The higher-patched alarm rings through the speaker.

To set the pressure-preset respirator alarm: 1) The selector knob is turned to "p" position, which simultaneously positions switches S_1, S_2, S_3, and S_4 in "p" positions. 2) The level of Ep is adjusted to touch Sp with each expiration. 3) The power switch is turned on.

When the volume of gas expired by the patient is reduced, Ep does not make contact with Sp. Transistor Tr_2 and relay Ry_2 are not energized, and all r_2 switches remained open. Ten seconds later transistor Tr_1 and relay Ry_1 are energized by the delay–p circuit and all r_1 switches close. The higher-pitched alarm rings through the speaker.

Electric power source alarm. When the electric power source is disconnected, relay Ry_3 does not energize and switch r_3 closes. The middle-pitched alarm rings through the speaker.

REFERENCES

1. Lamont H, Fairley HB: A pressure-sensitive ventilator alarm. ANESTHESIOLOGY 26:359, 1965
2. Wilger RN, Myers RA, Duffy JP, *et al.*: Waring system for piston-type respirator. ANESTHESIOLOGY 27:509, 1966

Pneumotachometry—A Means to Prevent Malfunction Caused by Mucous Deposition

MEYER SAKLAD, M.D., AND ROBERT WEYERHAEUSER

Pneumotachometry, the measurement of air flow into and out of the lungs, is being increasingly employed to monitor ventilation during acute illness. The pneumotachometer is placed in the air stream close to the patient's mouth. On the patient end it may be attached to a mask or an endotracheal or tracheostomy tube. On the other end a pneumotachometer may be open to the atmosphere or it may be attached to an anesthesia apparatus or a ventilator.

The two most commonly used devices for this purpose are the Fleisch and the Silverman pneumotachometers, which function by creating a very slight resistance to air flow. The pressure differential across this resistance is proportional to, and in phase with, the speed of air movement. Through electronic means, change in pressure is converted to an electrical signal which may be displayed on an oscilloscope. Such a tracing is informative of respiratory flow patterns. This flow signal, coupled with airway and/or intraesophageal pressure, can be manipulated by an analog or digital computer to measure continuously many ventilatory values such as minute volume, compliance, and work of breathing. The information thus obtained is valuable for both diagnosis and treatment. Such data may also be used to evaluate and guide ventilator performance and adjustment.

In the Silverman pneumotachometer the resistance is produced by a very fine wire mesh screen, and in the Fleisch device, by a series of parallel tubes. In clinical use, the screen and the parallel tubes accumulate both water condensation and mucus or exudate coughed up by the patient. Deposits of such material on the screen or within the parallel tubes result in an immediate but unknown change in the metering characteristics of the apparatus. The pneumotachometer becomes nonfunctional. The effect of water condensation is overcome by electrical heating, but the heating device does not prevent the alterations in the efficiency of the instrument by deposition of exudate. Pneumotachometry is sufficiently im-

Received from the Division of Anesthesia Research, Rhode Island Hospital, Eddy Street, Providence, Rhode Island 02902.

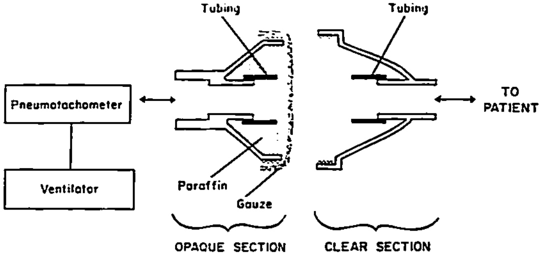

FIG. 1. Diagram of the trap.

portant that a device to trap mucus or exudate to prevent interference with accurate measurement became necessary. The following is a description of a device (fig. 1) which we found practical and satisfactory.

A Bird micronebulizer (catalog #9993-15S) is used as a basis for the construction of the trap (fig. 2). The nebulizer consists of an opaque section and a clear section which screw together. The opaque portion is modified for our purposes by removing the nebulizer and opening the orifice to maintain at least 15 mm in internal diameter. The nebulizer capillary is snapped out easily. The semicircular baffle and the nozzle are cut or drilled out and the resulting small holes are filled with cement. To minimize the added deadspace of the trap, the 15-mm orifice at each end is extended to within several mm of the center when assembled. This approximation of orifices appears to channel air flow, thereby possibly decreasing the functional deadspace within the nebulizer chamber. The opaque portion is filled with paraffin to reduce deadspace further. The clear portion is not so filled, thereby allowing visual inspection of the trap for presence of secretions.

A double layer of gauze is placed across the wide portion of the modified housing, and the other section is screwed down snugly to effect a reasonably airtight seal. This unit, with standard 15–22-mm fittings, is placed in the airway between the patient and the penumotachometer to serve as a trap for exudate. The surface area of the gauze is 17.4 cm^2, or roughly ten times the cross-sectional area of the inlet tube (1.77 cm^2). Therefore, a considerable amount of secretion can collect on

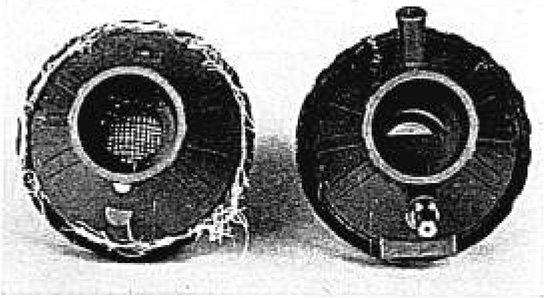

FIG. 2. The trap ready for use (left) and the unaltered micronebulizer (right).

the gauze with little increase in air-flow resistance, and penumotachometer sensitivity remains unchanged. The resistance of the trap itself is 0.3 cm H_2O/l/sec. It is difficult to estimate the functional deadspace accurately because of the almost directly opposed inlet and outlet. The inlet and outlet tubes alone have a deadspace volume of 15 ml. The volume of the chamber by itself is 15 ml. The maximum deadspace possible is 30 ml. The units are sufficiently inexpensive that several sterile complete units with gauze already in place can be kept on hand for easy replacement.

A Safety Signal for Detection of Excessive Anesthetic Gas Flows

CHARLES LOMANTO, M.D.,* AND MICHAEL LEEMING, B.E.E.†

In many institutions it is common practice to drain the gas lines of the anesthesia machines at the end of the working day by turning the pin valve to the full-open position. At times these valves are inadvertently left open. At the start of a new day, when the gas cylinders are opened or gas supply hoses connected to central outlets, the bobbins are projected to the top of the glass column with such speed that it goes unnoticed. This has led to serious overdosages of anesthetic gases. Fortunately, there have been no fatalities or permanent sequelae in this institution. The most common alerting sign has been "dark blood" in the operating field especially when the offending agent was nitrous oxide.

Using a closed system, it becomes immediately obvious when excessive gases are flowing, as evidenced by an overdistended reservoir bag. However, with a semiclosed system, the fault is more difficult to detect since the gas escapes from the pop-off valve and distention of the rebreathing bag may not occur.

We have developed a mechanical device which provides a visual warning of excessive gas flows. A lightweight aluminum pin is contained in an airtight lucite chamber attached to the top of the flow column. The pin has a bright red top for easy visualization. Should the bobbin come into contact with the pin (as it would during excessive flow rates), the bob-

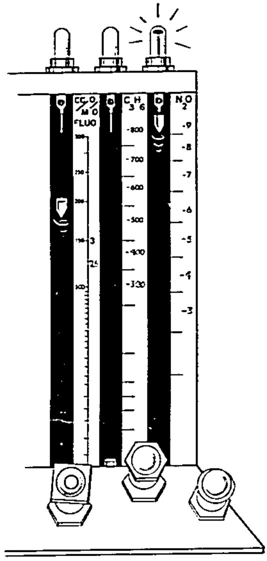

FIG. 1. Signal device in the raised position (right) during excessive gas flow.

* Associate Attending Anesthesiologist.
† Biomedical Engineer.
Received from the Department of Anesthesiology, Memorial Hospital, 444 East 68th Street, New York, New York 10021.