July 11, 1933. J. A. HEIDBRINK 1,917,940

PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 1

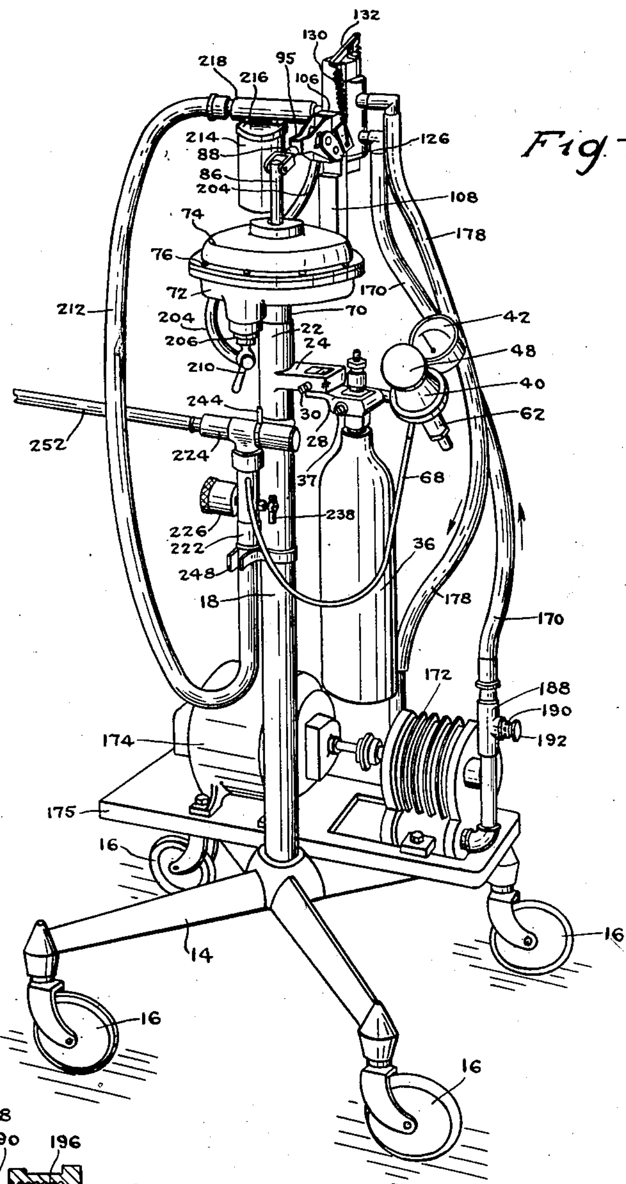

Fig-1.

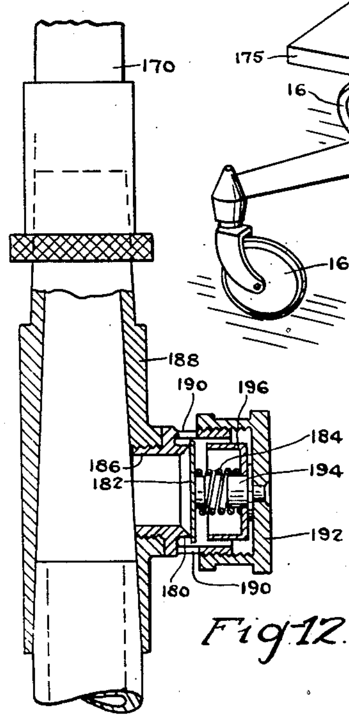

Fig 12.

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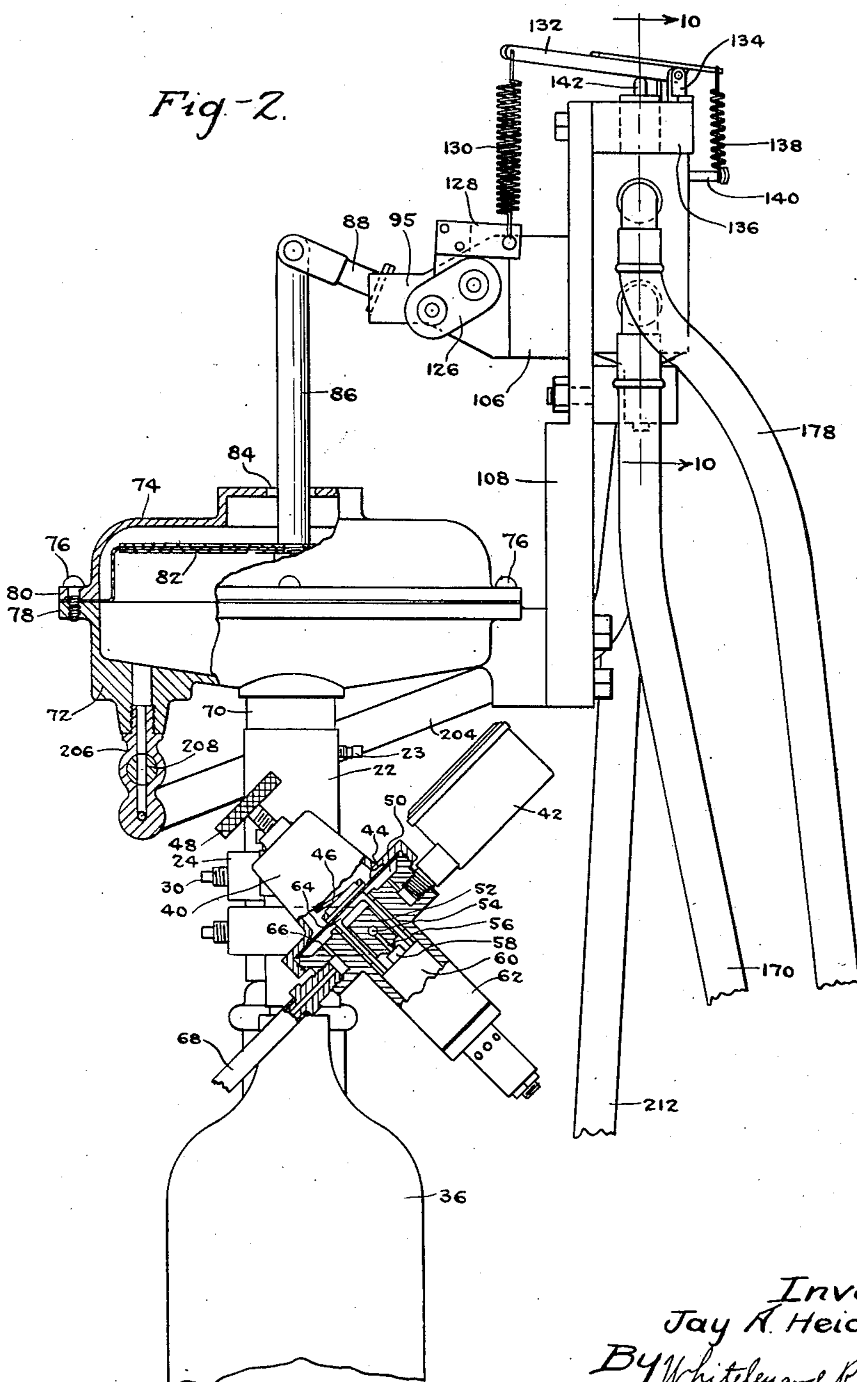
July 11, 1933. J. A. HEIDBRINK 1,917,940

PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 2

Fig-2.



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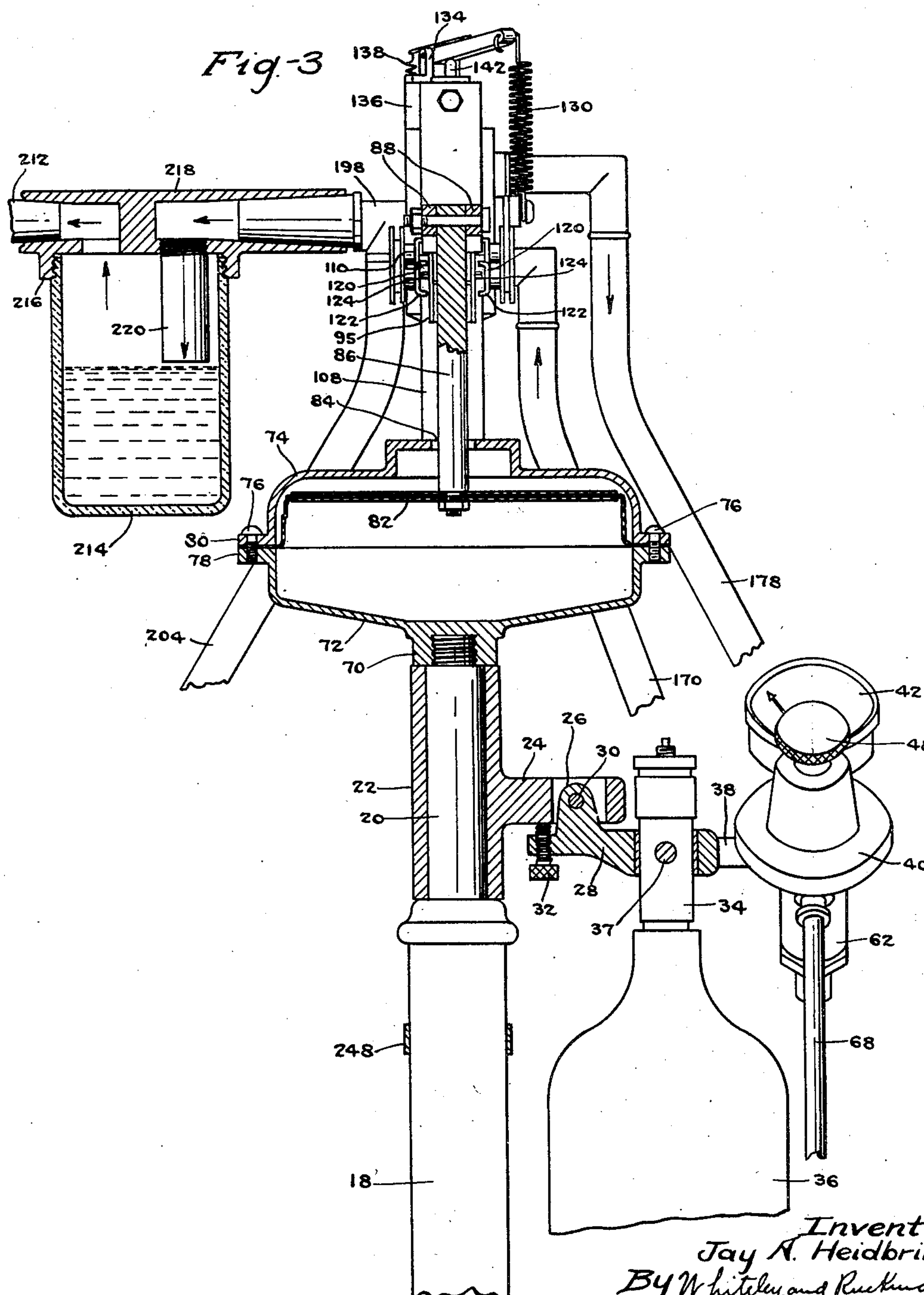
PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 3

Fig-3



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PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 4

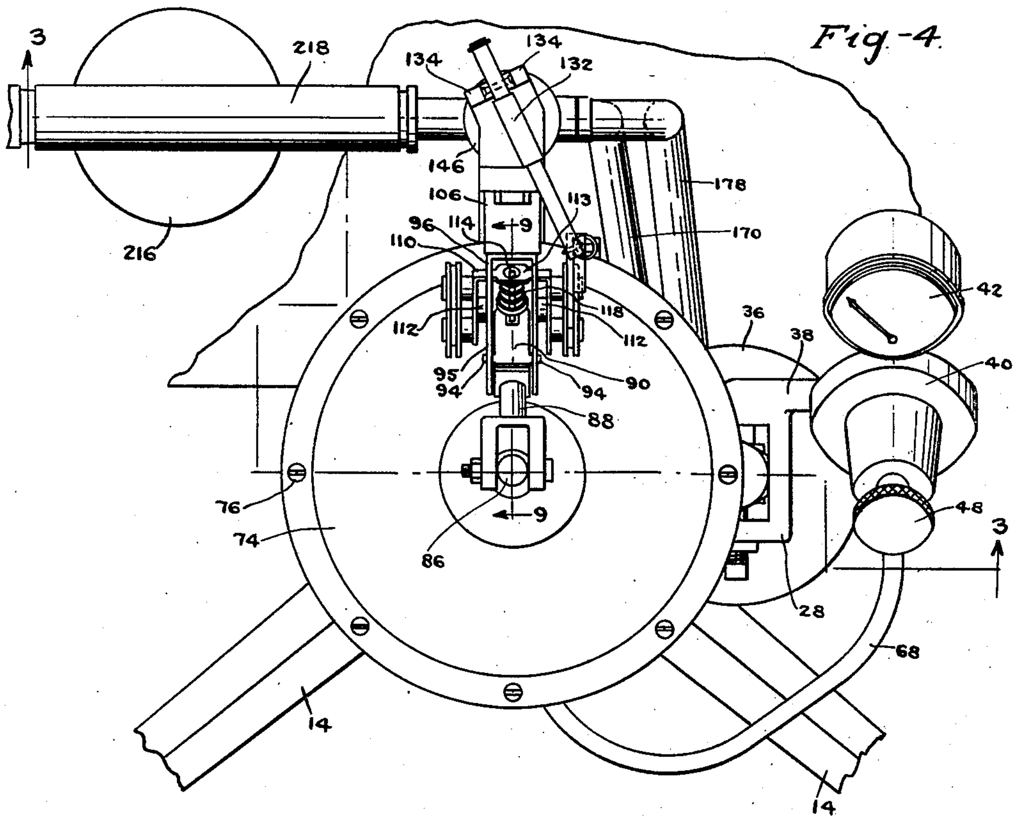


Fig-4.

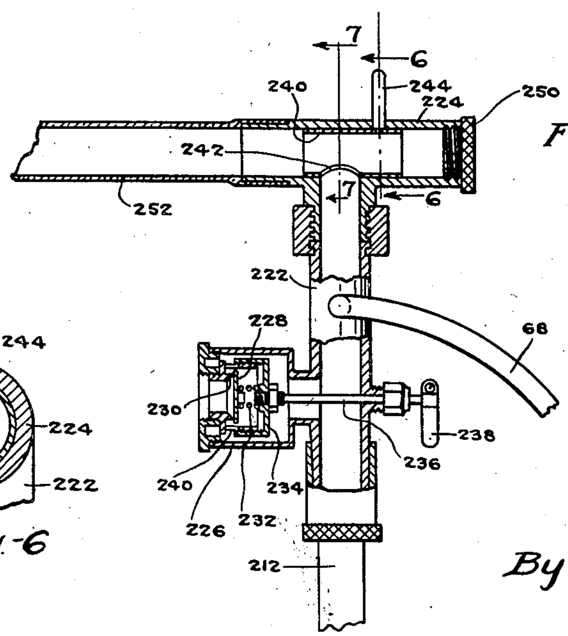


Fig-5

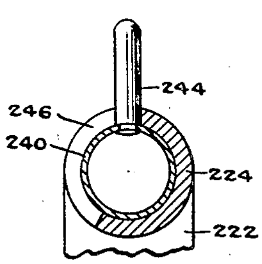
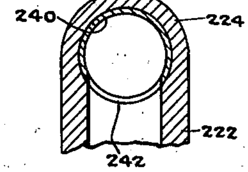


Fig-6

Fig-7



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July 11, 1933. J. A. HEIDBRINK 1,917,940

PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 5

Fig-8

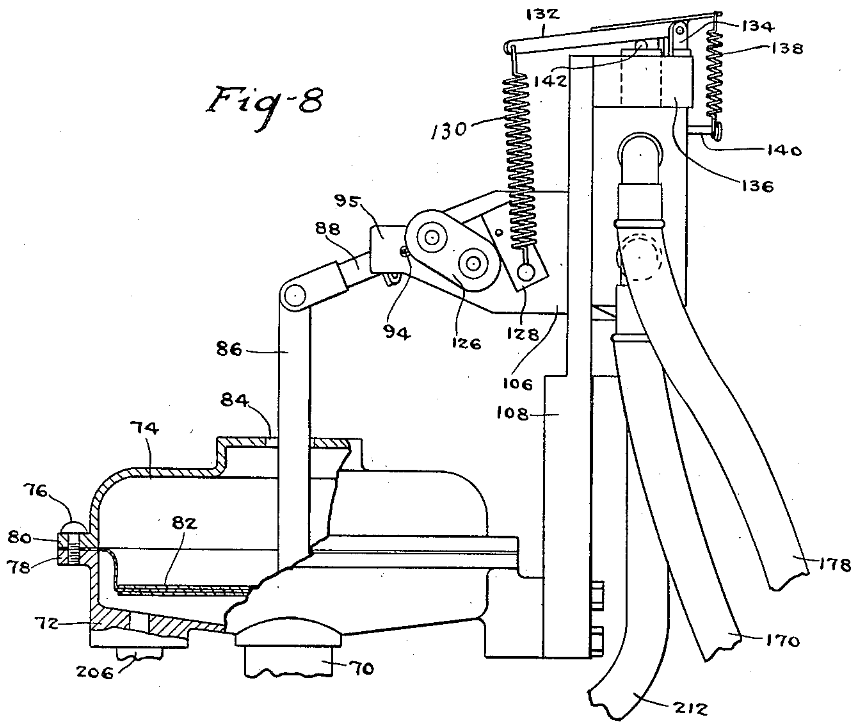
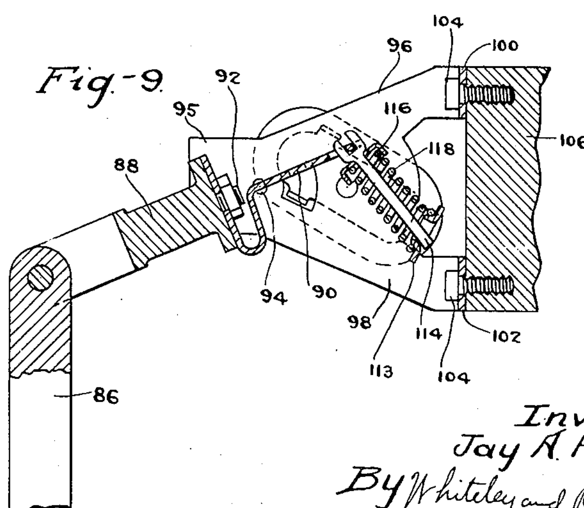


Fig-9



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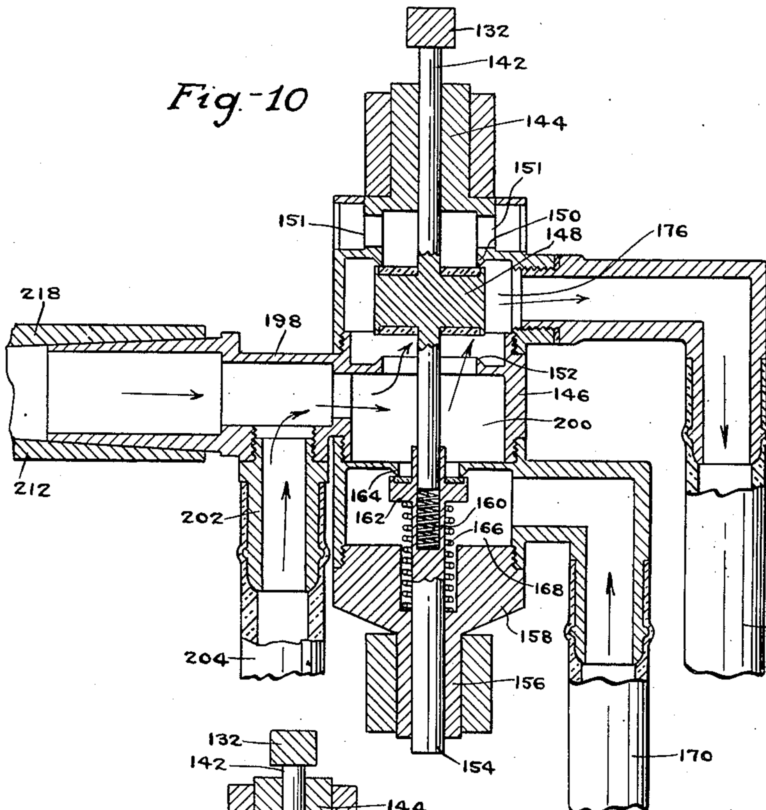
July 11, 1933. J. A. HEIDBRINK 1,917,940

PULMONARY VENTILATING APPARATUS

Filed Nov. 23, 1929 6 Sheets-Sheet 6

Fig.-10



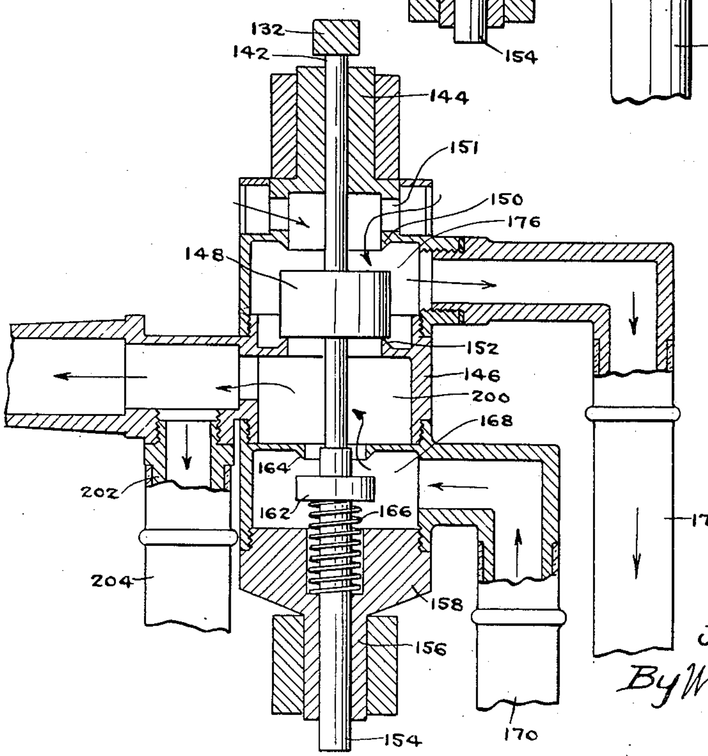


Fig.-11

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Patented July 11, 1933

1,917,940

UNITED STATES PATENT OFFICE

JAY A. HEIDBRINK, OF MINNEAPOLIS, MINNESOTA

PULMONARY VENTILATING APPARATUS

Application filed November 23, 1929. Serial No. 409,246.

My invention relates to pulmonary ventilating apparatus, and more particularly to mechanism intended for use when for any reason, a person's respiratory organs are impaired or paralyzed, as sometimes occurs with inhalant anæsthesia. Obviously the patient will soon die in case of too greatly depleted or discontinued respiration if such unnatural condition is not remedied. Among the objects of the invention are to perform the function of breathing for the patient until natural breathing is restored and to be able to regulate the amount of each inflation and deflation, and to regulate the number of respirations per minute as desired. Another object is to provide for passing a stream of air or of air mixed with gas in any desired proportions through an intertracheal tube into the bronchi or bronchiales of the lungs, thus obtaining an exchange of air without necessarily rhythmically inflating and deflating the lungs. Another object is to be able to limit, as desired, the amount of pressure it is possible to exert for inflating the lungs, and also to limit as desired, the amount of suction it is possible to exert for deflating the lungs so that no injury may be done to the lung tissues.

The full objects and advantages of my invention will appear in connection with the detailed description thereof, and the novel features of my invention will appear in connection with the claims.

In the accompanying drawings which illustrate a practical embodiment of my invention,—Fig. 1 is a perspective view of the machine. Fig. 2 is a side elevational view on a larger scale of the upper part of the machine with a small portion in section and with the bellows in raised position. Fig. 3 is a view in vertical section on the line 3—3 of Fig. 4. Fig. 4 is a top plan view. Fig. 5 is a sectional view of a valve and the structure in which it is embodied. Fig. 6 is a view in section on the line 6—6 of Fig. 5. Fig. 7 is a view in section on the line 7—7 of Fig. 5. Fig. 8 (Sheet 5) is a fragmentary view similar to Fig. 2 and with the bellows in lowered position. Fig. 9 is a view in section on the line 9—9 of Fig. 4. Fig. 10 (Sheet 6) is a view in section on the line 10—10 of Fig. 2 and showing the position of movable parts when suction is applied to the lungs of a patient. Fig. 11 is a similar view showing the position of the movable parts when pressure is applied to the lungs. Fig. 12 (Sheet 1) is a sectional view of an exhaust valve.

Referring to the drawings, it will be seen from Fig. 1 that I provide a suitable base 14 mounted on caster wheels 16. A standard or post 18 extends up from the base 14 and as shown in Fig. 3, the upper end of this standard has a reduced portion 20 around which there is a sleeve 22 held in place by a set screw 23 as shown in Fig. 2. Extending out from the sleeve 22, there is a perforated lug 24 in the perforation of which, a lug 26 extending up from an arm 28 is pivotally mounted by means of a pivot pin 30 extending across the perforation. The arm 28 is held adjustably in position by a screw 32 extending through the inner end of the arm and engaging the underside of the lug 24. The arm 28 contains an opening in which the neck 34 of a gas container 36 is secured by a screw 37. The outer end of the arm 28 consists of a hollow member 38 which connects the neck 34 with a pressure regulating device 40 of well known or suitable construction having a pressure gauge 42 attached thereto. As shown in Fig. 2, the regulating device includes a diaphragm 44 whose upper surface is engaged by a compression spring 46, the tension of which is adjusted by a hand screw 48. Below the diaphragm 44 there is a chamber 50 having a bottom wall 52 containing a lateral opening 54 which is in communication with the hollow member 38. A passageway 56 extends down from the opening 54 and a valve 58 is adapted to engage the delivery end of this passageway. The valve 58 is carried by the upper end of a slidable block 60 contained in a tubular extension 62 and normally urged upwardly therein. A staplelike member 64 engages the lower surface of the diaphragm 44 and the two arms of this member extend down loosely through perforations in the member 52 and engage the upper surface of the slidable block 60. It is obvious that the pressure of gas passing down through the passageway 56 may be minutely controlled by turning the screw 48. The gas thus controlled passes up around the arms of the staplelike member 64 and into the chamber 50 from which it passes in regulated amount through a perforation 66 and into a tube 68 for delivery to the patient when desired in a manner which will be described later. It is to be understood that when air alone is to be used unmixed with gas from the container 36, the delivery passage therefrom may be shut off in customary manner by loosening the screw 48.

As best shown in Fig. 3, the upper end of the member 20 is threaded to engage threads formed in a socket 70 extending down from a cupshaped casting 72. An inverted cupshaped casting 74 is secured upon the casting 72 by screws 76 passing through circumferential flanges 78 and 80 formed on the castings. The two castings form a chamber for a piston or flexible bellows member 82, the margin of which is secured between the flanges 78 and 80. The portion of the chamber above the bellows is open to atmosphere through a central opening 84 through which loosely passes a rod 86, the lower end of which is secured to the member 82 and the upper end of which is pivotally attached to the forked outer end of an arm 88. To the inner end of the arm 88, a switch arm 90 is secured by a screwbolt 92 as shown in Fig. 9. The arm 90 is intermediately pivoted by pivot members 94 to a frame 95 having a pair of side members each of which consists of an upper branch 96 and a lower branch 98, the pair of upper branches 96 being connected by a cross piece 100 while the pair of lower branches are connected by a cross piece 102. The two cross pieces 100 and 102 are secured by screws 104 to a lug 106 which extends out from a support 108 extending up from the casing 72 as shown in Figs. 2 and 8. A U-shaped member 110 is pivoted to the frame 95 on trunnions 112 carried by the latter as best shown in Fig. 4. The connecting portion 113 of the U-shaped member 110 has a perforation through which slidably extends one end of a pin 114 whose other end is pivotally attached to the free end of the arm 90. Adjacent this place of attachment, a cup member 116 surrounds the pin 114. A coiled spring 118 surrounding the pin 114 is interposed between the cup 116 and the cross piece 113 of the U-shaped member 110. When the bellows is down as shown in Fig. 8, the member 110 and the spring 118 occupy the position shown in Fig. 9. When the bellows is up, the member 110 and the spring 118 occupy the position shown in Figs. 3 and 4. When the member 110 passes from one of these positions into the other position, the spring 118 causes the member 110 to pass over dead center. In order to cause this movement to be completed with a quick snappy action, the two branches of the U-shaped member 110 are each provided with a pair of projections 120 and 122 as best shown in Fig. 3. When the arm 90 is rocked by upward or downward movement of the rod 86, the projections 120 or the projections 122 as the case may be, engage projections 124 extending out from the frame 95 and cause the movement of the spring 118 over dead center. This gives the quick snappy action of the U-shaped member 110 previously referred to. In order to utilize this action, clamping members 126 carried by the member 110 clamp in place a right-angled piece 128 as shown in Fig. 2. The lower end of a coiled spring 130 is attached to the piece 128. The upper end of the spring 130 is attached to one end of a lever 132 intermediately pivoted on bracket members 134 extending up from a lug 136 which projects out from the upper end of the support 108. A coiled spring 138 connects the other end of the lever 132 with the projection 140. The long arm of the lever 132 rests upon the upper end of a rod 142 which is slidable in a bearing 144 forming part of a valve casing 146 as shown in Figs. 10 and 11 and which is carried by the support 108. The rod 142 carries a double-acting plunger valve 148 which engages an upper valve seat 150 when the rod 142 is moved into upper position. The valve casing above the valve seat 150 is provided with openings 151 for entrance of air when the valve 148 is moved off the seat 150. The valve 148 engages a lower valve seat 152 when the rod 142 is moved into lower position. The lower end of the rod 142 fits slidably into a socket formed in the upper end of a rod 154 which is slidable in a bearing 156 extending down from a member 158 which forms the bottom wall of the valve casing 146. A spring 160 is interposed between the lower end of the rod 142 and the bottom of the socket. The upper socketed end of the rod 154 carries a plunger valve 162 which engages a valve seat 164 when the rod 142 is in upper position as shown in Fig. 10. A coiled spring 166 surrounding the rod 154 and interposed between the valve 162 and the bottom of a socket formed in the member 158 tends to hold the valve 162 against the seat 164 as shown in Fig. 10. The chamber 168 between the valve seat member 164 and the bottom member 158 is connected by a tube 170 with the pressure end of a pump 172 of well known construction and hence not described in detail. The pump 172 is driven by a constant speed electric motor 174 which as well as the pump is mounted on a shelf 175 secured to the base of the machine. The chamber 176 between the valve seat members 150 and 152 is connected by a tube 178 with the suction end of the pump 172. The tube 170 is provided with a relief valve shown in detail in Fig. 12 (Sheet 1). This valve includes a seat 180 which is engaged by a disk valve 182 normally held against this seat by a coiled spring 184. The seat 180 is formed in a nipple 186 extending out from a coupling member 188 included in the tube 170, the nipple 186 being provided with perforations 190. This nipple is also provided with a screw cap 192 having a stem 194 which carries a cup member 196. The spring 184 is interposed between the valve 182 and the bottom of the cup 196 so that by turning the cap 192, the pressure of the spring 184 against the valve 182 may be regulated. Upon turning the cap 192 down to substantially its full extent, the margin of the cup member 196 will engage the valve 182 and securely hold it in closed position. The valve casing 146 carries a tubular member 198 which is in communication with the chamber 200 located between the valve seat members 152 and 164. The tubular member 198 is provided with a downwardly extending nipple 202 which is connected by a tube 204 with a nipple 206 extending down from the casting 72 as shown in Fig. 2. The nipple 206 contains a rotary valve 208 provided with a handle 210 by which the valve may be turned for the purpose of controlling the passageway through the nipple. A tube 212 is connected at one end with the tubular member 198. However, instead of being connected directly to the tubular member 198, a water receptacle 214 is preferably interposed in the connection with the tubular member 198. As shown in Fig. 3, the receptacle 214 has a screw cover 216 carrying a cylindrical member 218 through which the tube 212 is in communication with the upper portion of the receptacle 214. The tubular member 198 is in communication through the cylindrical member 218 with a tube 220 which extends down nearly to the surface of the water in the receptacle so that air passing into and out of this receptacle will take up moisture during its passage through the receptacle. Also any sputum or débris sucked from the patient will be trapped and retained in the receptacle 214. The other end of the tube 212 is connected to the lower end of a hollow T having a vertical member 222 and a horizontal or top member 224. Connected with the member 222, there is a valve casing 226 containing an inwardly opening valve disk 228 normally held against a valve seat 230 by a coiled spring 232 interposed between the valve and a cupshaped member 234 secured to the inner end of a stem 236 which at its outer end is provided with a handle 238. The cup member 234 has threaded engagement with a perforated and threaded cylindrical member 240 so that the tension of the spring 232 may be regulated by turning the handle 238. The tube 68 previously referred to as being connected with the gas tank 36 leads into the member 222 above the valve casing 226, whereby gas such as oxygen in regulated quantity may be supplied to the patient. The supply of gas from the tank 36 may however be entirely shut off in the usual manner if desired. The passageway between the members 222 and 224 is controlled by a cylindrical valve 240 containing a hole 242 in its side. The valve 240 is rotatably mounted in the member 224 and may be turned by a handle 244 which works in a slot 246 in the member 224 as shown in Fig. 6. The T member when not in use is supported in suitable manner as by means of a clamp connection 248 with the post 18 as shown in Fig. 1. One end of the horizontal member 224 is closed by a screw plug 250 while the other end is connected to a tube 252, the outer end of which may be applied to the patient in any well known manner or any suitable manner for use use in connection with the lungs of the patient, such as in intertracheal tube or some well known inhaler such as used in administering anæsthetics.

The operation and advantages of my invention will be apparent in connection with the foregoing description. When the motor 174 is driving the pump 172 and assuming the valves 148 and 162 to be in their downward position as shown in Fig. 11 and the piston member 82 to be in downward position as shown in Fig. 8, air is drawn by the pump through the openings 151 and through the tube 178 and forced through the tube 170. The pressure is prevented from exceeding a predetermined amount according to the setting of the valve 182 as will be understood from the detail view in Fig. 12. From the tube 170, the air goes past the valve 162 and into the chamber 200 from which a portion of it passes through the receptacle 214, across the surface of the water therein thereby picking up moisture. The air thus moistened passes through the tube 212 to the T-device 222–224 shown in Fig. 5 and then through the tube 252 to the patient, the speed of inflation being regulated as desired by the position of the valve 240. The other portion of the air from the chamber 200 passes through the tube 204 and the nipple 206 into the space below the piston member 82, the speed at which the air passes through the nipple being regulated by the setting of the valve 208. The pressure of air below the piston member 82 causes the latter to move from the position of Fig. 8 into that shown in Figs. 2 and 3 thereby lifting the rod 86. The speed as previously intimated is governed by the position of the valve 208. When the rod 86 is approaching its upper position, the spring 118 is forced over dead center from its position shown in Fig. 9 into that shown in Fig. 4 and the tension of the spring 130 is thereby relieved. The tension of the spring 138 immediately pulls the lever 132 from the position shown in Fig. 8 into that shown in Fig. 2, thereby releasing the pressure on the top of the rod 142. The tension of the spring 166 now forces the valve 162 upwardly while the tension of this spring and of the spring 160 forces the valve 148 upwardly so that the two valves now occupy the position shown in Fig. 10. The valve 148 in this upper position, closes the passage from the openings 151 to the tube 178 and at the same time, the passage from the chamber 200 to the tube 178 is opened. As will be apparent from the direction of the arrows in Fig. 10, the pump now draws air both from the tubes 212 and 204. The air drawn through the tube 212 comes from the lungs of the patient through the tube 252, the suction being prevented from exceeding a predetermined amount according to the setting of the valve 228 as will be understood from Fig. 5. The air drawn through the tube 204 comes from the space below the piston member 82 and causes this member to move from the position shown in Fig. 2 into that shown in Fig. 8 at a speed depending upon the setting of the valve 208. The downward movement of the piston member 82 pulls the rod 86 downwardly. When this rod is approaching its lower position, the spring 118 is forced over dead center from its position shown in Fig. 4 into that shown in Fig. 9 and the tension thus imposed upon the spring 130 pulls the lever 132 from the position shown in Fig. 2 into that shown in Fig. 8, thereby causing the rod 142 to move the valves 148 and 162 downwardly into the position of Fig. 11 so that the pump will again force air into the lungs of the patient. If it is desired to mix a gas such as oxygen or carbon dioxid, for instance, with the air thus supplied to the patient, the valve in the passageway from the tank 36 is opened the proper amount so that gas controlled by the pressure regulating device 40 passes through the tube 68 into the T-member 222 to mix with the air passing therethrough to the patient.

It will be understood from what has already been set forth that the valve 208 operated by the handle regulates the speed of travel of the piston 82 in both directions and hence determines the number of respirations per minute. Further, the valve 240 operated by the handle 244 regulates the speed of inflation when air is passing to the lungs and the speed of deflation when air is passing from the lungs. It is evident that when the valve 240 is in its opened up position, the lungs will be inflated and deflated quickly during the first portion of the respiratory movements and before the switch is thrown for the reverse movement. When the apparatus is set to operate in this manner, and the lungs are in deflated condition waiting for the next inflation, a fluttering or vibrating action will be imparted thereto which tends to increase the circulation of blood, and thereby stimulates the lungs. It is also to be understood that while as shown in Figs. 10 and 11, the chamber 168 is the lower chamber and the chamber 176 is the upper chamber, this positioning does not need to be absolutely fixed and the apparatus may be arranged to operate with these chambers in reverse position. It will also be understood that while the spring 138 is always under tension, the spring 130 in the position shown in Fig. 2 is relaxed so as not to place additional load on the spring 138.

I claim:

1. A pulmonary ventilating apparatus comprising a pump having a pressure end and a suction end, a valve casing containing two end chambers and an intermediate chamber, a tube connecting one of said end chambers with the suction end of said pump, a tube connecting the other one of said end chambers with the pressure end of said pump, valve mechanism in said casing adapted to alternately close and open communication between the first of said end chambers and the atmosphere, and between said end chamber and said intermediate chamber, a valve adapted to alternately close and open communication between the second of said end chambers and said intermediate chamber, a casing having one of its ends open to atmosphere, a tube connecting said intermediate chamber and the other end of said casing, a piston device in said casing, a switch device connected with said piston device, connections between said switch device and said valve mechanism and valve which move them into their first position when said piston device is moved in one direction and which move them into their second position when said piston device is moved in the other direction, and a tube for connecting said intermediate chamber with the patient.

2. A pulmonary ventilating apparatus comprising a pump having a pressure end and a suction end, a valve casing containing two end chambers and an intermediate chamber, a tube connecting one of said end chambers with the suction end of said pump, a tube connecting the other one of said end chambers with the pressure end of said pump, a double-acting valve in said casing adapted when in one extreme position to close communication between the first of said end chambers and the atmosphere and when in its other extreme position to close communication between said end chamber and said intermediate chamber, a single acting valve in said casing adapted when in closed position to close communication between the second of said end chambers and said intermediate chamber, a casing having one of its ends open to atmosphere, a tube connecting said intermediate chamber and the other end of said casing, a regulating valve for said tube, a piston device in said casing, a switch device

connected with said piston device, connections between said switch device and said double-acting and single-acting valves which move both of them into their first position when said piston device is moved into one extreme position and which move both of them into their second position when said piston device is moved into its other extreme position, a T member, a tube connecting said intermediate chamber with said T member, a regulating valve in said T member, and a tube for connecting said T member with the patient.

3. A pulmonary ventilating apparatus comprising a pump having a pressure end and a suction end, a valve casing containing three chambers disposed one above the other, a tube connecting the upper one of said chambers with the suction end of said pump, a tube connecting the lower one of said chambers with the pressure end of said pump, a relief valve in said last-mentioned tube, a double-acting valve in said valve casing adapted when in upper position to close communication between said upper chamber and the atmosphere and when in lower position to close communication between said upper chamber and the intermediate chamber, a single-acting valve in said valve casing adapted when in upper position to close communication between said lower and intermediate chambers, a casing having its upper end open to atmosphere, a tube connecting said intermediate chamber and the lower end of said casing, a regulating valve for said tube, a piston device in said casing, a switch device connected with said piston device, connections between said switch device and said double-acting and single-acting valves which move both of them into their upper position when said piston device is moved into its upper position and which move both of them into their lower position when said piston device is moved into its lower position, a T member, a tube connecting said intermediate chamber with said T member, a tensioned inwardly-opening valve for said tube, a regulating valve in said T member, and a tube for connecting said T member with the patient.

4. A pulmonary ventilating apparatus comprising a pump having a pressure end and a suction end, a valve casing containing three chambers disposed one above the other, a tube connecting the upper one of said chambers with the suction end of said pump, a tube connecting the lower one of said chambers with the pressure end of said pump, a double-acting valve in said valve casing adapted when in upper position to close communication between said upper chamber and the atmosphere and when in lower position to close communication between said upper chamber and the intermediate chamber, a single-acting valve in said valve casing adapted when in the upper position to close communication between said lower and intermediate chamber, a casing having its upper end open to atmosphere, a tube connecting said intermediate chamber and the lower end of said casing, a piston device in said casing, a switch device connected with said piston device, connections between said switch device and said double-acting and single-acting valves which move both of them into their upper position when said piston device is moved into its upper position and which move both of them into their lower position when said piston device is moved into its lower position, a T member, a tube connecting said intermediate chamber with said T member, a tube for connecting said T member with the patient, a tank for holding gas under pressure, a tubular connection between said tank and said T member, and a shut-off device for said tubular connection.

In testimony whereof I hereunto affix my signature.

JAY A. HEIDBRINK.