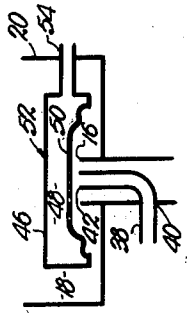


Fig. 4.

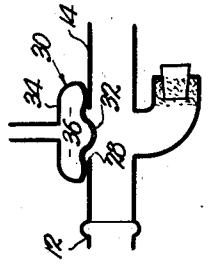


Fig. 3.

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United States Patent Office 3,191,595 Patented June 29, 1965

3,191,595

ELECTRICALLY CONTROLLED RESUSCITATOR APPARATUS

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Filed Nov. 16, 1959, Ser. No. 853,256
10 Claims. (Cl. 128—29)

This invention relates generally to the field of controlled induction or assistance of respiration, certain features of the inventon having applicability to various kinds of equipment including intermittent, positive pressure breathing (I.P.P.B.) units, assistors, resuscitators, respirators, ventilators and the like. More particularly, the invention is herein illustrated with reference to an improved form of resuscitator apparatus embodying control means of primarily electrical character for providing increased accuracy, reliability and versatility of performance at a cost substantially below that involved in providing apparatus utilizing conventional types of control means for achieving even a portion of the functions accomplished by the apparatus of the present invention.

It is most desirable in apparatus of the class in question that the physician supervising operation of the apparatus in administering to patients having various kinds of respiratory difficulties, be able to utilize the apparatus selectively or progressively with a given patient in any of several ways, namely, for completely automatic, time controlled, induction of breathing functions, for patient effort responsive assistance of inhalation and automatic, time controlled, induction of exhalation, for patient effort responsive assistance of exhalation and automatic, time controlled, induction of inhalation, or for patient effort responsive assistance of both inhalation and exhalation. It is also desirable that such apparatus provide for overriding any automatic time control exercised by the apparatus over breathing functions in response to a significant patient effort to initiate the corresponding breathing function. It is further desirable that such apparatus provide the attending physician with means for independently varying the ratio of inhalation time to exhalation time and the total respiration cycle time without substantial alteration of the other.

Heretofore, no apparatus for successfully performing all of the above-mentioned functions or even certain badly needed subcombinations thereof has been available. Moreover, efforts to provide apparatus for performing even isolated ones of such functions by conventional approaches have involved the use of costly and complex valves and other mechanical and pneumatic devices which are difficult both to produce and maintain.

Accordingly, it is the primary object of this invention to provide improved apparatus of the subject class for performing all of the above-mentioned functions accurately, reliably and relatively inexpensively.

It is another important object of this invention to provide such apparatus utilizing a combined electrical, electromechanical and pneumatic system for accomplishing the desired timing of and control over the various phases of functioning of the apparatus.

It is still another important object of the invention to provide such apparatus in which improved electronic multivibrator means are employed to control the timing of functions of the apparatus being automatically cycled.

It is still another object of the invention to provide such apparatus utilizing an improved arrangement of pneumatic paths, valves and pressure responsive control devices.

It is still another important object of the invention to provide an improved form of multivibrator circuitry by

which astable or free running, monostable and bistable operation may be selectively and progressively caused to occur and in which both the period of the entire cycle and the ratio of durations of the two portions of the cycle may be independently varied and controlled. It should be noted that references herein to "monostable" and "bistable" operation are to be understood as descriptive of the operating characteristics which prevail under normal conditions of cyling time for the apparatus, rather than implying absolute stability over indefinite periods of time substantially in excess of those occurring during normal use of the apparatus.

Still further important objects of the invention will be made clear or become apparent from the accompanying drawings and the description of an illustrative embodiment of the invention which follows.

In the accompanying drawings:

FIG. 1 is a schematic diagram showing the electrical portion of the timing and control part of the apparatus;

FIG. 2 is a diagrammatic representation of the pneumatic portions of the apparatus;

FIG. 3 is a fragmentary, diagrammatic representation of the exhalation valve portion of the apparatus in actuated or closed condition;

FIG. 4 is a fragmentary, diagrammatic representation of the auxiliary control valve portion of the apparatus in actuated or opened condition; and

FIG. 5 is a fragmentary, diagrammatic representation of the main control valve portion of the apparatus in actuated, opened condition.

The structure of the embodiment of apparatus chosen for illustrating the principles of the invention will first be described, then the operation of such structure will be explained.

Structure of the pneumatic portion of the system

Referring first to FIGS. 2, 3, 4 and 5, the numeral **10** generally indicates structure for effecting a pneumatic connection with a patient, which may be in the form of a mask, a tracheotomy tube, an endotracheal tube or the like of any suitable conventional construction known to those skilled in the art and per se forming no part of the present invention. The mask or equivalent structure **10** is pneumatically coupled by a tubular, preferably flexible conduit **12** with one extremity of a main pneumatic delivery tube **14** terminating at its opposite extremity in an open end **16** disposed within a chamber **18** enclosed by a hollow valve housing **20** pneumatically closed upon the side walls of the main delivery tube **14** and oppositely coupled with a gas supply tube **22** adapted for coupling with and herein representing any suitable source of air or other gas or mixture thereof under pressure and to be administered to the patient through mask or equivalent structure **10**.

Adjacent the extremity of main delivery tube **14** coupled with flexible conduit **12** is provided a connection **24** normally closed by means such as a cork **26** but which may in appropriate instances, be utilized for coupling to the main delivery tube **14** a nebulizer, aerosol generator or the like (not shown) for inducing medication or moisture into the main delivery tube **14**. Although not normally necessary, it will be understood that, if desired, a check valve (not shown) could be interposed in tube **14** adjacent the extremity of the latter coupled with housing **20** in order to exclude any medication or the like introduced through connection **24** from reaching the hereinafter described valve parts within housing **20**.

Also adjacent the extremity thereof coupled with the flexible conduit **12**, the main delivery tube **14** is provided with an atmospheric vent port as at **28** with which is operably associated and exhalation valve generally desig-

nated 30 having a flexible diaphragm 32 mounted on a housing 34 defining a chamber 36 in such manner that, when the pressure of gas within chamber 36 is below a certain predetermined level, the diaphragm 32 will, by virtue of its own resiliency or otherwise, be withdrawn away from the port 28 as shown in FIG. 2, to open the latter and, when the pressure of gas within the chamber 36 exceeds such predetermined level, will be forced into closing relationship with the vent port 28 as illustrated in FIG. 3. The chamber 36 within exhalation valve housing 34 is in communication with one extremity of an exhalation valve operating tube 38 which passes into the main delivery tube through a complementary opening at 40 adjacent the end 16 of the main delivery tube 14 and then extends through the latter to a point of termination in an open end 42 substantially flush with the open end 16 of main delivery tube 14. The exhalation valve operating tube 38 is provided with a small bleed port as at 44 therein for the purpose of releasing to the atmosphere any pressure which might otherwise be confined in the tube 38 when the end 42 thereof is closed in the manner hereinafter described.

Within the chamber 18 of valve housing 20 is disposed an auxiliary valve casing 46 having a chamber 48 therein and having one side thereof closed by a preferably flexible diaphragm 50 adapted to normally engage the end 16 of main delivery tube 14 and the end 42 of exhalation valve operating tube 38 simultaneously to close the latter as illustrated in FIG. 2 when the gas pressures on both sides of the diaphragm 50 are equal. The normal positioning of the diaphragm 50 in closing relation to the end 16 of tube 14 may be achieved either by the bias from resiliency of the diaphragm 50 itself, or may, if desired, be achieved or supplemented by a spring as at 51 bearing oppositely against the top of diaphragm 50 and an opposed wall of casing 46. When the gas pressure within chamber 48 falls below such predetermined level, as when the chamber 48 is vented to the atmosphere with a positive pressure remaining in chamber 18, the diaphragm 50 is adapted to move by virtue of the excess pressure on the outside thereof away from its engagement with the tube ends 16 and 42 to place main delivery tube 14 and the exhalation valve operating tube 38 in communication with the chamber 18 in housing 20, such actuated condition of the auxiliary control valve, which is generally designated 52 for identification, being illustrated in FIG. 4.

The gas pressure for controlling the operation of auxiliary valve diaphragm 50 is supplied to casing 46 through an auxiliary valve control tube 54 emerging from the housing 20 through a complementary hole as at 56 and reentering the housing 20 as at 58 to communicate with chamber 18 of the housing 20. The auxiliary valve operating tube 54 is provided with a port as at 60 communicating with the atmosphere and having operably associated therewith an electromagnetic valve device generally designated 62 and having a valve member 64 normally closing the port 60 (as illustrated in FIG. 2) connected with an armature 66 adapted to be moved to open the port 60 to the atmosphere and to close that portion of auxiliary valve operating tube 54 adjacent the connection 58 (as illustrated in FIG. 5) when an operating coil 68 is electrically energized through conductors 70 and 72. As a safety measure, the valve member 64 may be provided with a projection 65 thereon extending out through port 60 and which may be manipulated manually to provide for emergency operation in the event of a power failure or malfunction in the electrical portion of the apparatus.

A control pressure indicating gauge 74 is coupled with the chamber 18 of housing 20 as by a tube 76, it being understood that the gas source and connection means 22 will normally include valve or regulator means for adjusting the level of pressure applied from the source 22 to the chamber 18 of housing 20. Coupled with the main delivery tube 14 relatively adjacent the end 16 of the latter, is a pressure sensing tube 78 provided with branches 80, 82 and 84 respectively coupled with a pressure sensitive inhalation start controlling device 86, a mask pressure indicating gauge 88, and an exhalation start controlling device 90. Devices 86 and 90 may actually constitute different parts of a unitary assembly including switching means such as generally designated 92, effectively having a common pole piece 94 and a pair of opposed, normally open contacts 96 and 98, the device 86 being adapted to close an electrical circuit between switch piece 94 and contact 96 when the pressure within main delivery tube 14 is below a predetermined level, or, normally, at atmosphereic level and to reopen such circuit between piecs 94 and contact 96 when the pressure within main delivery tube 14 exceeds such predetermined level, while the device 90 is adapted to effectively close an electrical circuit between the switch piece 94 and the contact 98 when the pressure within main delivery tube 14 exceeds a predetermined level and to open such circuit when the pressure within main delivery tube 14 falls below such level, or, normally, back to atmospheric level. The operable association between the pneumatic sensing portions of the devices 86 and 90 and the electrical switching means 92 is indicated by the dotted lines 97 and 99, it being understood, however, that the electrical switching function of such devices 86 and 90 could be accomplished by either conventional switching means as diagrammatically shown for illustrative purposes, or by other means such as appropriate transducer type switching mechanisms responsive to pressure, or, perhaps even to other parameters responsive to patient breathing effort, e.g. carbon dioxide density. The manner of illustrating this portion of the system which was chosen, was selected since pressure responsive switches of conventional and readily available type may obviously be used as the devices 86 and 90 to provide essentially the switching function illustrated by the switching means 92 shown in FIGS. 1 and 2.

It will be appreciated by those skilled in the art that the relative lengths and sizes of various portions of the pneumatic portion of the system are not critical and that no attempt has been made to show the same to scale in the accompanying drawing by which their operative relationship is diagrammatically indicated. It will also be apparent that certain of the valve components shown may be characterized by different details of construction than those illustrated as preferred, without departing from the broader principles of the invention.

Operation of the pneumatic portion of the system

Assuming that air, gas or a mixture thereof to be administered to the patient is being applied from the source 22 into the chamber 18 of the housing 20, that the mask or equivalent structure 10 has just been operably associated with the patient, that the latter is not at the moment exerting any significant respiratory effort to either inhale or exhale, and that the operating coil 68 of main control valve 62 is deenergized, the condition of each of the main control valve 62, the auxiliary control valve 52 and the exhalation valve 30 will be as illustrated in FIG. 2.

In such stand-by condition of the apparatus, the valve element 64 of main control valve 62 is closing the atmospheric port 60 of valve control line 54, so that the fluid pressure within the chamber 18 is being communicated through such tube 54 to the chamber 48 of the auxiliary control valve 52. The diaphragm 50 will be in its normal position in which it closes the end 16 of main delivery tube 14 and the end 42 of exhalation valve control tube 38. With the end 16 of main delivery tube 14 being closed by the diaphragm 50, no air or gas under pressure is being delivered from the chamber 18 of housing 20 into the main delivery tube 14 or to the structure 10. Also, by virtue of the closing of end 42 of tube 38 by diaphragm 50, no air or gas pressure is being supplied from the chamber 18 into the tube 38, and, since the latter is vented to

the atmosphere as at 44, the pressure within chamber 36 of exhalation valve 30 will be essentially at atmospheric level so that the diaphragm 32 will remain in its normal position opening the vent port 28 in the main delivery tube 14. With the vent port 28 opened, the mask or equivalent structure 10 is, of course, in communication with the atmosphere through the conduit 12 and ports 28.

In such stand-by condition of the apparatus, with the main delivery tube 14 at atmospheric pressure by virtue of the venting thereof through the port 28, the devices 86 and 90 will each be in condition such that there is no electrical continuity between the switch part 94 and either of the switch parts 96 and 98.

Next, assuming that the operating coil 68 of the main control valve 62 is energized, either by action of the automatic control means or the patient responsive control means hereinafter to be more fully explained, the valve element 64 will be shifted to a position opening the atmospheric vent 60 and blocking the auxiliary valve control tube 54 intermediate its connections with the chamber 18 of housing 20 and the chamber 48 of the auxiliary valve housing 46. This permits any air or gas pressure within the chamber 48 in excess of atmospheric level to be vented to the atmosphere through port 60. Since the entire chamber 18 is being held at a pressure above atmospheric level by air or gas supplied from the source 22, such pressure within chamber 18 will act upon the outer side of diaphragm 50 to move the same to the condition shown in FIG. 4, which opens the end 16 of main delivery tube 14 and the end 42 of exhalation valve control tube into communication with the chamber 18. It may presently be noted that one way in which the operating coil 68 may be caused to be energized to commence this phase of the operation of the apparatus is by the patient making a significant effort at voluntary inhalation, which will tend to momentarily lower the pressure within the structure 10, conduit 12, main delivery tube 14 and device 86 to such an extent that the latter will momentarily establish a closed circuit between the switch parts 94 and 96, which parts 94 and 96 are operably coupled with means to be described for controlling the state of energization of coil 68.

With the end 42 of exhalation control tube 38 now open to the pressure of air or gas within the chamber 18, such pressure is communicated to the chamber 36 of exhalation valve 34, which results in shifting of the diaphragm 32 to a position closing the vent port 28, as shown in FIG. 3. With the closing of such vent port 28, the air or gas under pressure in chamber 18 and now communicating with the main delivery tube 14 through the open end 16 thereof, is delivered to the mask or equivalent structure 10 through the conduit 12. This constitutes the condition of the pneumatic portion of the system when in the inhalation phase of the respiratory controlling cycle of the apparatus, during which air, gas or the like is being administered under pressure to the patient. In view of the pressure level of the air or gas maintained in the main delivery tube 14 during such inhalation phase of the operation of the apparatus, the electrical continuity between switch parts 94 and 96 will, of course, be interrupted by the device 86. However, once the operating coil 68 has been energized as a result of the device 86 responding to a patient inhalation effort, however weak or short in duration, to momentarily establish a closed circuit between switch parts 94 and 96, if the inhalation phase of the cycle was so instituted rather than by timed operation of the automatic control means to be later described, such coil 68 will be retained in energized condition for a predetermined period by electrical portions of the apparatus hereinafter to be also described, even though the patient's inhalation effort may have ceased and the pressure within main delivery tube 14 operates device 86 to break the circuit connection between switch parts 94 and 96.

Next, assume that the operating coil 68 of the main control valve 62 is deenergized either through operation of the automatic control means to be described or by virtue of operation of the device 90 to momentarily close a circuit between switch parts 94 and 98 and the electrical control means associated therewith responsive to a significant effort on the part of the patient to exhale, which raises the pressure within main delivery tube 14 above a predetermined level. Such deenergization of coil 68 will result in return of the valve element 64 to its normal condition closing the atmospheric vent 60 in tube 54, and the latter will again supply gas or air under pressure from chamber 18 into chamber 48. Such pressure applied to the chamber 48 will balance the pressures on both sides of the diaphragm 50, and the latter will return to its normal position illustrated in FIG. 2, in which it closes the end 16 of main delivery tube 14 and the end 42 of exhalation valve control tube 38. The pressure within chamber 36 of exhalation valve housing 34 will bleed off through the port 44, and the diaphragm 32 will return to its normal or collapsed position, as illustrated in FIG. 2, opening the vent port 28 of main delivery tube 14 to the atmosphere. This removes the application of pressurized air or gas to the structure 10 and permits the patient to exhale with both the exhaled air or gas and the air or gas previously under pressure in main delivery tube 14 escaping to the atmosphere through open vent port 28. It may be noted that, during such exhalation phase of operation of the apparatus, since the level of air or gas pressure applied to the devices 86 and 90 is thus returned to substantially atmospheric level above that required for operation of device 86 and below that required for operation of device 90, the electrical continuity between switch part 94 and the switch 98 will be interrupted. It will be further observed that all parts of the pneumatic system of the apparatus are in the same condition, during such exhalation phase of the respiration controlling cycle of the apparatus, as characterized the same during the initial or stand-by condition of the apparatus. Accordingly, the apparatus is ready for a repetition of its respiration controlling cycle, by initiation of the next inhalation phase thereof, upon reenergization of the operating coil 68 either by operation of the automatic control means next to be described or through completion of a circuit between switch parts 94 and 96 by actuation of device 86 responsive to a significant voluntary inhalation effort on the part of the patient.

Structure of the electrical control portion of the system

The electrical control portion of the system is composed of various functional stages and parts which those skilled in the art will understand may be constructed either with electron emission tube devices or solid state semiconductor devices, such as transistors and the like. For purposes of illustration, however, a preferred embodiment utilizing electron emission tube type devices has been selected and includes a power rectifier tube generally designated 100, a controlled switching tube 102, an isolating amplifier tube 104, an indicator amplifier tube 106, and a pair of multivibrator tubes 108 and 110.

Alternating current power main terminals 112 and 116 are coupled with the primary winding 118 of a power supply transformer 120 through an on-off switch 122 and a fuse 124. The center tap 126 of a high voltage secondary winding 128 is coupled with ground by a conductor 130. One side of the high voltage secondary winding is coupled by conductive means 72 with one side of the operating coil 68 of main control valve 62. The two ends of the secondary winding 128 are also coupled with plates 132 and 134 respectively of power rectifier tube 100 whose filaments 136 are coupled with a rectifier filament supply, secondary winding 138 of transformer 120. One side of the filament 136 is coupled through a filtering resistor 140 with a high voltage, positive, direct current supply lead 142, there being a pair of filtering capacitors 144 and 146 connected between the positive potential

lead 142 and ground on opposite sides of the resistor 140 in conventional manner. A further secondary winding 150 of transformer 120 is coupled by conductive means 152 with the filaments 154, 156 and 158 of the tube 102, 104–106, and 108–110 respectively, the opposite ends of whose filaments are coupled with secondary winding 150 through ground. The rectifier tube 100 may be of any conventional type, a 5Y3 vacuum tube having been found suitable for producing a positive potential on lead 142 of about 280 volts when used with a Thordarson type 2ROOU transformer with a 117 volt A.C. power main. The filter resistor 140 may be of about 2200 ohms, while the filter capacitors 144 and 148 may be of about 10 microfarads each.

The switching tube 102 may preferably be of the 2D21 thyratron type having, besides the filament 154, a cathode 160, a control grid 162, a second grid 164, and a plate 166. The cathode 160 is coupled to ground through a cathode resistor 168, which may be of the order of 680 ohms, and is also coupled by conductive means 170 with the second grid 164 and by a resistor 172 of the order of 47,000 ohms with the high voltage positive potential lead 142. The plate 166 of tube 102 is coupled by conductor 70 with the side of the operating coil 68 of the main control valve 62 opposite to that side thereof coupled with secondary winding 128 of transformer 120. A capacitor 167 of the order of about 2.0 microfarads may be bridged across the operating coil 68 between the conductors 70 and 72 if desired for the purpose of damping switching transients. It may be noted that in a preferred embodiment, the load presented by the operating coil 68 to the plate circuit of tube 102 was about 5,000 to 7,000 ohms with a current being drawn therethrough during energization of the coil 68 of the order of 30 milliamperes. The resistances 168 and 172 present a voltage divider between the positive potential lead 142 and ground which imposes a positive bias on the cathode 160 relative to ground. With the values of resistances 168 and 172 mentioned for illustrative purposes as satisfactory with a type 2D21 tube 102, the bias relative to ground normally applied to cathode 160 will be of the order of plus 4 volts.

It will now be apparent to those skilled in the art that the tube 102 will remain cut off and substantially nonconducting between its cathode 160 and its plate 166 whenever the potential applied to control grid 162 thereof is significantly negative relative to the bias potential maintained on cathode 160, but, when a positive potential relative to cathode 160 is applied to control grid 162, the tube 102 will conduct heavily between the cathode 160 and plate 166 thereof to energize the operating coil 68 through a circuit traceable from ground through resistor 168, cathode 160, tube 102 to plate 166 thereof, conductor 70, operating coil 68 and conductor 72 to secondary winding 128 of transformer 120 whose center tap 126 is grounded by conductor 130.

It will be obvious, therefore, that the potential applied to the control grid 162 of the switching tube 102 controls the energization and deenergization of the operating coil 68 of the main control valve 62, the range of voltage variation upon grid 162 utilized in the illustrated embodiment with the voltage and component values mentioned as exemplary is from about plus 3 volts relative to ground for the exhalation stage of the cycle (placing the control grid 162 at about 1 volt negative relative to the cathode 106) to plus about 14 volts relative to ground (placing the control grid 162 at a positive voltage of about 10 volts relative to the cathode 160).

Since the circuitry associated with tube 104 constitutes essentially a buffer amplifier used for isolating the load effects of the switching tube 102 from the multivibrator tubes 108 and 110, serves primarily a coupling function between such multivibrator and such switching parts of the apparatus, it will be appropriate to now consider the multivibrator means and then describe the fashion in which same are coupled to the control grid 162 of the switching tube 102.

The multivibrator tubes 108 and 110 may consist of a pair of vacuum tube triodes enclosed in a single envelope, for example, a type 12AU7 vacuum tube. Besides the filament 158, the tube 108 includes a cathode 174, a control grid 176 and a plate 178, and the tube 110 includes a cathode 180, a control grid 182, and a plate 184. The cathodes 174 and 180 are coupled with each other and with ground by conductive means 186. The plate 178 of tube 108 is coupled with the positive voltage supply lead 142 by a resistor 188, while the plate 184 of tube 110 is similarly coupled with lead 142 by a resistor 190, suitable values for resistances 188 and 190 being of the order of 68,000 ohms each.

Conductive means 192 couples the plate 178 of multivibrator tube 108 with one side of each of a plurality of capacitors 194, 196, 198, 200, 202 and 204, the other sides of such capacitors being respectively coupled with contacts 206, 208, 210, 212, 214 and 216 of one gang of a switch mechanism generally designated 218 having a pair of shiftable shorting bar means 220 and 222 in the respective gangs thereof, the shorting bar 220 being adapted ot normally short together all of the contacts 206 to 216 inclusive when the switch 218 is in one extreme position thereof and to successively exclude such contacts 206, 208, 210, 212 and 214 from the commoned connection with the remainder of contacts 206 to 216 inclusive as the switch 218 is advanced in discreet steps. The contact 216 is coupled by conductive means 224 and 226 with the control grid 182 of multivibrator tube 110, it being noted that at least the capacitor 204 is, therefore, always coupled between the plate 178 of multivibrator tube 108 and the control grid 182 of multivibrator tube 110.

Similarly, the plate 184 of tube 110 is coupled by conductive means 228 with one side of each of a plurality of capacitors 230, 232, 234, 236, 238 and 240, the number of capacitors 230 to 240 inclusive being equal to the number of capacitors 194 to 204 inclusive. The other sides of capacitors 230 to 240 inclusive are respectively coupled with contacts 242, 244, 246, 248, 250 and 252 associated with the shorting bar 222 of the other gang of switch mechanism 218. When the switch 218 is in its normal position corresponding to that in which the shorting bar 220 commons all of the contacts 206 to 216 inclusive, such shorting bar 222 is engaging only the contact 242 but is adapted to successively engage the remainder of the contacts 244 to 252 inclusive as the switch is advanced to common same together successively until all of the contacts 242 to 252 inclusive are commoned when the switch 218 is in its opposite extreme position at which the shorting bar 220 is engaging only the contact 216. The contact 242 is coupled by conductive means 254, 256 and 258 with the control grid 176 of the multivibrator tube 108, it being apparent, therefore, that at least the capacitor 230 is always coupled between the plate 184 of multivibrator tube 110 and the control grid 176 of multivibrator tube 108.

The choice of values for the various capacitors 194 to 204 inclusive and 230 to 240 inclusive is critical in the preferred form of the invention insofar as the ratios and arrangement or mutual relationships are concerned. This is the case since the purpose of the switch 218 and the provision of multiple capacitors rather than a single capacitor between the plate 184 and the grid 176 and another single capacitor between the plate 178 and the grid 182 is to provide for adjustable control over the ratio between the periods of operation of the multivibrator in each of its quasi-stable conditions during functioning thereof as an astable multivibrator circuit without affecting the total period of each complete cycle of such operation. It has been found that such result can be attained by selectively or progressively adding capacitance between the plate 184 of tube 110 and the grid 176 of

tube 108 while simultaneously removing an exactly equal amount of capacitance from between the plate 178 of tube 108 and the grid 182 of tube 110. The important factor, therefore, is that the total of all of the capacitance actually included in both of the circuit connections mentioned shall remain constant at all times, but that the ratio between the amounts of such total capacitance included respectively in each of the two mentioned circuits, may be varied to effect the desired control over the ratio of durations of the two conditions of astable cycling of the multivibrator without changing the total cycle time. One example of a set of suitable capacitance values by which such result may be attained is for capacitances 230 to 240 inclusive to have the respective values 1.0 mfd., 0.22 mfd., 0.15 mfd., 0.1 mfd., 0.068 mfd. and 0.1 mfd., while the capacitances 194 to 204 inclusive have the respective values 0.22 mfd., 0.15 mfd., 0.1 mfd., 0.068 mfd., 0.1 mfd. and 1.0 mfd., the total capacitance involved in both of the plate to grid circuits of the multivibrator in such case always being 1.638 mfd. in any position of the switch 218. Since it will be apparent to those skilled in the art that the parallel arrangement of capacitors common together in either of the subject circuits results in arithmetical addition of their individual capacitance values, it will be unnecessary to recite each of the ratios made possible by the various positions of the switch 218, and it should be observed that the particular ratios chosen are a matter of choice anyway and that a smaller or greater number of capacitors and corresponding positions of switch 218 may be provided, if desired. It may be pointed out, however, that with the switch 218 in the position illustrated in FIG. 1, the ratio between the periods of the two conditions of astable operation of the multivibrator would be 1.0 to 1.638, with the other extreme position of switch 218 giving a ratio of 1.638 to 1.0. The further explanation of other circuit connections and resistance component portions of the multivibrator circuit hereinafter will render clear the way in which the values of the capacitors just discussed affect the resistance-capacitance time constants of such circuits to achieve the results described.

A function switch generally designated 260 is provided and has a pair of ganged pole members 262 and 264 along with contacts 266, 268, 270, 272 and 274 associated with the pole member 262 and contacts 276, 278, 280, 282 and 284 opposite the contacts 266 to 274 inclusive respectively. The contact 274 is always in circuit completeing engagement with the pole member 262, and the contact 276 is always in circuit completing engagement with the pole member 264. Pole member 262 is normally in engagement with contact 266 and adapted for successive engagement with the contacts 268, 270 and 272 as the switch 260 is advanced, while pole member 264 is normally in engagement with contact 276 and adapted for successive engagement with contacts 278, 280 and 282 as the switch 260 is advanced. A pair of rheostats or resistances 286 and 288 having respective, ganged, variable contacts 290 and 292 have such variable contacts electrically coupled with each other and with ground by conductive means 294. One of the ends of variable resistance 286 is coupled with a variable tap 296 on a rheostat or resistance 298 whose end is in turn coupled by conductive means 300 with contact 266 and contact 272. One end of resistance 288 is coupled with the variable tap 302 on a rheostat or resistance 304 whose end is in turn coupled by conductive means 306 with contacts 280 and 282. The resistances 286 and 288 may be of the order of 1.5 megohms each and are preferably linear in resistance with respect to shifting adjustment of the taps 290 and 292 thereon. Such resistances 286 and 288 serve as a rate control for adjusting the total cycling time of the multivibrator when same is operating in an astable manner and for controlling the time of the constant of the unstable portion of the cycle during monostable operation of the multivibrator, as will be hereinafter more fully explained. The resistances 298 and 304 may be of the order of 500,000 ohms each, and their variable tap characteristics are utilized for calibration and balancing purposes. As will be apparent to those skilled in the art, the resistances 286 and 298 are adapted upon proper positioning of the switch 260 to be coupled between the grid 176 and the cathode 174 of tube 108, while the resistances 288 and 304 are adapted to be similarly coupled upon proper adjustment of switch 260 between the grid 182 and the cathode 180 of multivibrator tube 110.

Returning now to the function switch 260, it may be noted that there are no connections made to the contacts 266 and 170 or to the contacts 278 and 284. Accordingly, the position of the switch 260 illustrated in FIG. 1, is an off position in which the multivibrator is in bistable condition depending upon external "excitation" (using such term broadly to include completion of a grounding connection) for initiation of either of the "flip" or "flop" operations thereof. Such positioning of the switch 260 is utilized where full patient effort control over initiation of inhalation and exhalation phases of the respiration assisting functions of the apparatus is to be employed, such mode of operation being commonly referred to as "intermittent positive pressure breathing" control.

When the switch 260 is advanced to the next position clockwise from that illustrated in FIG. 1, the pole member 262 closes a circuit between contact 268 and contact 274, while the pole member 264 closes a circuit between the contact 276 and the contact 282. It should now be noted that contact 274 is coupled with the grid 176 of tube 108 through conductive means 308 and 248 while the contact 276 is coupled with the grid 182 of tube 110 through conductive means 310 and 226. Accordingly, the mentioned advancement of switch 260 couples the resistances 298 and 286 between the grid 176 of tube 108 and the grounded cathode 174 thereof, while the grid 182 of tube 110 is being similarly coupled with the grounded cathode 180 thereof through resistances 304 and 288. This positioning of the function switch 260, therefore, couples the multivibrator tubes 108 and 110 in what may be referred to as a plate-coupled, astable or free running multivibrator circuit in which both the "flip" and "flop" portions of the multivibrator cycle occur automatically with their durations controlled by the time constants of the resistance-capacitance combinations coupled with the tubes 108 and 110. Such mode of operation of the multivibrator is utilized for full automatic control of initiation of both the inhalation and exhalation phases of the respiration inducing function of the apparatus.

Assume that the switch 260 is now advanced to the next position in which the pole member 262 closes a circuit between contacts 270 and 274, while the pole member 264 closes a circuit between the contact 276 and the contact 280. The bridging of contacts 276 and 280 couples the resistance 304 and 288 in series between the grid 182 and the cathode 180 of tube 110. However, since the connection is made to contact 270, it will be clear to those skilled in the art that the grid 176 of tube 108 is left floating and will require external grounding for initiation of the corresponding phase of the multivibrator operation. With the function switch 260 in this condition, the tubes 108 and 110 are coupled in what may be called a plate-coupled, monostable multivibrator circuit. Excitation for initiating the stable phase of operation with such arrangement is achieved through connection of the control switch contact 98 with grid 176 of tube 108 through conductive means 312, 256 and 258, the pole piece 94 of switch 92 being coupled with ground through conductive means 314. Accordingly, when the switch 92 operates to ground contact 98 through pole piece 94 and conductive means 314, the grid 176 of tube 108 is grounded or, in effect, directly coupled with the cathode 174 thereof, which will initiate conduction of tube 108 to commence the shift away from the stable portion of the monostable cycle, the

resistance-capacitance combination associated with the grid 182 of tube 110 then serving to control the duration of the other or "unstable" portion of the cycle. This position of the function switch 260 is utilized where initiation of the exhalation inducing effect of the apparatus is to be automatically controlled, with the initiation of inhalation assistance to the patient being triggered by his own inhalation efforts.

When the switch 260 is advanced to its final position in a clockwise direction, the pole member 262 completes a circuit between contacts 272 and 274, while the pole member 264 completes a circuit between contacts 276 and 278. The bridging of contacts 272 and 274 couples the resistances 298 and 286 in series between the grid 176 and the cathode 174 of tube 108. However, since no connection is made to the contact 278, the grid 182 of tube 110 remains floating and will require external excitation for initiation of the corresponding portion of the multivibrator cycle. Such excitation is provided for by the coupling of control contact 96 with grid 182 of tube 110 through conductive means 316 and 266. The tubes 108 and 110 are thus coupled when the switch 260 is in such position in a plate-coupled, monostable multivibrator circuit exactly opposite to that just above described with respect to the phase of the mutivibrator cycle which is normally stable and requires external excitation for initiation. Such position of the function switch 260 is used where the initiation of induction of patient inhalation is to be automatically controlled with the initiation of exhalation assistance to the patient being responsive to his own exhalation efforts.

It should perhaps be presently noted that the connections of grids 176 and 182 with control switch contacts 98 and 96 respectively are always in circuit, so that upon engagement of the grounded pole piece 94 with either of contacts 98 or 96, the corresponding of grids 176 and 182 will be directly connected with the corresponding of cathodes 174 and 180 in such manner as to short across the corresponding resistances 298 and 286 or 304 and 288 which may be in circuit between such grids 176 and 182 and their corresponding cathodes depending upon the position of function switch 260. The significance of this will be understood by those skilled in the art as involving the provision thereby of means by which a significant effort of the patient at either inhalation or exhalation will override any normally timed phases of operation of the mutivibrator circuit and immediately initiate the corresponding inhalation or exhalation assisting function of the apparatus responding to such patient effort.

The output from the mutlivibrator stage presented by tubes 108 and 110 and their associated components, is taken from the plate 178 of tube 108 and delivered through conductive means 318, a coupling capacitor 320 and a limiting resistance 322 to the grid 324 of tube 104, which tube 104 is also provided with a plate 326 and a cathode 328 that is common to both tubes 104 and 106. A suitable arrangement utilizes a type 6J6 vacuum tube having two triodes in the same envelope which may be employed in the illustrated circuitry as tubes 104 and 106. The cathode 328 of tube 104 is grounded by conductive means 330, and a grounded grid resistance 332 is coupled with the grid 324.

It is believed unnecessary to go into detail concerning the nature of the triggering pulses delivered from the plate 178 of multivibrator tube 108 to the grid 324 of the isolating buffer amplifier tube 104, since the nature of same is both well known to those skilled in the art and is described in any of a number of well known texts, for example, "Electronic Designers' Handbook," McGraw Hill Book Company, Inc., 1957, Section 8. It may be observed, however, that with the exemplary component and voltage values being discussed for illustrative purposes, the plate 178 will normally be at about plus 50 volts during the inhalation portion of the cycle and will rise to about plus 275 volts during the exhalation portion of the cycle. A suitable value for the coupling capacitor 320 would be of the order of 0.5 microfarad, while values for the resistances 322 and 332 may be of the order of 4.7 megorms and 2.7 megohms respectively.

The plate is coupled with positive potential lead 142 through a plate resistance 334. Also coupled between the plate 326 and the grounded cathode 328 of tube 104 are a neon glow bulb or the like 336 (adjacent the plate 326) and a resistance 338 (adjacent the cathode 328). The glow discharge bulb 336 may be of type NE–51, while the resistance 338 may be of the order of 470,000 ohms. The control grid 162 of switching tube 102 is coupled through a resistance 340 of the order of 100,000 ohms with a point of the last-mentioned circuit between the bulb 336 and the resistance 338. The bulb 336 thus serves the double function of indicating by its lit condition the duration of the inhalation portion of the cycle and, more importantly, serving as a portion of a voltage divider also including the resistance 338 from which the output feed to control grid 162 of switching tube 102 may be derived. As is known to those skilled in the art, such glow discharge bulbs 336 require a minimum potential difference thereacross for firing and are characterized by extremely high impedance before firing, but drop substantially in resistance once the required firing potential is exceeded and the glow discharge has commenced. With voltages and component values as described for illustration, the plate 326 of tube 104 will be at about plus 15 volts during the exhalation phase of the cycle when a positive voltage is applied to the grid 324 of tube 104 from the plate 178 of multivibrator tube 108 so that the tube 104 is conducting heavily, and such voltage on plate 326 will arise to about plus 125 volts during the inhalation phase when the low level of voltage supplied to grid 324 of tube 104 from plate 178 of multivibrator tube 108 is insufficient to overcome the bias being applied to grid 324 to normally cut off the tube 104 and prevent substantial conduction between cathode 328 and plate 326 thereof. It will be appreciated that the plate 178 of multivibrator tube 108 could conceivably be directly coupled to the grid 162 of switching tube 102. However, the provision of the isolating, buffer amplifier tube 104 is definitely to be preferred because of the increased stability and lack of objectionable loading upon the multivibrator tube 108 which is achieved thereby.

The indicator amplifier tube 106, besides the filament 156 and cathode 328 which it may share in common with tube 104, is provided with a control grid 342 and a plate 344. Plate 344 is coupled through a plate resistance 346 of the same order of resistance as at 334, which may be about 220,000 ohms with the positive potential supply lead 142. The plate 184 of multivibrator tube 110 is coupled through conductive means 228, a coupling capacitor 348 and a resistance 350 with the grid 342 of indicator amplifier tube 106, the latter being grounded through a grid resistance 352. A glow discharge lamp 354, such as a NE–51 neon bulb, and a resistance 356 are coupled in series between the plate 344 and grounded cathode 328 of tube 106. The values of capacitor 348 and resistances 350, 352 and 356 may be comparable to the corresponding components associated with the tube 104. In the illustrated embodiment, the tube 106 is used merely to operate and isolate from the multivibrator tube 110 the indicator lamp 354, which it will be understood fires and glows to give a visible indication during the exhalation phase of the cycle of operation of the apparatus. It will be apparent to those skilled in the art, however, that if different valve or pneumatic control means than those described for illustrative purposes were to be used, and if such alternative valving or pneumatic control means required a separate source of energizing excitation for the initiation of the exhalation portion of the cycle of operation, a second switch tube and stage similar to that described at 102 could be provided and coupled to the indicating amplifier tube 106 in a manner similar to that described for the

connection made between switching tube **102** and buffer amplifier tube **104**.

It will be understood that other types of tubes or correspondingly different sets of component values, and even different circuit connections, might be used in many portions of the circuitry of which an illustrative embodiment is shown in FIG. 1. It is particularly to be pointed out that the circuitry may be readily constructed by those skilled in the art by the use of transistors and the like rather than vacuum tubes, if desired. The general arrangement and functional association and interrelationships are, however, believed to be important to the provision of a suitable, reliable and versatile instrument. In particular, the manner in which the circuitry associated with the tubes **108** and **110** is arranged to provide any of four types of multivibrator action with independent control over both total cycling time and the ratio of the periods of the two portions of each cycle without mutual intereffect, is believed important.

Operation of the electrical control portions of the system

Attempt has been made to indicate more specific facets of the operation of various portions of the circuitry as the description of same progressed. It should be necessary, therefore, only to summarize the general functioning and interrelationship between such parts.

In adjusting the apparatus, with the switch **122** closed and all voltages applied, the calibration and balancing rheostats **298** and **304** should be adjusted with the aid of a suitable ohmmeter or the like so that the total resistance of the portion of rheostat **298** placed in circuit by the tap **296** together with the resistance of rheostat **286** will be equal to the portion of resistance **304** placed in the circuit by tap **302** together with the resistance of rheostat **288**. This adjustment may be checked with the ganged taps **290** and **292** of rheostats **286** and **288** respectively in several positions to insure proper tracking.

With the balancing rheostats **298** and **304** so adjusted, the ganged taps **290** and **292** may be adjusted as desired along the linear resistances **286** and **288** respectively to control the total period of each complete cycle of the multivibrator's operation. As previously explained, the switch **218** may be operated to various positions to vary the ratio of duration of the two phases of each cycle of operation of the multivibrator. It should be observed that both of these adjustments are extremely desirable and necessary in providing a physician with the exact timing of a respiratory cycle needed to treat a particular patient condition. It is also significant that such adjustments are effective as to the portions of the operating cycle of the multivibrator which are being automatically controlled in any of the positions of the function switch **260**.

Depending upon the particular patient condition being treated, it will be understood that the physician may find it necessary to progressively alter either the total respiratory cycle time or the ratio of duration of the inhalation and exhalation phases thereof as the treatment progresses.

Likewise, the physician may need to alter the function of the apparatus as the treatment progresses, for example, from full, automatically timed, induced respiration to automatically timed and induced respiration with patient controlled exhalation and then patient controlled but assisted respiration in both the inhalation and exhalation phases of the cycle. The function switch **260** provides such control over the apparatus by the physician to fit the prevailing condition of the patient and his needs.

As previously explained, the connections from switch **92** to the multivibrator tubes **108** and **110** provide for patient override of otherwise automatically timed respiratory functions being controlled automatically by the operation of the multivibrator portion of the apparatus. This is important particularly during the period of transition from a condition of the patient in which he is making no significant breathing effort and all respiration must be induced and controlled by the apparatus, to an improved condition wherein the patient is making some effort of his own either to inhale, exhale or both. Naturally, such independent efforts on the part of the patient are desired and are to be encouraged and assisted by the apparatus, rather than discouraged or opposed thereby. The override feature of the present invention provides such desirable result.

By electrically coupling the override switch **92** to the main control valve operating coil **68** through the multivibrator tubes **108** and **110** and the switching tube **102**, not only is direct control of the operating coil **68** by the switch **92** provided, but operations of the switch **92** will directly affect the multivibrator tubes **108** and **110** in such manner that the same will continue their automatic timing of respiratory functions, so that the apparatus may take over and induce continuance of a series of respiratory cycles of the patient in properly timed sequence with even the most spasmodic breathing efforts on his own part.

The interrelationship between the electrical control means of FIG. 1 and the pneumatic controls of FIGS. 2–5 inclusive, will be apparent from recognition that the output from the electrical control means to the pneumatic control means is accomplished through the electrical connection of switching tube **102** with main control valve operating coil **68**, while feedback control intelligence responding to pneumatic conditions induced by the patient's own breathing efforts are coupled from the pneumatic portion of the system back to the electrical control portion thereof through the devices **86** and **90**, the switching means **92** responsive to the latter and the electrical coupling of such switching means with the multivibrator tubes **108** and **110**.

It is believed that the manner in which the electrical control portions and the pneumatic control and operating portions of the apparatus work together to accomplish the desired functions will be apparent from the description above of the modes of operation of each and the means for intercoupling therebetween.

It will be appreciated by those skilled in the art that a number of minor modifications and changes may be made from the details of construction of a preferred embodiment shown and described for illustrative purposes without departing from the true spirit and concept of the invention. Accordingly, it is to be understood that the invention should be deemed limited only by the scope of the claims that follow.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In resuscitator apparatus, the combination of a source of gas under pressure to be administered to a patient; conduit means for coupling said source with the patient, said conduit means having an atmospheric vent port therein; first pneumatic pressure responsive valve means having a control inlet and operably associated with said vent port for closing the latter when gas under pressure is applied to said control inlet of said first valve means; tube means coupling said control inlet of said first valve means with said conduit means at a zone of the latter between said source and said vent port; second pneumatic pressure responsive valve means forming a chamber within said conduit means and including structure for permitting the passage of gas from said source through said zone to the patient and said tube means only when the gas pressure surrounding said chamber is greater than the pressure within said chamber, the latter having a control inlet; fluid carrying means coupling said control inlet of said chamber with said conduit means at a part of the latter between said source and said zone, said fluid carrying means having an atmospheric vent opening therein; third electrically responsive valve means operably associated with said vent opening for opening and closing the latter in response to electrical signals applied to said third valve means, said third valve means closing communication between said source and said

chamber when said vent is open; and electrical control means coupled with said third valve means and adapted for producing electrical signals for alternately opening and closing said third valve means repeatedly.

2. In resuscitator apparatus as set forth in claim 1, wherein said control means includes a pair of pressure responsive electrical switches, means pneumatically coupling said switches with said conduit means between said zone of the latter and the extremity thereof adjacent the patient, and means including a source of electrical power electrically coupling said switches with said third valve means.

3. In resuscitator apparatus as set forth in claim 1, wherein said control means includes an electrical multivibrator having an electrical output, and electrical means for coupling said output with said third valve means.

4. In resuscitator apparatus as set forth in claim 3, wherein said control means further includes at least one pressure responsive switch, means pneumatically coupling said switch with said conduit means between said zone of the latter and the extremity thereof adjacent the patient, and means coupling said switch with said multivibrator for controlling the latter.

5. In resuscitator apparatus, the combination of a source of gas to be administered to a patient; means, including conduit structure, for coupling said source with the patient; valve means coupled with said structure for controlling the flow of gas through the latter; electrically responsive means operably associated with said valve means for controlling operation of the latter; an electrically multivibrator including a pair of electrical devices, a number of electrical impedance components and circuit means arranged and intercoupling said devices and components to present a multivibrator of the astable type in which the initiation and duration of both phases of cycling time are controlled by the values of certain of said components; electrical means coupling the output of said multivibrator with said electrically responsive means for alternately actuating and deactuating said electrically responsive means repeatedly; and a pressure responsive electrical switching mechanism pneumatically coupled with the extremity of said conduit structure adjacent the patient and electrically coupled with at least one of said certain components for shunting the latter to override the normal timing control effect thereof, whereby significant breathing efforts of the patient override the multivibrator controlled respiratory functions and allow the resuscitator apparatus to assist the patient in establishing normal breathing.

6. In resuscitator apparatus, the combination of a source of gas to be administered to a patient; means, including conduit structure, for coupling said source with the patient; valve means coupled with said structure for controlling the flow of gas through the latter; electrically responsive means operably associated with said valve means for controlling operation of the latter; an electrical multivibrator including a pair of electrical devices, a number of electrical impedance components, a pressure responsive electrical switching mechanism pneumatically coupled with the extremity of said conduit structure adjacent the patient, and a number of electrical circuit means arranged and intercoupling said devices, components and mechanism to present a multivibrator of the monostable type in which the initiation of one phase of cycling of said multivibrator is controlled by operation of said switching mechanism and initiation of the other phase of cycling time is controlled by the values of certain of said components, whereby initiation of said one phase of cycling is controlled by the breathing efforts of the patient and initiation of the other phase is automatically controlled by the multivibrator; and electrical means coupling the output of said multivibrator with said electrically responsive means for alternately actuating and deactuating said electrically responsive means repeatedly.

7. In resuscitator apparatus, the combination of a source of gas to be administered to a patient; means, including conduit structure, for coupling said source with the patient; valve means coupled with said structure for controlling the flow of gas through the latter; electrically responsive means operably associated with said valve means for controlling operation of the latter; an electrical multivibrator including a pair of electrical devices, a number of electrical impedance components, a pressure responsive electrical switching mechanism pneumatically coupled with the extremity of said conduit structure adjacent the patient, and a number of electrical circuit means arranged and intercoupling said devices, components and mechanism to present a multivibrator of the bistable type in which the initiation of both phases of cycling of said multivibrator is controlled by the operative condition of said switching mechanism, whereby inhalation and exhalation of the patient initiates the respective cycling phase; and electrical means coupling the output of said multivibrator with said electrically responsive means for alternately actuating and deactuating said eletcrically responsive means repeatedly.

8. In a resuscitator apparatus, the combination of a source of gas to be administered to a patient; means for coupling said source with a patient; valve means coupled with said structure for controlling the flow of gas through the latter; electrically responsive means operably associated with said valve means for controlling operation of said valve means; an electrical multivibrator including a pair of electron devices, a plurality of electrical impedance components and circuit means arranged and intercoupling said devices and components to present a multivibrator of the astable type in which the initiation and duration of both phases of cycling time are controlled by the cumulative impedance values of certain of said components; means for varying the cumulative impedance values controlling the initiation and duration of each phase; electrical means coupling the output of said multivibrator with said electrically responsive means for alternately actuating and deactuating said electrically responsive means repeatedly; and a pressure responsive electrical switching mechanism pneumatically coupled with the extremity of said conduit structure adjacent the patient and electrically coupled with at least one of said certain components for shunting the latter to override the normal timing control effect thereof, whereby significant breathing efforts of the patient override the multivibrator controlled respiratory functions and allow the resuscitator apparatus to assist the patient in establishing normal breathing.

9. Apparatus as set forth in claim 8, wherein said means for varying the cumulative impedance values is coupled to means for maintaining the sum of the cumulative impedance values controlling both phases constant.

10. In a resuscitator apparatus, the combination of a source of gas to be administered to a patient; means for coupling said source with a patient; valve means coupled with said structure for controlling the flow of gas through the latter; electrically responsive means operably associated with said valve means for controlling operation of said valve means; an electrical multivibrator including a pair of electron devices, a plurality of electrical impedance components and circuit means arranged and intercoupling said devices and components to present a multivibrator of the astable type in which the initiation and duration of both phases of cycling time are controlled by the cumulative impedance values of certain of said components; means for varying the cumulative impedance values controlling the initiation and duration of each phase; electrical means coupling the output of said multivibrator with said electrically responsive means for alternately actuating and deactuating said electrically responsive means repeatedly; a pressure responsive electrical switching mechanism pneumatically coupled with the extremity of said conduit structure adjacent the patient and

electrically coupled with at least one of said certain components for shunting the latter to override the normal timing control effect thereof, whereby significant breathing efforts of the patient override the multivibrator controlled respiratory functions and allow the resuscitator apparatus to assist the patient in establishing normal breathing; and means for selectively switching the electrical impedance components and circuit means intercoupling said electron devices to present a multivibrator of either the monostable or bistable types.

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