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3,276,446

SEMI-CLOSED ANESTHETIC SYSTEM

Filed Sept. 6, 1962

FIG. 1

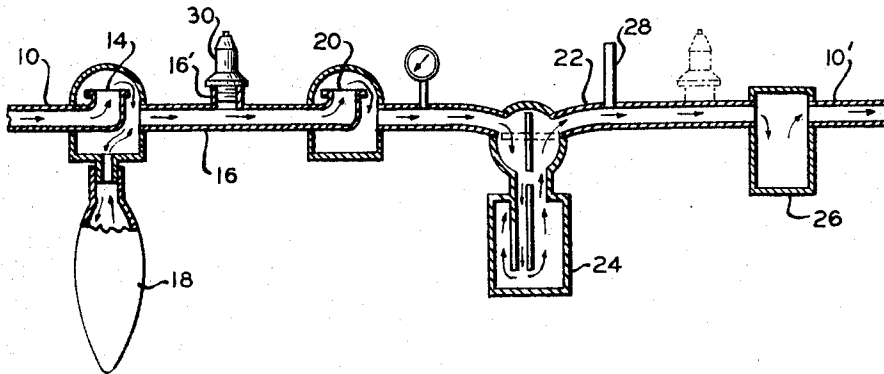


FIG. 3

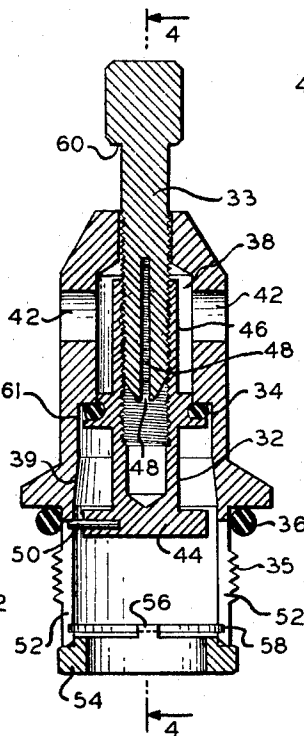


FIG. 2

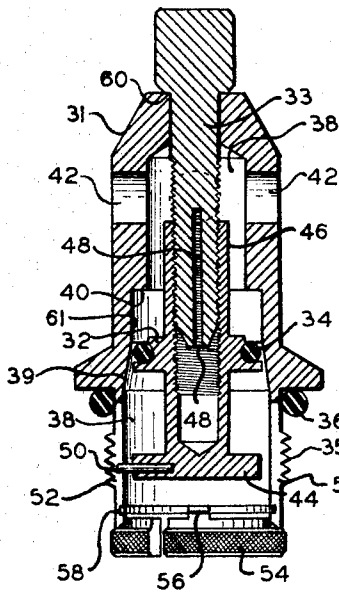


FIG. 4

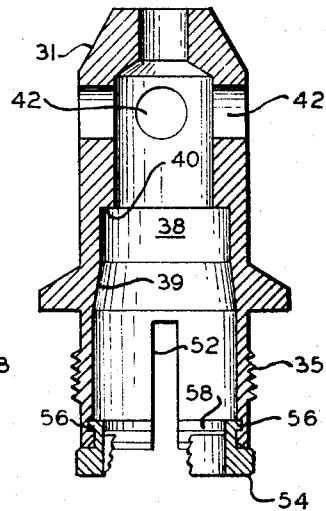
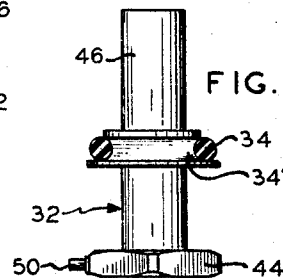


FIG. 5



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SEMI-CLOSED ANESTHETIC SYSTEM

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This invention relates to anesthesia apparatus and more particularly to improvements in the venting or relief of excess gas from anesthetic circuits of the semi-closed type and to an improved relief valve construction for such systems.

It is a common practice in the administration of inhalant anesthetics when circumstances may require assistance of the patient's breathing for adequate ventilation to render such assistance by the periodic application of positive inflationary pressure during inhalation. This is frequently accomplished in the closed and semi-closed anesthetic breathing techniques by compression of the reservoir or rebreathing bag.

In the closed circuit apparatus, such manual ventilation is characterized by a close correlation between the volume of gas displaced from the bag and the volume which enters the patient's lungs, since gas is vented from the closed circuit only through inadvertent leakage. An increase in respiratory resistance is reflected in the need for increased pressure for inflation to the desired level and is readily discernible under the manual control of the anesthetist.

In the conventional semi-closed technique, however, gas in excess of the patient's needs is vented during the inhalation phase whenever the selected relief valve pressure is attained, regardless of the degree of ventilation. Normally, the relief pressure is attained during each positive inflation. Whether the venting pressure is high or low, the volume of gas forced into the lungs in this type of system is always less than the volume displaced from the bag by an amount corresponding to the volume vented to the atmosphere during the period that the bag is compressed. Accordingly, an increase in airway resistance or lung compliance may go undetected and difficulty may be experienced in assessing the actual degree of ventilation.

It has been found that the semi-closed anesthetic system may advantageously be modified to re-establish the correlation typical of the closed circuit technique while maintaining the advantages of the semi-closed method. This is accomplished by allowing the excess gas to be vented from the circuit during the exhalation phase and preventing venting during the assisted respiratory phase of positive pressure inflation. Thus, the gas displaced from the bag is virtually all delivered to the lungs and any change in airway resistance or lung compliance is reflected by an increased pressure or decreased displacement of the bag.

According to the present invention, such modification of a conventional semi-closed type system is effected by novel valve means forming a part of the breathing circuit in which a valve element normally biased toward open or vent position is pressure-actuated to closed position in response to positive pressure inflation and is adjustable to an operative setting between a full open position and a fixed closed position to vary the effective flow restriction from the venting opening and in which such valve element extends at least partially externally of the valve to permit adjustment of its operative setting.

An object of the present invention is to provide a compact and reliable valve for such an anesthetic circuit which is of a gravity loaded type and wherein the external portion of the valve element is so constructed as to provide

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a visual indication of the pressure-actuation of the valve to closed position.

A further object of the present invention is to provide improved relief valve means for semi-closed anesthetic systems wherein the valve simply and effectively can be positively actuated manually to its open or to a fixed closed, or sealed, position and can be adjustably disposed in an operative setting to vary the flow restriction of gas vented therethrough during the exhalation phase, without dismantling or in any other way requiring disorganization of the valve structure.

Other objects and advantages of the present invention will be better understood upon reference to the following description and accompanying drawings in which:

FIG. 1 is a schematic view of an anesthetic circuit of the semi-closed type including improved relief valve means in accordance with the present invention;

FIG. 2 is a vertical enlarged sectional view of the relief valve means incorporated in the schematic circuit of FIG. 1 shown in its normal open or vent position;

FIG. 3 is a vertical sectional view substantially identical to that shown in FIG. 2, but illustrating the valve element in its closed pressure actuated position;

FIG. 4 is a vertical section of the valve shown in FIGS. 2 and 3 taken substantially along the line 4-4 in FIG. 3 omitting the valve stem element and illustrating the construction of the valve body; and

FIG. 5 is an elevational view of the valve stem element.

A breathing circuit adapted for semi-closed administration of anesthesia is shown in FIG. 1. This circuit is of the type generally described more fully in the United States Letters Patents Nos. 2,864,363 and 2,848,309 of Wayne W. Hay. The circuit comprises an exhalation conduit 10 extending from a breathing mask or other equivalent respiratory device, through an exhalation check valve 14 to a conduit 16 with which a reservoir bag 18 is connected. Completion of the breathing circuit is made through a check valve 20 and conduit 22, the latter conduit also being adapted to contain a typical soda lime canister 24 for the removal of carbon dioxide from the recirculated respiratory gases, and an ether vaporizer 26. Also associated with the conduit 22 may be a make-up gas connection 28 through which necessary oxygen together with any gaseous anesthetic agent may be supplied to the breathing circuit. The conduit 10' forms a return connection to the patient.

The semi-closed operation of the circuit described above is imparted by the operation of the relief valve 30 connected with the breathing conduit 16. The valve 30 is a relief valve which is responsive to positive pressure created in the circuit during assisted ventilation of the patient, such as by compression of the bag 18, to close and prevent discharge of gas to the atmosphere. However, the valve is normally biased toward a normal open position as will be hereinafter fully described to permit an adjustable rate of discharge of excess gas from the breathing circuit during exhalation or when inflation pressures are not induced in the circuit.

In accordance with the preferred embodiment of the present invention, the valve 30 is constructed as shown in FIGS. 2-5. The valve comprises a cylindrical shell 31 housing a piston 32, an adjusting screw 33 and an O-ring 34. The O-ring 34 is seated on a radial flange portion 34' of the piston 32 forming a valve-seat engaging surface for the piston. The valve body has a threaded lower end 35 whereby the valve assembly may be detachably mounted in a suitable fitting of the anesthetic circuit such as the boss 16' in FIG. 1. A suitable gasket such as the O-ring shown at 36 is arranged around the threaded lower end to afford a gas-tight connection.

The central bore 38 of the valve within which the

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piston element is vertically movable is provided with a tapered portion 39 and an upper shoulder 40 against which the piston element is adapted to be seated at the uppermost end of its travel. A series of radial venting passages 42 connect the upper end of the valve bore 38 with the atmosphere so as to permit venting of gas therethrough when the valve piston is not in seated engagement with the shoulder 40.

The lower end of the piston 32 forms a flange 44 which is of hexagonal cross section as may be seen from the side view shown in FIG. 5, the points of which cooperate with the cylindrical sidewalls of the lower end of bore 38 to act as a guide for the piston element. As will be understood, the clearance between the hexagonal side faces of the flange 44 and the cylindrical sidewall of bore 38 permit the ready flow of gas upwardly through the bore during venting.

The piston element 32 is vertically adjustable to different operative positions within the valve bore 38 by rotation of the screw 33. The end of the valve stem is threadedly received in an internally threaded sleeve portion 46 of the piston and is slotted as at 48 at its lower end and distorted slightly outwardly so as to provide frictional engagement between the threaded parts and thereby maintain the desired adjusted setting of the piston. A pin 50 carried by the lower hexagonal flange of the piston projects radially outwardly and is received within one of the vertical slots 52 formed in the lower end of the valve body. Upon engagement of the protruding portion of the pin in one of the slots, rotation of the piston is prevented while threading of the valve stem 33 produces upward or downward movement of the piston depending upon the direction of rotation.

The seating flange 34' of the piston carrying the O-ring 34 cooperates with the tapered section 39 of the valve bore 38 to provide an annular metering orifice whose effective area is adjustably varied by the vertical setting of the piston to provide any desired degree of restriction to the flow of gas vented from the valve through the venting passages 42. It is particularly advantageous in such valve device to provide for an adjustable vent restriction in order that a desired bag pressure may be maintained in the breathing circuit and to allow the rebreathing or reservoir bag of the circuit to be maintained partially inflated while gas is being delivered at a given rate to the breathing circuit such as through the make-up gas connection 28 in FIG. 1.

A removable retaining ring 54 is secured at the lower end of the cylindrical valve housing in order, in the event of complete unthreading of the piston 32 from the valve stem 33, to avoid its inadvertent separation from the valve mechanism. The retaining ring is provided with a pair of lugs 56, only one of which is seen in FIGS. 2 and 3, having out-turned lips that are adapted to be received in circumferential grooves 58 formed in the inner sidewall at the lower end of the valve bore 38. The lugs are adapted to be raised into registry with the groove within the lateral space provided by the diametrically opposite slots 52 in the valve body so that upon raising the retaining ring to such position and rotating it slightly the lugs are actively brought into engagement with the retaining grooves 58 to hold the retaining ring in place. One side of the retaining ring is split about midway between the position of the lugs so that the ring may be deformed slightly when the lugs are engaged in the retaining grooves 58 and produce some degree of frictional seating engagement.

The valve 30 operates with the axis of the piston 32 in a vertical position. When no pressure differential is present between the anesthetic circuit and the atmosphere, both the piston 32 and the adjusting screw 33 are suspended by the shoulder 60 of the adjusting screw from the top of the valve body. To raise or lower the piston 32 to a desired operating setting with respect to the valve body under these circumstances, it is necessary merely

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to turn the adjusting screw as described above. If desired, the piston may be raised until the O-ring seal is compressed against the shoulder 40 thereby effectively sealing the valve against the venting or discharge of breathing gas from the system.

With the valve 30 installed in the anesthetic breathing circuit as shown in FIG. 1 and adjusted to a normal operating setting such as shown in FIG. 2, it may be seen that any excess of pressure to the circuit above the ambient atmosphere pressure will cause a flow through the valve as shown by the arrows in FIG. 2. As the pressure differential increases sufficiently so that it exerts a differential pressure on the piston greater than the combined weight of the piston and the adjusting screw, these assembled elements will move upwardly. Since the annular metering orifice formed between the piston and the tapered bore portion is reduced progressively as the piston rises, it will be seen that the continued application of this pressure differential will move the piston to the limit of its upward travel. When the pressure is removed, the weight of the piston and adjusting screw will cause the piston to drop from its pressure-actuated position shown in FIG. 3 and permit the piston to return to its adjusted normal operating setting shown in FIG. 2. The increase and decrease in pressure in response to which the piston is moved in this manner correspond to squeezing and relaxing of the reservoir bag 18 by the anesthetist.

The length of the straight section 61 of the bore of the valve body between the tapered portion 39 and the seating shoulder 40 is determined by the need for having sufficient vertical movement of the piston 32 and adjusting screw 33 so that operation of the valve during forced inhalation can be visibly ascertained easily by the user. It will be seen that the extent of this vertical distance corresponds to the extent to which the upper end of the valve stem 33 is raised from the top of the valve body when the piston has been forced against the shoulder 40 to prevent discharge of gas during positive inflation of the breathing circuit. By making this of sufficient magnitude the operator can immediately discern the functioning of the valve and sealing element therein in the manner described above.

It is conceivable that due to an extra long duration of the application of pressure to the reservoir bag 18 the flow of make-up gas to the system through the make-up connection 28 will so inflate the breathing circuit that even when the operator releases the bag the pressure within the system may remain high enough to prevent the opening of the valve. This could result in hazardous pressure levels in the circuit if allowed to proceed long enough so that the presence of the visible warning in the form of the raised protruding end of the valve stem is an important safeguard. Not only does the valve stem immediately notify the anesthetist of such a possible difficulty but it also permits the anesthetist to immediately rectify the situation simply by depressing the upper end of the valve stem whereby the valve piston is manually unseated so as to permit the venting of the accumulated excess gas within the circuit.

It will be apparent to those skilled in the art to which the present invention pertains that the valve 30 may be located at any suitable point in the breathing circuit. The invention is not limited to the specific preferred embodiment herein described but may be used in other ways without departing from its spirit as defined by the following claims.

I claim:

1. In a semi-closed, partial rebreathing anesthetic system, the combination of a gas-flow circuit, exhalation and inhalation valves, a reservoir bag, said reservoir bag being operative when compressed to produce positive pressure inflation of a patient, and a relief valve means, said relief valve means having a valve element externally adjustable to open and closed settings in which said valve element, alternatively, is positively seated in a closed posi-

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tion or disposed in an open position providing a selected venting flow restriction, means for actuating said valve element in its open positions in responsive to a predetermined pressure differential acting thereon to displace said valve element to said closed position, independently of said external adjustment, during positive pressure inflation and signal means projected from said valve by displacement of said valve element to give visual indication of the closed position of said valve element in response to said predetermined pressure differential and externally operable to manually unseat said valve element against said predetermined pressure differential acting thereon.

2. A relief valve means for anesthetic breathing systems comprising a valve housing having a reciprocal valve element therein, adjustable within a valve chamber to a closed position against a valve seat and to open settings spaced from said valve seat, said valve element being normally urged toward said open settings and responsive to a predetermined pressure differential acting thereon to move to said closed position, said valve chamber having a tapered wall portion coacting with said valve element in its open settings to vary the size of the valve opening formed between said valve element and the tapered wall portion of said valve chamber, and a valve stem projecting externally of said valve housing and having means adjustably connected with said valve element, operative to positively seat said valve element in its closed position or to preset said valve element in a selected open setting in said valve chamber, said stem mounting said valve element for movement from its open settings to said closed position in response to said predetermined pressure differential acting thereon independent of said adjusting means, said movement projecting said valve stem outwardly of said valve housing to give visible indication of the closed position of said valve element.

3. A relief valve means for anesthetic breathing systems comprising a valve housing having a reciprocal valve element vertically movable within an elongated valve bore, a valve stem threadedly connected with said valve element projecting externally of said housing and having a shoulder engageable with said valve housing from which said valve stem and valve element are suspended, said valve stem being threadedly adjustable to place said valve element in a closed position in positive engagement with a valve seat in said valve bore at the upper limit of travel of said valve element by the engagement of said valve stem shoulder against said valve housing, said valve element being alternatively positionable, by threaded adjustment of said valve stem, in a plurality

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of open settings in a tapered wall portion of said valve bore vertically spaced from said valve opening, so as to vary the size of the valve passage between said valve element and the tapered wall of said valve bore in successively spaced vertical positions of said valve element, said valve stem being mounted for reciprocation in said housing independent of said threaded connection, said valve element being responsive to a predetermined pressure differential acting thereon when disposed in any of said open settings to move from a preselected open setting to said closed position, said valve element, being thereby lifted in said valve bore, raising said engaging shoulder of said valve stem from said valve housing and ejecting a length of said valve stem corresponding to the vertical displacement of said valve element, said ejected valve stem portion visually indicating the closed position of said valve element due to said predetermined differential pressure acting thereon and operable by manual depression thereof to unseat said valve element from said closed position.

4. A relief valve means for anesthetic breathing systems according to claim 3, wherein said tapered wall portion of said valve bore converges upwardly and is separated from said valve seat by an intervening wall portion of substantially uniform diameter such that said valve element is displaced to the upper limit of its travel in response to said predetermined differential pressure and said vertical ejection of said valve stem upon such movement of said valve element is at least the length of said intervening wall portion.

5. A relief valve means for anesthetic breathing systems according to claim 4, wherein said valve element includes vertically slidable cam means engageable with said valve bore for preventing relative rotation of said valve element in said valve bore to permit vertical longitudinal displacement of said valve element by threaded adjustment of said valve stem.

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