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R. M. SMITH, JR
ANESTHETIC APPARATUS
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Fig. 1

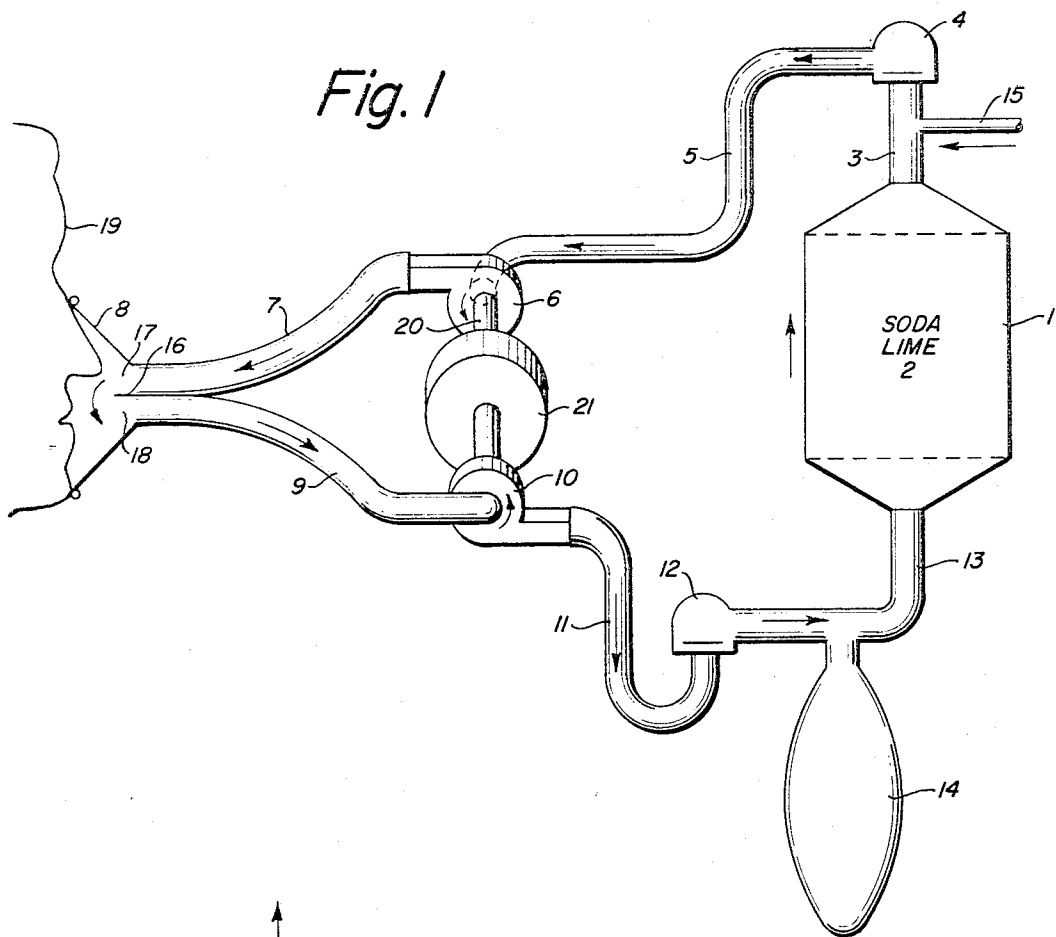
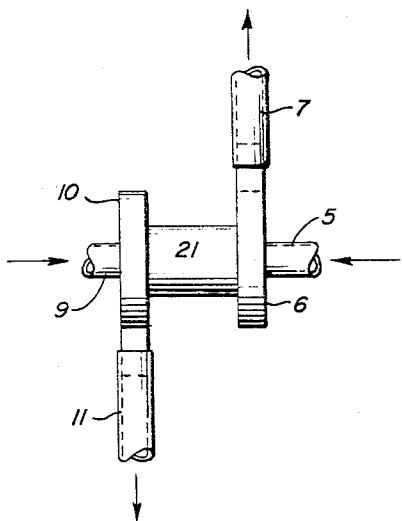


Fig. 2



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3,378,005

ANESTHETIC APPARATUS

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ABSTRACT OF THE DISCLOSURE

A non-positive-displacement pump is connected to the inspiratory side of a breathing mask to continuously circulate anesthetic gases towards the mask. Another non-positive-displacement pump is connected to the expiratory side of the mask to continuously circulate exhaled gases away from the mask. Both pumps are driven by a common prime mover. A breathing bag in the system can be manipulated to override the pumps, whereby the anesthetist maintains contact with his patient.

This invention relates generally to method and apparatus for anesthetizing a patient. Specifically, this invention relates to method and apparatus for providing continuous circulation in the lines of an anesthetizing system thereby to minimize the effect of mechanical dead space therein by reducing the concentration of carbon dioxide in the said lines.

In conventional anesthetizing systems of the "closed circle" type, the anesthetizing gas mixture (comprising oxygen and anesthetic) is circulated in a loop including the lungs of the patient and the canister of carbon-dioxide-absorbing material such as soda lime. In the inspiratory portion of the breathing cycle, the patient inhales the anesthetizing gas mixture from one side of the loop (the "inspiratory" side of the loop) and, on the expiratory portion of the breathing cycle, the patient exhales gases (comprising carbon dioxide and anesthetic) into the other side of the loop (the "expiratory" side of the loop) and thence to the canister of soda lime for the removal of carbon dioxide. A makeup line communicates with the loop for the introduction thereto of oxygen and makeup anesthetic which may have been lost from the loop through metabolism or leaks. A breathing bag adapted to be manipulated by the anesthetist also communicates with the loop; when the breathing bag is squeezed, the anesthetizing gas mixture is forced into the patient's lungs whereby the inspiratory portion of the breathing cycle is effected, and, when the anesthetist's hands release the breathing bag, the patient's lungs deflate to effect the expiratory portion of the breathing cycle. Check valves are provided in the loop between the patient and the breathing bag and canister to maintain in one direction the flow of gases induced by manipulation of the breathing bag.

In the conventional closed circle system just described, the internal volume or dead space of the lines between the check valves and the patient may assume critical proportions for some patients, particularly infants and those adults whose tidal volume is, for any reason, reduced. The smaller the tidal volume, the more deleterious to the patient is this imposed dead space. For instance, the tidal volume of an infant, which is perhaps 20-30 cc., is many times smaller than the above-mentioned dead space or internal volume of the lines between the check valves and the infant and, as a practical matter, there is a lower limit to this internal volume or dead space. Thus, if the conventional closed circle system were used, the infant would be rebreathing those gases between him and the check valves several times over and the carbon dioxide buildup would cause serious, if not fatal results due to hypoxia, it being apparent that, if the internal

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volume or dead space of the lines as above described were several times greater than the tidal volume of the infant, it would require several breathing cycles for a tidal volume bolus of fresh anesthetizing gas mixture from the carbon-dioxide-absorbing canister to reach the infant. For this reason, closed circle systems of the type described are not normally used for infants, and other anesthetic systems are therefore required to be used. These other anesthetic systems do not possess the advantages normally attending the use of the closed circle system, particularly the economy in use of anesthetic.

One solution to the foregoing problem has been reported in Can. Anaes. Soc. J., vol. 6, No. 2, April 1959, pages 98-107 and in Anesthesiology, 1961, vol. 22, pages 583-590. Briefly, this solution involves placing an air- or suction-operated turbine driven rotary pump in the inspiratory portion of the loop between the canister and the patient to continuously forceably circulate the gases to the breathing mask and then back through the expiratory portion of the loop to the canister. Neither the breathing bag nor the patient are included in this circulation, so that the tidal exchange of gases between the patient and the breathing bag is substantially unaffected; that is to say, the breathing bag moves normally to reflect the tidal excursion moved by the patient. The breathing bag is manipulated by the anesthetist in the normal manner, and the patient is able to breathe from under the breathing mask fresh gases which do not contain recently exhaled carbon dioxide. An alternate solution reported in the above-mentioned references involves placing the rotary pump in the expiratory portion of the loop. There are disadvantages to each of these solutions which may be critical for some patients. If the rotary pump is placed in the inspiratory portion of the loop, a continuous positive pressure is built up under the breathing mask and this may well have adverse physiological effects on the patient. If the rotary pump is placed in the expiratory portion of the loop, a continuous negative pressure is created under the breathing mask, and this too may well have adverse physiological effects on the patient.

The present invention solves all of the foregoing problems by providing for a continuous circulation of gases in the system to avoid carbon dioxide buildup without creating continuous positive or negative pressures under the breathing mask. In other words, with the present invention, in the interim between patient exhaling and inhaling, the pressure under the breathing mask is substantially the same as that pressure which normally obtains in the conventional closed circle anesthetizing system.

One of the objects of this invention is to provide an improved anesthetizing method and apparatus.

Another object of this invention is to provide for the continuous circulation of gases in the anesthetic system to avoid carbon dioxide buildup in the patient.

A further object of this invention is to provide for the continuous circulation of gases in the anesthetic system to avoid carbon dioxide buildup in the patient and hypoxia without creating continuous positive or negative pressures in the anesthetic system breathing mask.

Other and further objects of this invention will become apparent during the course of the following description and by reference to the appended drawing and claims.

Briefly, this invention comprises introducing a rotary pump both in the inspiratory portion of the anesthetic system and in the expiratory portion of the anesthetic system, both rotary pumps serving to continuously circulate gases in the anesthetic system in one direction, the positive pressure which normally would be built up under the breathing mask by that rotary pump in the inspiratory portion of the anesthetic system being cancelled by the nega-

tive pressure which normally would be created under the breathing mask by that rotary pump in the expiratory portion of the anesthetic system.

Referring now to the drawing, in which like numerals represent like parts in the several views:

FIGURE 1 represents schematically a closed loop anesthetic system and shows diagrammatically in exploded perspective the two rotary pumps in the inspiratory and expiratory portions of the closed loop with the prime mover common to both rotary pumps.

FIGURE 2 represents a view in plan of the two rotary pumps and their common prime mover, together with adjacent portions of the lines of the anesthetic system.

In the preferred embodiment shown in FIGURE 1, a closed circle anesthetic system is seen as comprising a canister or absorber 1 holding a body 2 of carbon-dioxide absorbing material such as soda lime therein, a line or hose 3 connected to the discharge end of canister or absorber 1 and communicating with check valve 4, a line or hose 5 communicating between the check valve 4 and the intake or suction of rotary pump 6, a line or hose 7 communicating between the discharge of rotary pump 6 and one side of breathing mask 8. This portion of the closed circle anesthetic system just described may be termed the inspiratory portion of the closed circle system or loop. Continuing, line or hose 9 communicates between the other side of the breathing mask 8 and the intake or suction of rotary pump 10, a line or hose 11 communicates between the discharge of rotary pump 10 and check valve 12, and a line or hose 13 communicates between check valve 12 and the intake end of canister or absorber 1. This portion of the closed circle anesthetic system just described may be termed the expiratory portion of the closed circle system or loop. A breathing bag 14 communicates with line 13 as shown, and one or more makeup lines 15 for oxygen and anesthetic is indicated diagrammatically in FIGURE 1 as communicating with line or hose 3. It will of course be understood that the system just described may include a vaporizer and other auxiliary equipment (not shown) as is known to those familiar with the art. Also, breathing mask 8 may include a chimney piece 16 known in the art to divide the breathing mask 8 into two passages 17 and 18 communicating with each other adjacent the nose and mouth of the patient 19.

In the preferred embodiment as shown, rotary pumps 6 and 10 are not positive displacement pumps for reasons which will hereinafter appear. Further, rotary pumps 6 and 10 should be of the same capacity and should be operated at the same speed, in order to avoid creating positive or negative pressures under breathing mask 8. While rotary pumps 6 and 10 may be operated by separate prime movers, advantageously these rotary pumps 6 and 10 are operatively connected to the opposite ends of shaft 20 of a prime mover 21 common to both the said rotary pumps 6 and 10. Prime mover 21 may be a turbine operated by fluids such as air or water or may be operated by suction, and may also be a battery-operated explosion-proof electric motor, it being understood that due to the explosive or inflammable nature of certain anesthetics such as cyclopropane, suitable safeguards must be taken in the design and operation of such prime mover 21 as will eliminate such hazards. FIGURE 1 is partially exploded to clearly show the shaft 20 operating both rotary pumps 6 and 10. However, as shown in FIGURE 2, the rotary pumps 6 and 10 may be mounted directly to the housing of prime mover 21 and, of course, shaft 20 will not show. Obviously, if rotary pumps 6 and 10 are operated by separate prime movers, suitable precautions against the hazards of explosive or inflammable anesthetics must be taken, and these separate prime movers may be fluid driven as by air or water or may be suction driven, and may also be battery-operated explosion-proof electric motors.

The operation of the present invention will now be described, it being assumed that breathing mask 8 is in proper position over the face of the patient 19.

Prime mover 21 is operated to drive rotary pumps 6 and 10 in the direction indicated by arrows in FIGURE 1. This causes a continuous circulation of gases in the anesthetic system in the direction indicated by arrows, forcing carbon-dioxide-free anesthetic gases through the space under the breathing mask 8 to displace from under the said breathing mask 8 the carbon-dioxide-rich exhaled atmosphere before the next inhalation takes place. Thus, patient 19 is able to breathe fresh gases which do not contain recently exhaled carbon dioxide. As the suction of the intake of rotary pump 10 cancels the pressure of the discharge of rotary pump 6, no continuous positive or negative pressures are created under the breathing mask 8 to the physiological advantage of patient 19. Rotary pumps 6 and 10 are preferably operated at such a speed as will maintain check valves 4 and 12 just at the point of opening, and will not be operated at such speed as will interfere with the manipulation of breathing bag 14. It will be noted that breathing mask 8 is substantially equidistant between rotary pumps 6 and 10, and thus the pressure drops in lines 7 and 9 will be substantially the same. Where patient 19 is partially or completely incapable of breathing, the anesthetist in attendance manipulates breathing bag 14 in the customary manner. As previously mentioned, rotary pumps 6 and 10 are not positive displacement pumps, and manipulation of the breathing bag 14 will "override" these rotary pumps 6 and 10. In other words, circulation of gases in the loop caused by manipulation of breathing bag 14 is not impeded by rotary pumps 6 and 10 whether they are in normal operation driven by prime mover 21 or whether they are not in operation in an emergency such as failure of prime mover 21. In this manner, the anesthetist does not lose touch with his patient 19 and is completely in command at all times. The circulation of gases induced by rotary pumps 6 and 10 may also have the beneficial effect of reducing the effort of inhalation and exhalation.

While I have shown the best embodiment of my invention now known to me, I do not wish to be limited to the exact structure shown and described herein but may include within the scope hereof modifications, substitutions or equivalents. For instance, while the preferred embodiment shows a breathing mask 8, lines 7 and 9 may communicate with the lungs of the patient 19 through closed endotracheal sufflation or other means or methods. Further, while the preferred embodiment shows a closed circle anesthetic system, rotary pumps 6 and 10 may also be used with other anesthetic systems.

I claim:

1. Anesthetic apparatus for introducing anesthetic gas into the lungs of a patient, said anesthetic apparatus comprising:

- (a) first means communicating with the lungs of the patient and having an inspiratory side and an expiratory side,
- (b) inspiratory conduit means communicating with the inspiratory side of said first means,
- (c) expiratory conduit means communicating with the expiratory side of said first means,
- (d) second means to introduce anesthetic gas into said inspiratory conduit means,
- (e) first pump means operatively positioned in said inspiratory conduit means to continuously circulate anesthetic gas toward said first means,
- (f) second pump means operatively positioned in said expiratory conduit means to continuously circulate exhaled gases away from said first means,
- (g) prime mover means driving said first pump means and said second pump means.

2. Apparatus as in claim 1, further comprising:

- (h) said first pump means and said second pump means having substantially equal capacities,

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- (i) said prime mover means driving said first pump means and said second pump means at substantially equal speeds.
3. Apparatus as in claim 1, further comprising:
- (h) said first pump means and said second pump means being positioned in said inspiratory conduit means and said expiratory conduit means respectively substantially the same distance from said first means and having substantially equal capacities,
- (i) said prime mover means driving said first pump means and said second pump means at substantially equal speeds.
4. Anesthetic apparatus for introducing anesthetic gas into the lungs of a patient, said anesthetic apparatus comprising:
- (a) first means communicating with the lungs of the patient and having an inspiratory side and an expiratory side,
- (b) inspiratory conduit means communicating with the inspiratory side of said first means,
- (c) expiratory conduit means communicating with the expiratory side of said first means,
- (d) second means to introduce anesthetic gas into said inspiratory conduit means,
- (e) first pump means operatively positioned in said inspiratory conduit means to continuously circulate anesthetic gas toward said first means,
- (f) second pump means operatively positioned in said expiratory conduit means to continuously circulate exhaled gases away from said first means,
- (g) single prime mover means operatively associated with both said first pump means and said second pump means and simultaneously driving both said first pump means and said second pump means at substantially the same speeds.
5. Apparatus as in claim 4, further comprising:
- (h) said first pump means and said second pump means having substantially equal capacities.
6. Apparatus as in claim 4, further comprising:
- (h) said first pump means and said second pump means being positioned in said inspiratory conduit means and said expiratory conduit means respectively substantially the same distance from said first means and having substantially equal capacities.
7. Anesthetic apparatus for introducing anesthetic gas into the lungs of a patient, said anesthetic apparatus comprising:
- (a) first means communicating with the lungs of the patient and having an inspiratory side and an expiratory side,
- (b) inspiratory conduit means communicating with the inspiratory side of said first means,
- (c) expiratory conduit means communicating with the expiratory side of said first means,
- (d) second means to introduce anesthetic gas into said inspiratory conduit means,
- (e) first non-positive-displacement pump means operatively positioned in said inspiratory conduit means to continuously circulate anesthetic gas toward said first means,
- (f) second non-positive-displacement pump means operatively positioned in said expiratory conduit means to continuously circulate exhaled gases away from said first means,
- (g) prime mover means driving said first pump means and said second pump means.
8. Apparatus as in claim 7, further comprising:
- (h) said first pump means and said second pump means having substantially equal capacities,
- (i) said prime mover means driving said first pump means and said second pump means at substantially equal speeds.
9. Apparatus as in claim 7, further comprising:
- (h) said first pump means and said second pump means being positioned in said inspiratory conduit

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- means and said expiratory conduit means respectively substantially the same distance from said first means and having substantially equal capacities,
- (i) said prime mover means driving said first pump means and said second pump means at substantially equal speeds.
10. Anesthetic apparatus for introducing anesthetic gas into the lungs of a patient, said anesthetic apparatus comprising:
- (a) first means communicating with the lungs of the patient and having an inspiratory side and an expiratory side,
- (b) inspiratory conduit means communicating with the inspiratory side of said first means,
- (c) expiratory conduit means communicating with the expiratory side of said first means,
- (d) second means to introduce anesthetic gas into said inspiratory conduit means,
- (e) first non-positive-displacement pump means operatively positioned in said inspiratory conduit means to continuously circulate anesthetic gas toward said first means,
- (f) second non-positive-displacement pump means operatively positioned in said expiratory conduit means to continuously circulate exhaled gases away from said first means,
- (g) single prime mover means operatively associated with both said first pump means and said second pump means and simultaneously driving both said first pump means and said second pump means at substantially the same speeds.
11. Apparatus as in claim 10, further comprising:
- (h) said first pump means and said second pump means having substantially equal capacities.
12. Apparatus as in claim 10, further comprising:
- (h) said first pump means and said second pump means being positioned in said inspiratory conduit means and said expiratory conduit means respectively substantially the same distance from said first means and having substantially equal capacities.
13. Apparatus as in claim 1, further comprising:
- (h) third conduit means communicating between said inspiratory conduit means and said expiratory conduit means and completing a conduit loop comprising said inspiratory conduit means, said expiratory conduit means and said third conduit means,
- (i) carbon dioxide absorbing means operatively interposed in said third conduit means,
- (j) a breathing bag operatively interposed in said third conduit means,
- (k) check valve means operatively interposed in said third conduit means and adapted to permit only unidirectional flow of gases in and around said conduit loop from said inspiratory conduit means to said expiratory conduit means and through said carbon dioxide absorbing means.
14. Apparatus as in claim 5, further comprising:
- (i) third conduit means communicating between said inspiratory conduit means and said expiratory conduit means and completing a conduit loop comprising said inspiratory conduit means, said expiratory conduit means and said third conduit means,
- (j) carbon dioxide absorbing means operatively interposed in said third conduit means,
- (k) a breathing bag operatively interposed in said third conduit means,
- (l) check valve means operatively interposed in said third conduit means and adapted to permit only unidirectional flow of gases in and around said conduit loop from said inspiratory conduit means to said expiratory conduit means and through said carbon dioxide absorbing means.
15. Apparatus as in claim 7, further comprising:
- (h) third conduit means communicating between said inspiratory conduit means and said expiratory con-

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- duit means and completing a conduit loop comprising said inspiratory conduit means, said expiratory conduit means and said third conduit means,
- (i) carbon dioxide absorbing means operatively interposed in said third conduit means, 5
- (j) a breathing bag operatively interposed in said third conduit means,
- (k) check valve means operatively interposed in said third conduit means and adapted to permit only unidirectional flow of gases in and around said conduit loop from said inspiratory conduit means to said expiratory conduit means and through said carbon dioxide absorbing means. 10
16. Apparatus as in claim 11, further comprising:
- (i) third conduit means communicating between said inspiratory conduit means and said expiratory conduit means and completing a conduit loop comprising said inspiratory conduit means, said expiratory conduit means and said third conduit means, 15
- (j) carbon dioxide absorbing means operatively interposed in said third conduit means, 20

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- (k) a breathing bag operatively interposed in said third conduit means,
- (l) check valve means operatively interposed in said third conduit means and adapted to permit only unidirectional flow of gases in and around said conduit loop from said inspiratory conduit means to said expiratory conduit means and through said carbon dioxide absorbing means.

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