AN INFLATING SPILL VALVE FOR CONTROLLED RESPIRATION IN A SEMICLOSED CIRCUIT

BY

D. C. MAXWELL
Department of Anaesthetics, St. Vincent's Hospital, Sydney, Australia

AND G. C. GRANT
Medical Section, The Commonwealth Industrial Gases Limited, Sydney, Australia

One of the main problems in a semiclosed circuit is the disposal of excess gases. When the patient's lungs are manually inflated, this difficulty is usually overcome by intermittently opening an expiratory valve or by inflating against a fixed leak. When a mechanical ventilator is used the operation of the machine itself may be disturbed by the increase in mean pressure in the circuit which occurs unless there is a "spill" to deal with the continuously increasing volume of gases (Mushin et al., 1959).

To overcome this problem we have introduced a valve which is similar to that described by Steen and Lee (1960). As will be seen it differs from Steen and Lee's valve in that it is possible to adjust the distance between the seat faces by screwing them together or apart. This is important for this means the amount of "spill" can be adjusted to the varying gas flows into the circuit. It consists of a lightly spring-loaded disc situated between two seat faces (fig. 1). Any pressure due to excess gases lifts the disc and these pass freely to atmosphere (fig. 1 (i)).

At the commencement of inflation the pressure in the circuit rises rapidly due to squeezing of the bag or compression of the ventilator bellows. The disc then flips up to the position shown (fig. 1 (ii)) and closes the circuit from the atmosphere so that full lung inflation is possible.

(i)
(ii)
(iii)

FIG. 1
Diagrams illustrating the principle of the valve:
(i) Excess gases lifting the disc and passing to atmosphere.
(ii) Inflation. The disc seals against the upper seat face.
(iii) Commencement of negative or resting phase. The disc closes against the lower seat face.

616
At the end of the inspiratory phase, when the hand pressure is released or the ventilator mechanism trips, the disc returns to the resting position (fig. 1 (iii)). If a negative expiratory phase is provided the disc remains against the lower seat face until excess gases lift it gently when this phase ends.

The appearance and structure of the valve can be seen in figures 2, 3 and 4. It is mechanically simple and moisture does not cause sticking of the disc.

When manually inflating, “spills” may, if desired, be effected consciously by gentle squeezing of the bag sufficiently to lift the disc, but not to seal it against the upper seat face. However, there is another feature; during the rapid travel of the disc on normal inflation some gas must escape as the disc moves from one seat face to the other. In practice the valve has been designed so that the amount of this spill can be adjusted by varying the distance between the seat faces (figs. 2 and 3). Thus it is possible to adjust this position so that the amount spilled in this manner equals the amount of fresh gases added to the circuit and the volume in the circuit can therefore be kept constant without repeated manipulation. As opposed to a “fixed leak”, this introduces an “intermittent leak” into the circuit and when the valve closes after spilling in this manner the anaesthetist can accurately feel the degree of lung inflation.

Ideal inflating curves show a fall to zero pressure in the resting phase (Cournand et al., 1958). With the valve in use, if manual pressure on the bag is maintained after inflation, the disc will remain in the “up” position, ultimately locking there if the bag becomes over-distended. Early release of the pressure on the bag will prevent this. Thus the valve efficiently detects the fault in technique of not allowing circuit pressures to return to near-zero levels.

When a mechanical ventilator is used in a semi-closed circuit the effect of an inadequate “spill”
will be determined by whether the ventilator is pressure or volume cycled.

In pressure-cycled ventilators the pressure at which the mechanism trips marking the end of the inspiratory phase is fixed for a given machine and continuous increase in retained volume of gases causes a diminishing pressure difference between resting and peak pressure values. This results in (a) a rise in mean intrapulmonary pressure and (b) a diminishing exchange of gases per cycle.

In volume-cycled machines the end-inspiratory peak pressure rises steadily with each cycle as fresh gases are added. A constant volume is being delivered but at a rising pressure. At a certain point the pressure limit of the safety valve of the machine is reached and a percentage of the delivered volume goes now, not to the patient but to atmosphere. Again we have: (a) a rise in mean intrapulmonary pressure and (b) diminished exchange of gases per cycle.

These effects are shown diagrammatically in figures 5 and 6.

Most mechanical ventilators at present in use have no provision for effective disposal of gases in excess of basal requirements. The use of the valve described solves this problem.

It is possible that the circuit might be rapidly filled (e.g. from the emergency oxygen supply) creating a positive pressure in the circuit, causing the valve to lock in the “up” position. Under these circumstances the pressure can be released by opening the circuit by the usual methods, but in practice this is an uncommon event.

The valve can be easily placed to discharge excess gases immediately before passing through the soda lime. With most other expiratory valves this situation, although theoretically ideal, is inconvenient for constant manipulation; however, constant manipulation is not required with this valve.

SUMMARY

A valve is described whose features are:

- It permits inflation of a patient in a semiclosed circuit without pressure build-up due to excess gases.
- If adjusted properly it enables the volume of gases in the circuit to be maintained at a relatively constant level without constant manipulation.
- It is mechanically simple, robust, sterilizable and electrically conductive.
- There is no pressure build-up in the circuit if the anaesthetist lays the inflating bag aside temporarily while performing some manipulation.
- It detects the fault in technique of not allowing circuit pressure to return to near-zero after inflation.
- The valve can conveniently be situated in the circuit before the soda-lime canister.

REFERENCES
