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LE ROY G. FOX
BREATHING MACHINE

2,737,176

Filed March 31, 1951

2 Sheets-Sheet 1

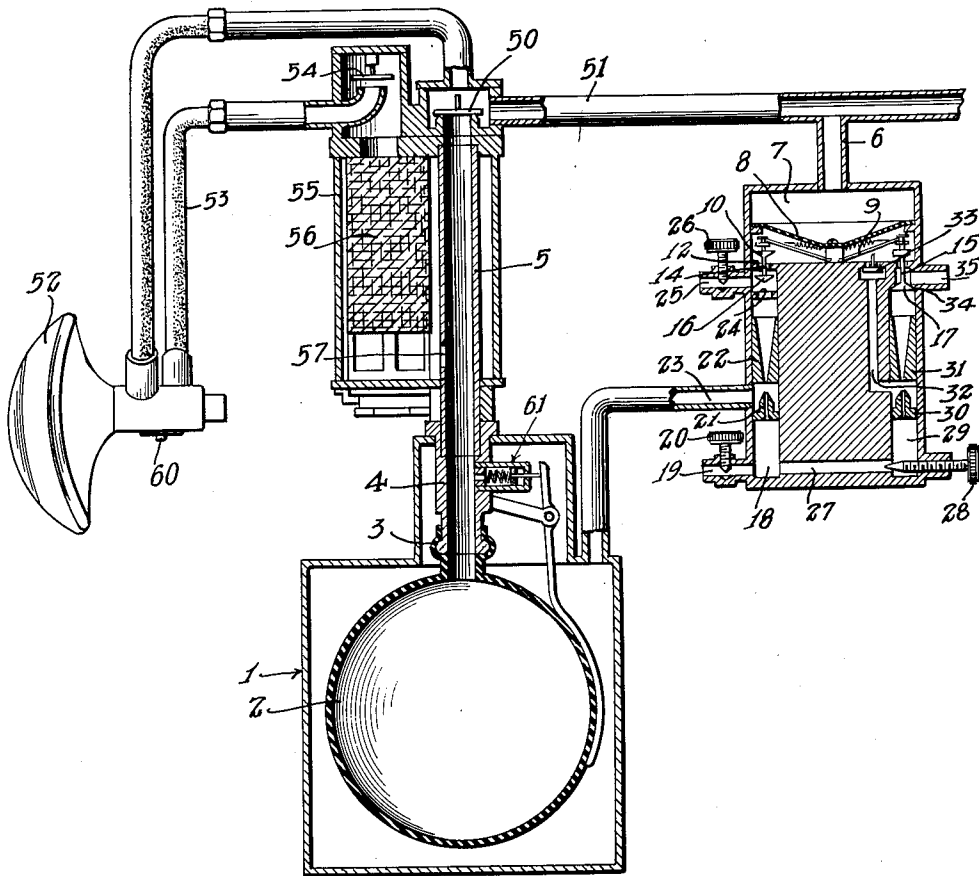


FIG. 1

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FIG. 2

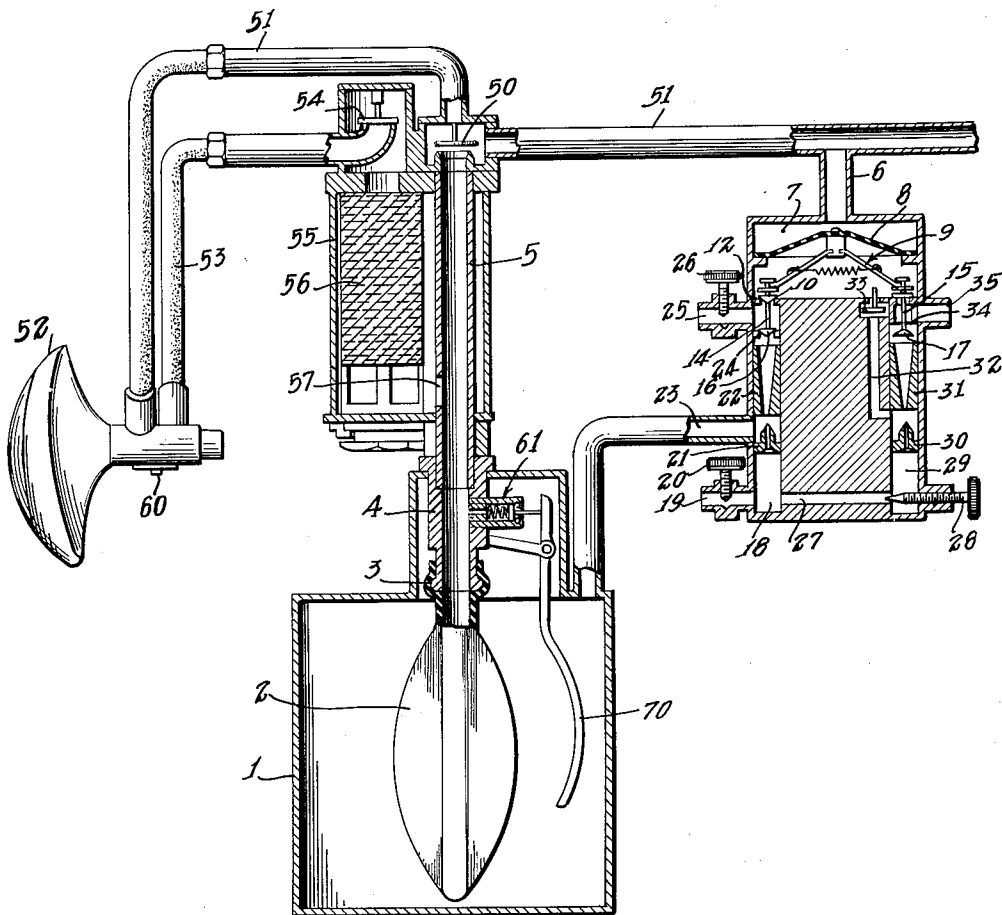
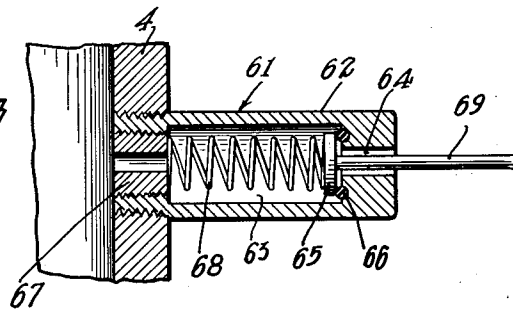


FIG. 3



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2,737,176

BREATHING MACHINE

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16 Claims. (Cl. 128—29)

My invention relates to a breathing machine and, more specifically, to a machine which is connected to a standard gas anesthetic machine to administer anesthesia to patients, or it can be used as a resuscitator as well as a positive pressure machine.

The purpose of this invention is to supply a controlled respiration to patients under an anesthesia.

It is an object of my invention to provide a breathing machine which will administer anesthetic gas or oxygen to a patient's lungs under a positive pressure of one cycle and a negative pressure on the other cycle.

Another object of this invention is to provide a breathing machine which has controllable positive and negative pressures.

Other objects and advantages of my invention will be apparent from the following description of the preferred embodiments thereof.

In the drawings:

Figure 1 is a sectional view of my breathing machine showing it in the cycle aspirating gas from a patient's lungs.

Figure 2 is a sectional view of my breathing machine showing it in the cycle to force gas into the patient's lungs.

Figure 3 is an enlarged sectional view of a detail thereof.

A breathing machine constructed in accordance with my invention comprises an airtight container 1 in which is suspended a rubber bag or bellows 2, which has an opening 3 into an adapter 4. The adapter 4 emerges from the container 1 and is connected to a delivery pipe 5 which is closed at its upper end by a plate valve 50 opening into a fresh gas delivery pipe 51. The pipe 51 is connected at its right end in the drawings to a source of anesthetic gas or oxygen which opens into a breathing mask 52 at its other end.

Connected to the delivery pipe 51 is a conduit 6 which pipes the anesthetic gas to a chamber 7, which has therein a diaphragm 8 actuated by a spring-loaded toggle 9. The diaphragm 8 divides the chamber 7 and is airtight, thus restraining the anesthetic gas to the upper half of the chamber 7. Positioned in the lower side of the chamber 7 is a valve member 10 adapted to be actuated by the toggle 9 to seat upon the valve seats 12. The valve stems 14 and 15 also support second valve members 16 and 17.

A passage 18 connects an air inlet 19 which is connected to a source of compressed air which is adjusted by a control valve 20. In the passage 18 is placed a venturi nozzle 21 and a venturi tube 22. Between the venturi nozzle 21 and the venturi tube 22 is an air passage 23 connecting the passage 18 with the interior of the container 1. The passage 18 has the valve seat 12 at its upper end and is adapted to be closed by the valve body 10. Disposed therebelow is the valve seat 24 adapted to be closed by the valve member 16. Between the valve seats 12 and 24 is an air outlet 25 controlled by the negative control valve 26.

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A passage 27 connects the air inlet 19 by way of a positive control valve 28 to a passage 29. In the passage 29 is a venturi nozzle 30 and a venturi tube 31. Positioned between the venturi nozzle 30 and the venturi tube 31 is a bore 32 connected by means of a plate valve 33 with the chamber 7 below the diaphragm 8.

A valve seat 34 is positioned in the passage 29 and is adapted to be closed by the valve member 17.

When the pressure in the chamber 7 above the diaphragm 8 is greater than that below the diaphragm 8 the toggle 9 will open the valves 10 and 16 and close the valve 17. In this position air enters through the valve 20 and passes through the passage 18.

In administering anesthesia to a patient there are two cycles, (1) is the positive pressure which forces gas into the patient's lungs and (2) is the negative cycle which removes the gas. These cycles are as follows:

Compressed air is admitted to the breathing machine through the air inlet 19 and the valve 20 where it passes through the venturi nozzle 21 against the valve 16, which is in closed position as the pressure in the lower half of the chamber 7 is greater than in the upper half.

The anesthetic gas is administered to the delivery pipe 51, into the mask 52 and into the patient's lungs, building up a pressure therein which then passes out through the mask 52, through the conduit 53 past the valve 54 and into a canister 55 containing soda lime 56. The exhalations of the patient pass through the soda lime 56 in the canister 55, which removes the CO₂ therefrom, and is exhausted through the port 57 into the bellows 2 by way of the delivery pipe 5.

When the valve 16 is in its closed position the compressed air passing through the air inlet 19 passes into the container 1 where it compresses the bellows 2, forcing the gas contained therein up through the delivery pipe 5 past the plate valve 50 and into the delivery pipe 51 and back into the mask 52 and on into the patient's lungs. This back pressure is sufficient to cause the valve 54 to close and prevent the exhalation of the patient, thus forcing gas into the patient's lungs under pressure. When the lungs have been filled by this positive pressure and the pressure has built up to a predetermined point, the pressure builds up in the chamber 7 which puts pressure on the diaphragm 8 greater than that on the underside of the diaphragm and this causes the spring-loaded toggle 9 to reverse its position and open the valve members 10 and 16, thus closing the valve member 17.

In order to vary the positive pressure in the patient's lungs the compressed air entering the air inlet 19 and control valve 20 passes through the positive control valve 28 into the venturi nozzle 30 and through the venturi tube 31, through the valve 17 and out to the air outlet. This creates a negative pressure in the passage 32, opening the plate valve 33, sucking air from the chamber 7 below the diaphragm 8 and therefore is drawn out through the passage 32 and through the air outlet 35. This creates a negative pressure under the diaphragm 8. The greater the amount of pressure under the diaphragm the lesser the amount of pressure needed in the patient's lungs to trip the toggle 9, which is adjusted by the amount of air passing through the positive control valve 28.

My breathing machine then enters its negative pressure cycle, a description of which is as follows:

With the diaphragm 8 in its lower position and held there by the toggle 9 because of a greater pressure in the chamber 7 above the diaphragm than below, the compressed air admitted by the air inlet 19 and control valve 20 goes through the venturi nozzle 21 and to the venturi tube 22, through the valve 16 to the air outlet. This creates a negative pressure in the container 1, thus drawing used gases from the patient's lungs into the bellows 2.

As the pressure in the bellows 2 is lower than in the lungs or in the delivery pipe 51, the plate valve 50 will close and the valve 54 open. At the same time some of the air passes through the valve 10 into the chamber 7 below the diaphragm 8. Thus the pressure in the upper half of the chamber 7 becomes less than that in the lower half, causing the toggle 9 to reverse its position and close the valves 10 and 16 and open the valve 17 to return the breathing machine to its positive pressure cycle.

By the adjustment of the negative control valve 26 the amount of air passing through the venturi tube 22 and out the air outlet 25 may be adjusted so as to force more air in through the valve 10 and into the lower half of the chamber 7, or vice versa, thus controlling the amount of the pressure in the lower half of the chamber 7, which is necessary to trip the toggle 9. By this adjustment the size of the patient's lungs can be compensated for in my invention.

Sometimes it is desirable to be able to bleed off a portion of the gas contained in the closed circuit above described because of the admission of fresh gas to the delivery pipe 51 at all times. Two ways of doing this are possible; one automatically and the other requiring the action of the anesthetist. A simple way to handle this problem is by use of a valve 60 on the breathing machine which can be opened manually by the anesthetist to bleed off a portion of the gas. However, I have found a more satisfactory solution to this problem by positioning an automatic valve mechanism 61 adapted to port gas from the adapter 4 into the container 1. This valve mechanism 61 comprises a boss 62 which is threaded into the adapter 4 and has an enlarged bore 63 therein with a discharge port 64. A plate valve member 65 is adapted to close against a rubber O-ring 66 to close the port 64. The valve member 65 is held in position by means of the plug 67 threaded into the boss 62 and holding a spring 68 against the valve 65. A plunger 69 is adapted to force open the valve member 65 when actuated by the lever 70. The lever 70 is adapted to engage the bellows 2 and when the bellows 2 is in its extreme filled position it will move the lever 70 and depress the plunger 69 to open the valve member 65, bleeding a portion of the gas in the system off into the container 1 where it is ejected by the compressed air passing through the venturi nozzle 21 to the venturi tube 22 and out through the air outlet 25.

I claim:

1. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, and a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened and a pipe connecting said pressure chamber to said passage between said air supply and said chamber.

2. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two,

a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, and a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and said venturi tube.

3. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and venturi tube, and a venturi nozzle and tube in said passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube.

4. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and said venturi tube, and a control valve to regulate the air passing

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through the passage between said air supply and said chamber.

5. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and venturi tube, a venturi nozzle and tube in said passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube, and a control valve to regulate the air passing through the passage between said air supply and said chamber.

6. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and venturi tube, a venturi nozzle and tube in said passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube, and a pressure control valve in the passage between said air supply and the atmosphere.

7. In a breathing machine, a delivery pipe connecting to a supply of gas at one end, a breathing mask connected to the other end of said delivery pipe, a bellows connected to said pipe, a pressure chamber surrounding said bellows, a control mechanism comprising: a case forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure, one of said chambers being ported to said delivery pipe, a passage porting air from said air supply to said second chamber, a toggle mechanism attached to said diaphragm, valves adapted to close the passage between said chamber and said air supply

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and connected to be driven by said toggle mechanism, a port in said passage between said valves opening to the atmosphere, a passage from said air supply to the atmosphere, a valve connected to be driven by said toggle mechanism to close said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and open when said first mentioned valves are closed, an exhaust passage from said second chamber to said last mentioned passage, a plate valve in said exhaust passage adapted to open when said last mentioned valve is opened, a venturi nozzle and tube in said passage between said air supply and said chamber, said pressure chamber being connected to said passage between said air supply and said chamber between said venturi nozzle and said venturi tube, a control valve to regulate the air passing through the passage between said air supply and said chamber, and a pressure control valve in the passage between said air supply and the atmosphere.

8. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, and a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened.

9. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, and a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube.

10. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said

lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube, and a venturi nozzle and tube in the passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube.

11. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube, and a control valve to regulate the air passing through the passage between the air supply and said lower chamber.

12. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube, a venturi nozzle and tube in the passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube, and a control valve to regulate the

air passing through the passage between the air supply and said lower chamber.

13. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube, and a pressure control valve in the passage between said air supply and the atmosphere.

14. An actuating device for a breathing machine, comprising: a case forming a chamber, a diaphragm dividing said chamber into upper and lower chambers, said upper chamber having means to connect the same to a flow of anesthetic gas between the source of said gas and a breathing mask, a passage connecting said lower chamber to a supply of air under pressure and to an airtight container, a toggle mechanism attached to said diaphragm operable by changes of pressure in said upper and lower chambers, valves adapted to close said passage between said lower chamber and said supply of air and connected to be driven by said toggle mechanism, an air outlet between said valves, a passage from a supply of air to the atmosphere, a valve connected to be driven by said toggle mechanism in said last mentioned passage, said last mentioned valve being closed when said first mentioned valves are open and opened when said first mentioned valves are closed, an exhaust passage from said lower chamber to said passage between said air supply and the atmosphere, a plate valve in said exhaust passage adapted to be open when said second mentioned valve is opened, a venturi nozzle and tube in the passage between said supply of air and said lower chamber, said airtight container porting into the last mentioned passage between said venturi nozzle and said venturi tube, a venturi nozzle and tube in the passage between said air supply and the atmosphere, said exhaust passage opening into said last mentioned venturi between said nozzle and said tube, and a pressure control valve in the passage between said air supply and the atmosphere.

15. In a regulator for a breathing machine, a case forming a chamber, a diaphragm dividing said chamber into two, a supply of air under pressure ported into one of said chambers, a delivery pipe porting into the other of said chambers, a toggle mechanism attached to said diaphragm and actuated by a differential of pressure on the sides of said diaphragm, valve means actuated by said toggle mechanism between said source of supply of air and said chamber, an exhaust passage from said source of air to the atmosphere, valve means actuated by said toggle mechanism and in opposite phase to said first mentioned valve means to open said passage from said supply of air to the atmosphere when said first mentioned valve means is closed, and an exhaust valve between said exhaust passage and said valve chamber.

16. In a regulator for a breathing machine, a case

forming a chamber, a diaphragm dividing said chamber in two, a supply of air under pressure ported into one of said chambers, a delivery pipe porting into the other of said chambers, a toggle mechanism attached to said diaphragm and actuated by a differential of pressure on the sides of said diaphragm, valve means actuated by said toggle mechanism between said source of supply of air and said chamber, an exhaust passage from said source of air to the atmosphere, valve means actuated by said toggle mechanism and in opposite phase to said first mentioned valve means to open said passage from said supply of air to the atmosphere when said first mentioned valve means is closed, a venturi nozzle and tube in said exhaust passage, and said exhaust valve porting

air from said chamber between said venturi nozzle and said venturi tube when said second mentioned valve means is opened.

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