

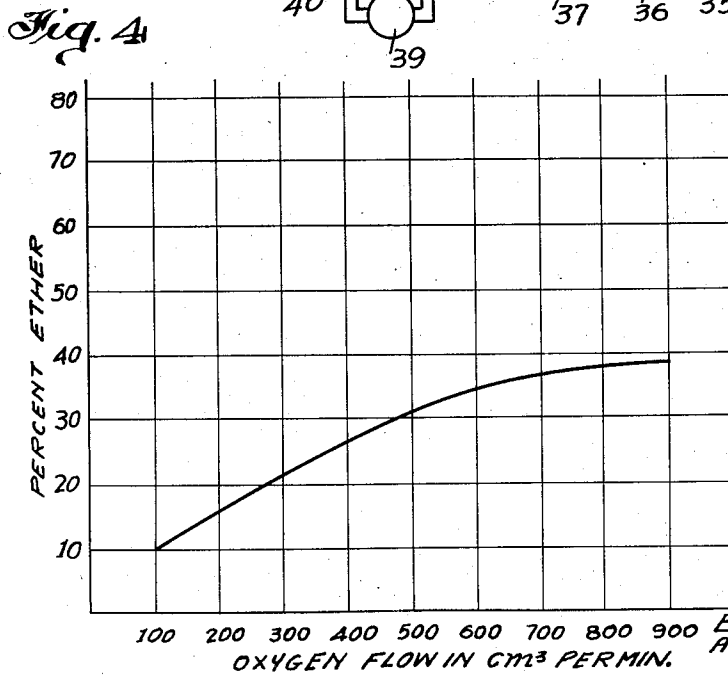
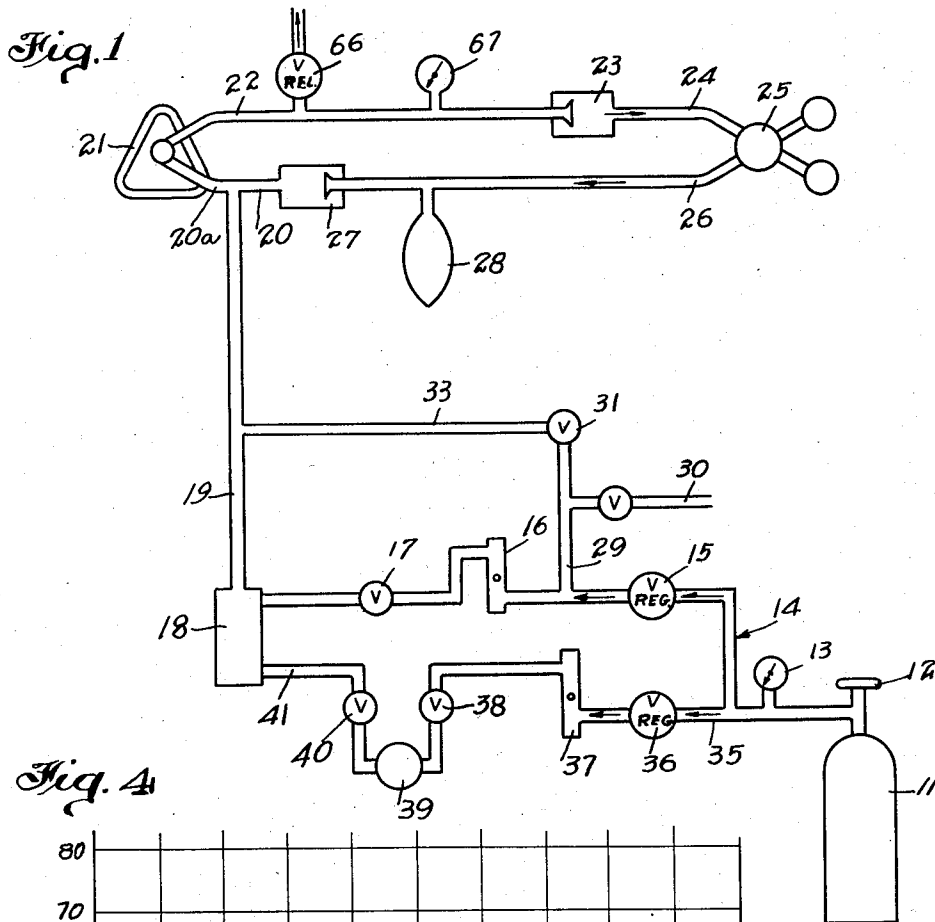
Jan. 27, 1959

B. E. CARLSON ET AL
ANESTHETIC GAS MACHINE

2,870,764

Filed Jan. 28, 1957

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2

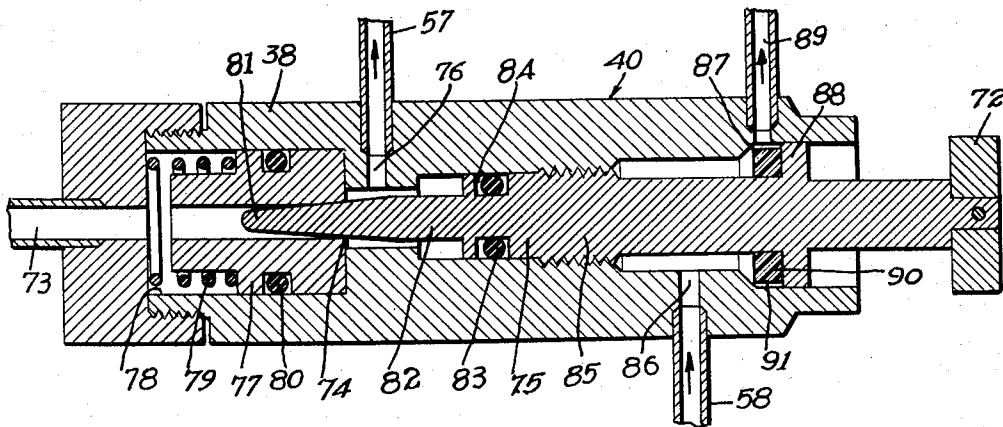
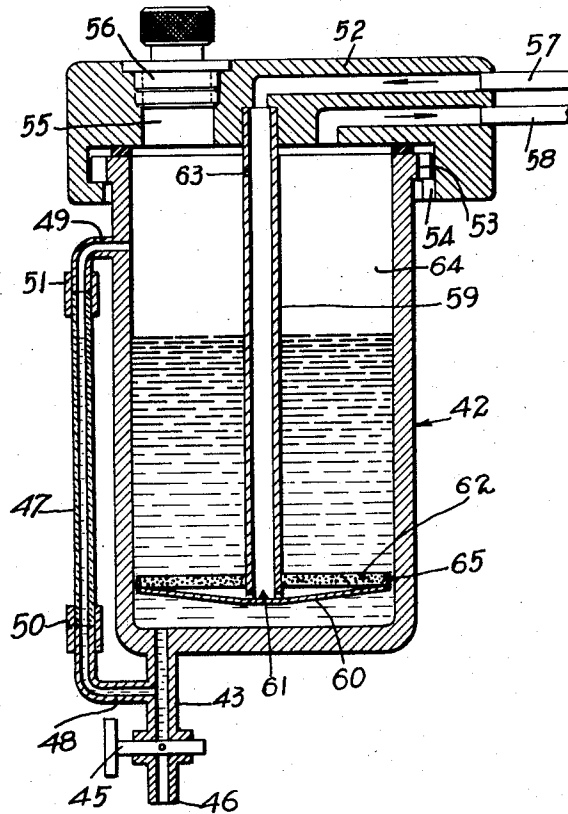


Fig. 3

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1

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ANESTHETIC GAS MACHINE

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Application January 28, 1957, Serial No. 636,683

10 Claims. (Cl. 128—188)

This invention relates to an anesthetic gas machine and refers particularly to the oxygen and ether supply systems of the machine.

In the use of anesthetic gas machines, it is important to have a known, even, predictable flow of the anesthetic agent. The busy anesthetist must be able to rely on the integrity of the anesthetic supply. When a liquid anesthetic agent is used, the vaporizer should produce low anesthetic concentrations at low oxygen flows and higher anesthetic concentrations at higher oxygen flows. This characteristic is particularly important in pediatric anesthesia where the patients are particularly sensitive to anesthetic agents and the small tidal volume of the patient necessitates low oxygen flows. Small amounts of the anesthetic agent may also be desired in combination anesthesia, where ether, or other liquid anesthetics, are used only to induce greater relaxation.

In the wick-type and bubbler-type vaporizers, only relatively low concentrations of ether could be obtained. Thus the effect of the anesthetic agent could be easily followed. Such anesthesia was slow under normal conditions and nearly impossible at high altitudes. Moreover, it was sometimes quite unpleasant for the patient. Newer vaporizers are highly efficient and give a fast, smooth induction. Such induction tends to mask the customary signs of over-dosing and increase this danger. The use of succinylcholine, and other curare-like drugs to improve muscle relaxation, lessens the customary reflex signs, thus adding to the danger of ether anesthesia.

It is also desirable to be able to determine the flow of anesthetic gases easily, quickly, and accurately. The flowmeters of anesthesia machines are usually calibrated for use at sea-level pressures. The use of such machines in high altitudes makes the flowmeter inaccurate or tedious recalibration necessary. Attempts to compensate for atmospheric pressure by relocation of the control valves, result in flowmeters which are highly unstable when the emergency oxygen system is used.

It is therefore an object of this invention to provide a safe, effective, inexpensive, easy-to-use gas machine.

Another object of the invention is to provide an oxygen-supply circuit having accurate, easy-to-determine flows of anesthetic gases.

Another object of the invention is to provide an oxygen-supply circuit having an emergency oxygen supply which will effectively eliminate anesthetic gases in the system.

A further object of the invention is to provide a vaporizer which produces a higher concentration of liquid anesthetic vapor at high oxygen flows than at low oxygen flows.

A further object of the invention is to provide a vaporizer which produces a predictable anesthetic concentration dependent only on the anesthetic agent used, its temperature, and the atmospheric pressure.

A still further object of the invention is to provide a

2

vaporizer circuit in which anesthetic vapor will not enter the system after the vaporizer oxygen flow is shut off.

The anesthetic gas machine of the present invention will be more fully understood from the following description of the preferred form of the invention, given with the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the gas machine;

Figure 2 is a sectional view of the vaporizer unit;

Figure 3 is a sectional view of the vaporizer valve;

Figure 4 is a graph showing the performance of the vaporizer at various oxygen flows.

Referring now to Figure 1, the oxygen tank 11 is provided with a tank valve 12 and a pressure gauge 13. The basic oxygen circuit 14 leads oxygen from the valve 12 through a pressure regulator 15, which is set to provide a regulated pressure of about 50 pounds per square inch, a dry-float flowmeter 16, and a needle valve 17, into a mixing manifold 18. The manifold 18 connects through the oxygen-supply line 19 and the inspiration line 20a, to the face mask 21. The expiration line 22 leads from the mask to the directional checkvalve 23 and is provided with an adjustable relief valve 66 and a pressure gauge 67. The absorber line 24 carries gases from the directional checkvalve 23 to the absorber 25. The absorber return line 26 leads from the absorber 25 to the rebreathing bag 28 and the directional checkvalve 27. The conduit 29 connects the checkvalve 27 to the inspiration line 20a.

The emergency oxygen line 29 connects to the basic oxygen line 14 between the pressure regulator 15 and the flow meter 16. A quick-connect oxygen supply source 30, for connection to a resuscitator or aspirator, may be conveniently provided on the line 29. The line 29 is provided with a fast-acting, emergency oxygen valve 31. The conduit 33 connects the emergency valve 31 to the oxygen-supply line 19 between the manifold 18 and the inspiration line 20a.

The vaporizer oxygen line 35 is provided with a vaporizer oxygen pressure regulator 36, which may also be set at 50 pounds per square inch. Oxygen from the regulator 36 passes through the flowmeter 37 to the vaporizer inlet valve 38. Flow from the vaporizer 39, through the ether supply line 41 to the manifold 18 is controlled by the vaporizer outlet valve 40.

The vaporizer unit, shown in Figure 2, is provided with a thick cylindrical copper body 42. A drain tube 43 connects with the inside of the body and is provided with a stopcock 45 and a drain outlet 46. A liquid anesthetic sight tube 47 is connected to the drain tube 43 by the horizontal tube 48, and to the body 42 by the second horizontal tube 49. The sight tube 47 may be made of glass, nylon, or other transparent material resistant to liquid anesthetics and is connected to the horizontal tubes 48 and 49 by the threaded collars 50 and 51.

The vaporizer body 42 is removably attached to the head 52 by the thread-like flanges 53 and 54. A port 55 is provided at the side of the head 52. A removable plug 56 closes the port 55. The oxygen inlet tube 57 and the oxygen-ether outlet tube 58, enter the head 52 on the side opposite the port 55 and turn downwardly near the center of the head. The tube 59 extends down from the inlet tube 57 through the liquid anesthetic to the brass plate 60. The end of the tube 59 is provided with holes 61 above which a porous disk 62 is attached to the tube. The edge of the disk may be provided with a solid portion 65 through which gases can not pass. A restricted, by-pass hole 63 is provided in the tube 59 above the liquid ether level. The by-pass 63 is preferably located on the side of the tube opposite the outlet tube 58 so that anesthetic vapor in the area 64 above the liquid anesthetic is swept into the outlet by oxygen from the by-pass 63. The by-pass 63 may also be located at other positions on

the tube 59, but should not be directed toward the outlet 58.

The porous disk 62 may be made of any material which provides a uniform and predictable pore size, is compatible with the anesthetic agents used and spark-proof. Sintered metal disks made of brass or bronze particles coated with tin and formed under heat and pressure, have been found very satisfactory. The pores of the disk 62 should be approximately 10 microns in diameter and must be closely controlled to avoid individual variations. Disks of the preferred pore size will pass oxygen bubbles through the ether when an oxygen flow of 250-350 cc. per minute is passed through the inlet 57. Disks having pores of 5 microns diameter do not produce bubbles until approximately 700 cc. of oxygen per minute pass through the inlet 57. Disks having pores of 20 microns in diameter tend to form large bubbles and only a single stream of gas passes through the liquid ether, thus resulting in poor vaporization. We, therefore, believe that the pore size of the disk must be between 5 and 20 microns, and is preferably between 7.5 and 15 microns.

The pore size of the disk 62 and the diameter of the by-pass 63 must be balanced so that each causes a restriction of flow, and therefore a back-pressure in the tube 59, at oxygen flows between 50 and 400 cc. per minute. With a 10 micron disk, a by-pass hole made with a No. 76 drill, diameter 0.020 inch, has been found ideal. If the by-pass hole is made with a No. 75 drill, diameter 0.021 inch, the oxygen starts to bubble through the disk at a flow of about 400 cc. per minute. A still larger by-pass (No. 69 drill, diameter 0.029 inch) causes dilution of the ether at low oxygen flows so that the ether concentration increases with increasing oxygen flows only above 400 cc. per minute. With a small by-pass hole, made by a No. 80 drill (diameter 0.013 inch), the ether concentration goes up rapidly from about 16% at 100 cc. per minute of oxygen, to 38% at 300 cc. per minute. Because of this high ether concentration at an oxygen flow of 300 cc. per minute, a by-pass hole smaller than 0.010 inch would probably not be suitable.

The outlet tube 58 connects to the vaporizer outlet valve 40. As shown in Figure 3, the vaporizer inlet valve 38 is located in the same valve body as the outlet valve 40 and both valves are operated by the handle 72. The inlet valve 38 has an oxygen inlet 73, a valve seat 74, a valve stem 75, and an outlet 76. The valve outlet 76 connects with the vaporizer inlet 57. The valve seat 74 is formed in the movable valve seat block 77, which is urged forward in the cylindrical block housing 78 by the spring 79. Leakage between the block 77 and the wall of the housing 78 is prevented by the O-ring 80. The valve stem 75 is provided with a tapered valve element 81, a cylindrical section 82, and an O-ring 83, located in the groove 84. A threaded section 85 forces the valve stem to move axially in the body when the handle 72 is turned.

The outlet valve 40 is provided with an inlet 86, a stationary valve seat 87, a valve element 88, and an outlet 89. The inlet 86 is located in front of, or upstream from the valve seat 87. The outlet 89 is located in back of, or downstream from the valve seat 87. The valve inlet 86 is connected to the vaporizer outlet 58. The valve element 88 is mounted on the valve stem 75 and moves in the valve body when the handle 72 is turned. The valve element 88 is provided with a plastic disk 90 having axial grooves 91 along its circumference.

As shown in Figure 4, the concentration of the anesthetic vapors produced by the vaporizer, increases as the oxygen flow through the vaporizer increases. In the example shown, ethyl ether is used as the liquid anesthetic agent. At a flow of 100 cc. per minute, the ether concentration is about 10%. At an oxygen flow of 400 cc. per minute, the ether concentration is about 26%. At

an oxygen flow of 800 cc. per minute, the ether concentration is about 38%.

In use, the tank valve 12 is opened, and the gauge 13 checked to be sure adequate oxygen is available. The pressure regulator 15 is usually set at 50 pounds per square inch. The needle valve 17 is opened to fill the manifold 18 and the lines 19 and 20a with oxygen, the absorber 25 is turned on, and the face mask 21 is applied to the patient. The exhaled gases pass from the mask 21 through the expiration line 22 to the directional valve 23. The adjustable relief valve 66 is set for any desired pressure and may be set for very low pressures for lung surgery or similar operations. The relief valve 66 is opened by excess pressure in the expiration line 22 or it may be opened by lifting the valve stem. The directional valve 23 permits the gases to flow only toward the absorber 25. Carbon dioxide is removed from the exhaled gases by the absorber 25, and the gases pass through the absorber return-line 26 to a rebreathing bag 28 and a directional valve 27. The degree of inflation of the rebreathing bag 28 indicates the amount of oxygen needed to replace the carbon dioxide removed by the absorber 25. The amount of oxygen is then controlled by the needle valve 17. The adequacy of the patient's oxygen intake is shown by the flowmeter 16. The gases then pass from the directional valve 27 through the conduit 20 and the inspiration line 20a to the face mask 21.

To start the anesthetic administration, the vaporizer 39 is filled to a level indicated by the sight tube 47 with a volatile liquid anesthetic, for example, ethyl ether. Vinyl ether and other similar liquid anesthetics may also be used. The valve handle 72 is turned slowly, opening the vaporizer outlet valve 40 first and then the vaporizer inlet valve 38. Oxygen flows through the vaporizer pressure regulator 36 and the flowmeter 37 to the inlet valve 38. Restriction caused by the inlet valve 38 maintains the regulated pressure, for example 50 pounds per square inch, on both sides of the flowmeter 37. Oxygen passing through the inlet valve 38 picks up anesthetic vapors in the vaporizer 39 and carries them through the outlet valve 40 to the mixing manifold 18. In the manifold 18 they are mixed with oxygen from the basic oxygen line 14 and pass through the lines 19 and 20a to the face mask 21. As the oxygen flow through the vaporizer is increased, it may become necessary to reduce the basic oxygen flow by adjusting the valve 17.

If an emergency develops and it is desired to put the patient on pure oxygen momentarily, this may be accomplished by lifting the mask 21 from the patient's face, opening the emergency valve 31, and replacing the mask on the patient's face. If the gases are being administered to the patient by an intratracheal tube, it is necessary to lift the stem of the relief valve 66, squeeze the rebreathing bag 28 to eliminate anesthetic gases, and then open the emergency valve 31. Dumping of the anesthetic gases through either the mask or the relief valve 66 is advisable to avoid possible dangers of fire when pure oxygen is suddenly mixed with the anesthetic gases.

As shown in Figure 2, oxygen enters the vaporizer 39 through the inlet 57. The oxygen passes down tube 59 through the by-pass hole 63 to the area 64 above the liquid ether. Here it picks up ether vapors formed by liquid ether in the vaporizer body 42 and carries them to the outlet tube 58. As the oxygen flow through the inlet 57 is increased to approximately 250-350 cc. per minute, pressure builds up in the tube 59 causing some of the gases to pass down the tube 59 and through the porous disk 62, against the capillary pressure of the liquid ether in the disk pores. This oxygen bubbles through the liquid ether and carries ether vapor through the area 64 to the outlet tube 58. Vaporization of the ether as oxygen bubbles through it, causes the temperature of the ether to drop. Heat, for vaporization of the ether,

5

is supplied by air surrounding the heat-conductive body 42. Since the vaporizer is suspended in air and contacts only a minimum of metal surfaces, the vaporizer temperature drops rapidly to an equilibrium, wherein the heat supplied by the air is equivalent to the heat needed for vaporization. At an oxygen flow rate of 1000 cc., considerably above normal, the temperature of liquid ethyl ether in the vaporizer is approximately 20° below room temperature.

This design results in the unusual vaporizer performance shown in Figure 4. The oxygen flow through the disk 62 depends on the back pressure caused by restriction of the by-pass 63. At oxygen flows below 250-350 cc. per minute, all the oxygen flows through the by-pass 63 picking up only surface ether vapors in the area 64. At slightly higher flows, some of the oxygen passes through the disk 62, bubbling through the liquid ether and increasing the ether concentration produced. At higher flow rates, the by-pass 63 allows only a small portion of the oxygen to pass through and most of the oxygen goes through the disk. Thus much higher ether concentrations are obtained at the higher oxygen flow rates.

When the use of the anesthetic gas machine is complete, the ether is turned off by closing the valve handle 72. This closes the inlet valve 38 first and then the outlet valve 40. More ether vapor can not be generated and enter the gas machine as the vaporizer 39 warms up.

We claim:

1. A gas anesthesia machine comprising: a source of oxygen; means for determining the amount of oxygen available; a basic oxygen circuit having a pressure regulator, means for controlling the oxygen flow through said circuit, a dry-float, flowmeter between said regulator and said control means, a mixing manifold connected by an oxygen supply line and an inspiration line to a face mask; an emergency oxygen line leading from the basic oxygen regulator to the oxygen supply line and having a fast-acting valve; an ether supply line having a second pressure regulator, an ether vaporizer, means for controlling oxygen flow through said vaporizer, a dry-float, flowmeter between said control means and the pressure regulator, a vaporizer outlet valve, means for connecting said vaporizer to the mixing manifold; and an absorber circuit having a means for connecting the face mask through a directional check valve to a carbon dioxide absorber, means between said face mask and said directional valve for releasing gases when a predetermined pressure is exceeded or when said means is operated by hand, an absorber return line connecting said absorber through a second directional valve to the inspiration line, and a flexible rebreathing bag attached to said return line; said vaporizer having a top attached to the anesthesia machine, a thick-walled, cylindrical, copper body detachable from said top, a port at the side of the vaporizer top and means for closing said port, inlet and outlet gas passages entering said top at the side opposite said port, a vertical extension of said inlet passage extending below the surface of the liquid in the vaporizer, a by-pass hole in said extension directing incoming gases to an area above the liquid anesthetic level, said by-pass having a diameter between 0.015 and 0.025 inch, a porous disk attached to said extension, means for directing gases from said extension through said disk, and pores in said disk having a diameter of 7.5 to 15 microns; said vaporizer inlet and outlet valves being combined in a single body and operated by a single control, the inlet valve portion having an oxygen inlet passage, a valve seat and a valve stem movably mounted in said inlet, a tapered valve element on said stem, an outlet passage at right angles to said inlet, a control handle on said stem, a spring urging said movable valve seat towards said valve element, the outlet valve portion having a second valve element attached to said stem and operated by said control handle, a plastic gasket on said valve element, axial grooves in the circumference of said gasket,

6

a fixed valve seat, an ether-oxygen passage entering in front of said valve seat, and an ether-oxygen outlet in back of said seat.

2. A gas anesthesia machine comprising: a source of oxygen; a basic oxygen circuit having a flowmeter attached to said oxygen source, means for controlling the oxygen flow attached to said flowmeter, a mixing manifold connected by a conduit to a face mask; an emergency oxygen line leading from the oxygen source to said conduit; an anesthetic supply line having a pressure regulator, an anesthetic vaporizer, means for controlling flow through said vaporizer, a flowmeter between said control means and the pressure regulator, a vaporizer outlet valve, and means for connecting said vaporizer to the mixing manifold; and an absorber circuit having a carbon dioxide absorber, a relief valve, and a flexible rebreathing bag; the vaporizer having a thick-walled metal body, inlet and outlet gas passages, a by-pass hole in said inlet directing incoming gases across the liquid anesthetic surface, said by-pass having a diameter between 0.01 and 0.03 inch, a porous disk connected to said inlet and located below the surface of the liquid anesthetic, means for directing incoming gases through said disk, pores in said disk between 5 and 20 microns diameter; said vaporizer inlet and outlet valves being combined in a single body and operated by a single control, the inlet valve portion having an oxygen inlet passage, a movable valve seat and a valve stem mounted in said inlet, a valve element on said stem, an outlet passage, a spring urging said movable valve seat towards said valve element; the outlet portion comprising a second valve element attached to said stem and operated by said control, a fixed valve seat, an anesthetic-oxygen passage entering in front of said valve seat, and an anesthetic-oxygen outlet in back of said seat.

3. A gas anesthesia machine comprising: a source of oxygen, means for supplying a known basic oxygen flow to a mixing manifold; a conduit connecting said manifold to a face mask; an emergency oxygen supply line leading from the oxygen source to said conduit; an anesthetic supply line having an anesthetic vaporizer, means for supplying a known flow of gas through said vaporizer, means for connecting said vaporizer to the mixing manifold; an absorber circuit having a relief valve, an absorber and a flexible rebreathing bag; said vaporizer having a metal body, gas inlet and outlet passages, a porous disk attached to said inlet passage, a by-pass hole in said inlet passage allowing incoming gases to by-pass said disk, vaporizer inlet and outlet valves combined in a single body, and operated by a single control, and means for opening the outlet valve first and closing the inlet valve first.

4. In an anesthesia machine, a vaporizer comprising: a top, a thick-walled, cylindrical, copper body; a port at the side of said top and means for closing said port; inlet and outlet passages entering said top at the side opposite said port; a vertical extension of said inlet extending below the surface of the liquid in the vaporizer; a by-pass hole in said extension directing incoming gases to an area above the liquid level, said by-pass having a diameter between 0.01 and 0.03 inch; a porous disk attached to said extension; means for directing gases from said extension through said disk, pores in said disk between 5 and 20 microns in diameter.

5. In a gas anesthesia machine, a vaporizer valve comprising: inlet and outlet valves combined in a single body and operated by a single control handle, the inlet valve portion having an oxygen inlet passage, a movable valve seat and a valve stem mounted in said inlet, a tapered valve element on said stem, an outlet passage, a control handle on said stem, a spring urging said movable valve seat towards said valve element, the outlet valve portion having a second valve element attached to said stem and operated by said control handle, a plastic gasket on said valve element, axial grooves on the cir-

7

cumference of said gasket, a fixed-valve seat, an anesthetic-oxygen passage entering in front of said valve seat, and an anesthetic oxygen outlet in back of said seat.

6. In an anesthesia administering device, a liquid anesthetic vaporizer, comprising: a top attached to said device, a thick-walled, cylindrical, copper body removably suspended from said top, a port at the side of said top and a removable closure for said port; an oxygen inlet passage through said top; a tube extending downwardly from said passage; a sintered metal disk near the end of said tube; numerous holes in said disk having a size of substantially 10 microns; a plate across the end of the tube directing incoming gas through said disk; an outlet passage through the top; and a by-pass hole substantially 0.02 inch in diameter in the inlet passage extension allowing oxygen to enter the outlet tube without passing through the sintered disk.

7. In an anesthesia administering device, an anesthetic vaporizer, comprising: a top, a thick-walled copper body removably attached to said top; a port and a removable closure for said port; a gas inlet passage; a porous disk below the liquid anesthetic level and connected to said inlet passage; means for directing the incoming gas through said disk; pores in said disk; and a by-pass hole in said inlet passage allowing gas to pass across the surface of the liquid anesthetic to the vaporizer outlet.

8. In a gas administering device, a basic oxygen supply line having a pressure regulator, a flowmeter, a needle valve, a mixing manifold, and a conduit leading to a face mask; an emergency oxygen circuit attached to said

8

basic oxygen supply line having a flush-type emergency valve, and a connection to said conduit between said face mask and said manifold; and a supply line for a normally liquid anesthetic agent connecting to said manifold and having an oxygen source, and a vaporizer in which the concentration of vaporized anesthetic agent increases with increasing oxygen flow.

9. In a gas administering device, a vaporizer comprising: a body containing liquid anesthetic, a gas inlet extending into said liquid, a porous disk connected to said inlet below the liquid surface, a gas outlet, means for determining the amount of anesthetic liquid in the body, means for adding more liquid anesthetic, and a by-pass hole in the gas inlet directing incoming gas across the liquid anesthetic surface to the gas outlet.

10. In a gas anesthesia machine, a vaporizer comprising: a body containing a liquid anesthetic, a gas outlet, a gas inlet, a passage from said inlet allowing gas to pass directly to said outlet, a second passage from said inlet allowing gas to pass through the liquid anesthetic, and means restricting the flow of gas through each of said passages.

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