# CURRENT COMMENT

Stuart C. Cullen, M.D., *Editor*

## GADGETS

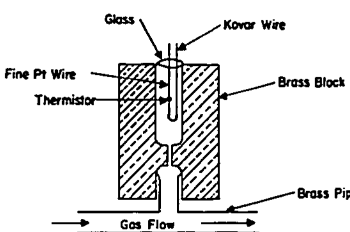
### Gas Analysis by Thermal Conductivity

Harry W. Linde, Ph.D., of the University of Pennsylvania notes that although gas analysis by thermal conductivity lacks the specificity and speed of response of the more elegant physical methods, its simplicity and low cost can often make it a method of choice. It is, for instance, a useful way to measure the concentration of a gas delivered from an anesthesia machine or a vapor from an anesthetic vaporizer. Although thermal conductivity analysis is limited to mixtures of two gases, prior absorption of other gases will allow more complex mixtures to be analyzed. He found this technique applicable to the analysis of mixtures of various anesthetic agents and carbon dioxide with oxygen.

The thermistor-thermal conductivity bridge used here * consists of two thermistors mounted in a single metal block. The block and a single "cell" are shown in cross section. One cell, the reference cell, is filled with dry air and the other cell is filled with the unknown gas mixture. The thermistors form two arms of a Wheatstone bridge whose other two arms are 230 ohm resistors. Thermistors were chosen because they need only to be heated to about 100–150 C. and may be operated on about 3 volts.† The bridge requires about five minutes to respond completely to a change in gas composition. The response is slow because the gas stream does not flow directly through the cell (see illustration). This design, however, renders the bridge output independent of variations in flow rate (to about 15 liters/minute).

The voltage supply was adjusted, oxygen was delivered to the analysis cell at 1 to 5 liters per minute for 5 minutes and the bridge was balanced. The flow of oxygen was continued for another 5–10 minutes and the balance rechecked. A standard or unknown gas mixture was delivered to the analysis cell until a steady reading was obtained and the current caused by the unbalancing of the Wheatstone bridge was recorded. Calibration curves were prepared by delivering a series of gas mixtures of varying concentration to the analysis cell and plotting current against gas concentration. Halothane, chloroform and trichloroethylene mixtures with oxygen were prepared by vaporizing weighed amounts of the liquids (in sealed glass ampoules) into a known volume of oxygen in a flask. Nitrous oxide-oxygen and cyclopropane-oxygen mixtures were delivered from an anesthesia machine with calibrated flowmeters, and carbon dioxide-oxygen mixtures were taken from high pressure cylinders whose contents had been analyzed chemically. Once the calibration curves had been prepared, it was easier to use a standard mixture of carbon dioxide in oxygen from a tank as a reference point on the curve rather than to prepare new calibration mixtures. A standard mixture of carbon dioxide in oxygen was used to check the calibration of the instrument before each use.

Calibration curves for mixtures of halothane, trichloroethylene, and chloroform were linear to concentrations of at least 4 per cent in oxy-




Cross section of thermal conductivity cell (about one-third actual size).

* Veco M-139, Victory Engineering Corp., Union, N. J.

† In spite of the low temperature and voltage, however, suitable precautions should be taken when these devices are used with explosive gas mixtures.

gen; cyclopropane in oxygen to 30 per cent and carbon dioxide in oxygen to 20 per cent. Mixtures between 0 and 100 per cent of nitrous oxide in oxygen gave a calibration curve which was convex in the upward direction. Ether-oxygen mixtures were not studied because of their low ignition temperature.

Thermal conductivity of a mixture of gases is related in a complex manner to the proportions of the individual gases and their conductivities; thus calibration curves are prepared using known gas mixtures rather than by calculation. Any mixture of two gases of dissimilar thermal conductivities may be analyzed by the measurement of the thermal conductivity of the mixture, but when more than two gases are present the other gases must be removed or their concentrations measured by other means. Thus binary gas mixtures delivered from an anesthesia machine to the rebreathing system may be analyzed directly, but if the expired gas mixture, for instance, is to be measured, water vapor and carbon dioxide must first be removed.

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## Volume Ventilation Valve

Drs. R. H. Smith and Perry P. Volpitto of the Department of Anesthesiology of the Medical College of Georgia have produced a valve which changes the semiclosed technique from a pressure-ventilation system to a volume-ventilation one. They state that volume ventilation may be defined as moving a fixed volume of gas into the lung with a variable pressure. (Examples of this type of ventilation now in use are (1) the closed system with carbon dioxide absorption, (2) the use of modified nonrebreathing valves such as the Fink and Lewis-Leigh valves, (3) mechanical ventilators, as the Etsten and Stephenson, and (4) the use of the open tail bag in a semiclosed system. In each instance a fixed volume, whether a measured volume as set in the Etsten, or a quantity from a closed bag, is moved into the lungs at whatever pressure is needed.)

In contrast to the volume-ventilation concept is pressure-ventilation. In the latter method, a fixed pressure is utilized. The volume of gas entering the lung at the fixed pressure depends upon the resistance encountered. (Examples of application of this concept are (1) the semiclosed system with a standard "closed" bag; (2) the tank respirators, Drinker and Emerson, and (3) most of the assistors (Bennett), resuscitators (Emerson); and ventilators (the old Jefferson).) The semiclosed system, on modern anesthesia machines, uses a pressure preset on a "pop-off" valve (Heidbrink) or variable aperture (Foregger). The operator applies pressure to the reservoir bag. The pressure moves gas into the patient until the preset pressure limit is reached. At that point the valve opens and the excess gas escapes. This method is satisfactory as long as there is no resistance to ventilation, or if the operator recognizes the resistance and changes the pressure setting on the machine. However, when unrecognized resistance develops, under-ventilation is inevitable with the pressure ventilation system.

The valve shown here has been designed to let excess gases escape until the operator applies pressure to the reservoir bag. At that point the valve closes, and a volume of gas moves into the patient exactly as in the closed system. Thereafter when pressure on the bag is released, the valve reopens and again the excess gases escape.

The valve has an aperture of variable size for gas escape. The aperture is present only to permit gas escape during the non-inspiratory phase and has nothing to do with the control of the degree of ventilation during inspiration. The opening can be set to accommodate gas flows of 2 liters to 15 liters per minute. The reservoir bag can be kept at any degree of distention the operator desires. This new tool is equally useful with assisted or controlled ventilation.

The valve is of brass tubing, ¾ inch, outside diameter, ⅝ inch, inside diameter, threaded 20 threads to the inch, 1 inch outside, upward from the bottom. A threaded cap with two ⅛-inch holes through it fits the bottom and contains a plastic washer. A ½-inch tube to fit the tail of the bag is soldered to a washer soldered to the top of the cylinder. A ⅜-inch nut rides the outside threads. A Teflon piston, 1 inch long, with a ¼-inch wide recess ⅛-inch deep ½-inch from the top, is the moving part. The piston is drilled with a ¼-inch hole ¾-inch deep, down from the top. This hole is met by a cross hole ¼-inch in diameter, drilled through the recessed portion. The piston is held in position by an 8-coil, .015 gauge spring between piston and base. Opposite the recessed part of the piston are two ¼-inch holes in the cylinder.

This is a piston vented to permit gas flows through it and out the cylinder side. The spring tension is a constant. The valve closes at a pressure of 8–12 mm. Hg. A quick flip opens the aperture to a point permitting 15–16 liters/minute flow. If the valve should jam, lifting the valve out of the socket lets the bag empty. The only variable is the size of the hole in the side of the cylinder, and that is varied by the position of the control nut on the outside of the valve.

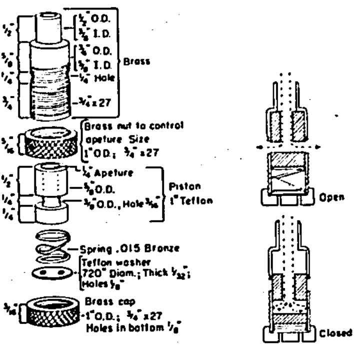



Diagram of volume ventilation valve showing component parts.

Volume ventilation valve for semiclosed system.

The following are practical points about the valve: (1) It can be adjusted quickly to accommodate gas flows up to 15 liters a minute or closed entirely, for a closed system. (2) The Teflon piston is self-lubricating, permitting 1/1000-inch clearance between piston and cylinder wall. (3) The spring is rustproof bronze and provides a constant closing pressure. (4) The valve weighs about 3 ounces, is inexpensive and can be disassembled quickly for washing by unscrewing the base cap. (5) The brass case will not rust or react with anesthetic agents. Plastic would be lighter but not resistant to Fluothane, and not as durable. (6) The valve can be inverted, and with an appropriate collar, fitted into the base of the "pop-off" valve seat, thus permitting the use of a closed bag. This has been adapted to the Heidbrink and Foregger machines. (7) In addition to the use for which the valve was designed, the valve works well in emergency ventilation equipment. An excellent ventilator can be made of a mask, connectors, and open tail bag to which a Georgia valve is applied. High flows, up to 15 liters of oxygen, can be used.

## Nonrebreathing System

Dr. Takao Saito of the Department of Anesthesiology, Tohoku University, Sendai City, Japan, has been using a special ventilatory system with which he is able to supply anesthetic mixture of accurately known concentration with or without using intermittent positive pressure. He believes that if the inhaled vapour concentration of liquid anesthetic, tidal exchange of the subject and the intratracheal pressure pattern (in the cases of controlled respiration) are

Fig. 1

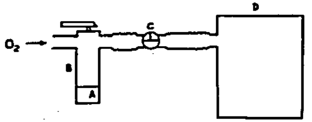



Fig. 1
A: Volatile Anesthetic Drug
B: Vaporizer
C: Three Way Stop Cock
D: Vinyl Bag (Capacity 300 Liters)

predetermined accurately, the experimental data would become more valuable than those lacking these determinations.

Figure 1 illustrates how to prepare the accurately percentage controlled anesthetic mixture (volatile anesthetic only). A vaporizer containing a certain volatile anesthetic is carefully weighed and incorporated to the system shown in figure 1. Oxygen through a calibrated flowmeter is supplied to a preemptied vinyl bag through the system. Then the vaporizer is fully open until the liquid anesthetic is completely vaporized. From the volume of oxygen given, the weight of anesthetic vaporized, the molecular weight of the anesthetic and the room temperature, the concentration of the anesthetic mixture contained in the flaccid vinyl bag can be easily calculated.

In a case which requires particular concentration of anesthetic vapor, the necessary oxygen flow for the weight of anesthetic contained in the vaporizer can be easily calculated from the molecular weight of the anesthetic and the room temperature. Almost any concentration of the anesthetic mixture is possible to be prepared with this method.

Figures 2A and B illustrate how to ventilate the subject with the anesthetic mixture of known concentration using intermittent positive pressure produced by a mechanical ventilator. The respirator is set to produce a desired pressure pattern including an adequate negative pressure phase and approximately predetermined tidal volume. The negative pressure delivers the mixture from the vinyl bag to the inhaler. Two bags are usually connected with a three way stop cock and each can contain the same anesthetic mixture of different concentration or different anesthetic mixtures, sometimes oxygen and anesthetic respectively. One can be switched to the other. If the bags are removed the subject can be ventilated with room air. A thumb should be applied to the

Fig. 2.A

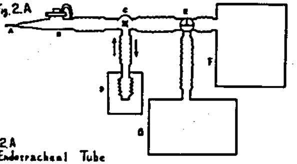


Fig. 2A
A: Endotracheal Tube
B: Fink or Lewis-Leigh Non-Rebreathing Valve
C: Ruben Valve
D: Jefferson Ventilator
E: Three Way Stop Cock
F: Vinyl Bag Containing Anesthetic Mixture
G: Vinyl Bag Containing Anesthetic Mixture or Oxygen

Fig. 2.B

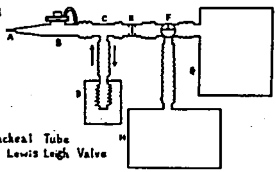


Fig. 2B
A: Endotracheal Tube
B: Fink or Lewis Leigh Valve
C: T-Piece
D: Jefferson Ventilator
E: Uni-Directional Valve
F: Three Way Stop Cock
G: Vinyl Bag Containing Anesthetic Mixture
H: Vinyl Bag Containing Anesthetic Mixture or Oxygen

Fig. 3A

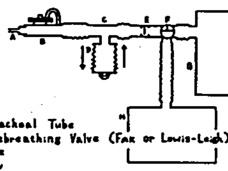


Fig. 3A
A: Endotracheal Tube
B: Non-Rebreathing Valve (Fink or Lewis-Leigh)
C: T-Piece
D: Bellow
E: Uni-Directional Valve
F: Three Way Stop Cock
G: Vinyl Bag Containing Anesthetic Mixture
H: Vinyl Bag Containing Anesthetic Mixture or Oxygen

Fig. 3.B

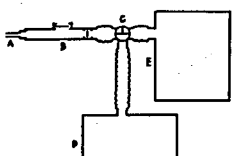


Fig. 3B
A: Endotracheal Tube
B: Non-Rebreathing Valve (any kinds)
C: Three Way Stop Cock
D: Vinyl Bag Containing Anesthetic Mixture
E: Vinyl Bag Containing Anesthetic Mixture or Oxygen

"pop-off" valve intermittently if the Fink or Lewis-Leigh valve is not available and only an ordinary non-rebreathing valve is incorporated.

The Ruben valve shown in figure 2A is not always necessary and a cheap unidirectional valve connected with a T-piece is good enough to perform the same function (fig. 2B).

If the mechanical respirator is not easily available a bellow can be connected to the T-piece with the unidirectional valve or the Ruben valve instead of the mechanical ventilator and produce positive and negative pressure manually (fig. 3A).

In a case which does not require assisted or controlled respiration, the only things necessary are the reservoir, a three way stop cock and an ordinary nonrebreathing valve (fig. 3B).

Dr. Saito has been using these systems in the laboratory and clinical studies for several months with good results.

## Lateral Position Mattress

Dr. Mary R. Wester of the Department of Anesthesiology, Temple University Medical Center, Philadelphia, notes that in the lateral decubitus the dependent arm should be protected in the axilla to avoid brachial plexus or vascular injury from prolonged pressure. In the past year she and her associates have used a specially constructed, simple, supportive mattress pad which has proved not only satisfactory for the patient and surgeon but also a boon to the assistants who lift the anesthetized patient for placement of suitable blankets or pads under the axilla. The lateral position mattress consists of two strips of synthetic or rubber foam across the operating table covered with conductive rubber sheeting and separated by a groove for the dependent arm. In addition, a shorter length of the same foam is attached to one strip in such a way that it may be turned over upon it for a head rest. When the patient is placed on his side

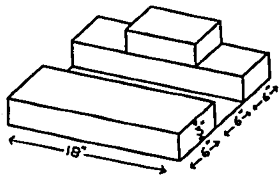
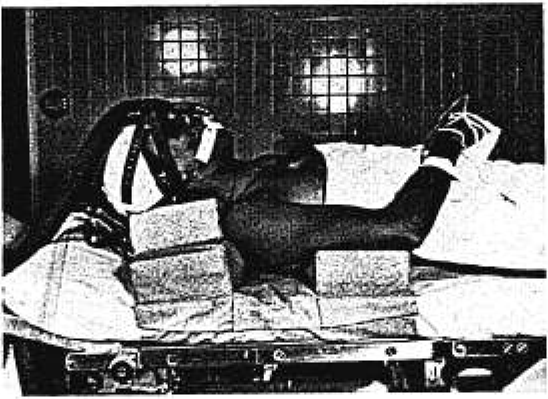



Diagram of mattress for lateral position.

Patient in place on his side with lower arm lying free in the 6-inch groove in mattress.



Patient, lying comfortably on the mattress, is being prepared for induction of anesthesia.

the lower arm lies free in a groove six inches wide. The thorax is supported by a foam strip three inches thick and the head rests six inches above the table top. An unanesthetized individual finds this support completely comfortable.

The three inch thickness of the supportive mattress has been the most satisfactory for a large group of patients regardless of extreme variations in size. The foam strips should be four or five inches shorter than the width of the table. The covering of the mattress must be reasonable water proof and can be made of extend laterally sufficiently to be tucked under the standard operating table pad.

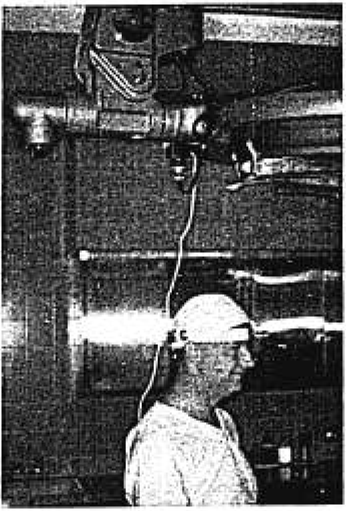
Patients do not find it uncomfortable if they are prepared for induction of anesthesia lying supine on the mattress. Anesthesiologists find the head rest provides the "sniffing position" most satisfactory for endotracheal intubation. There is no interference with table adjustments.

## Headlight

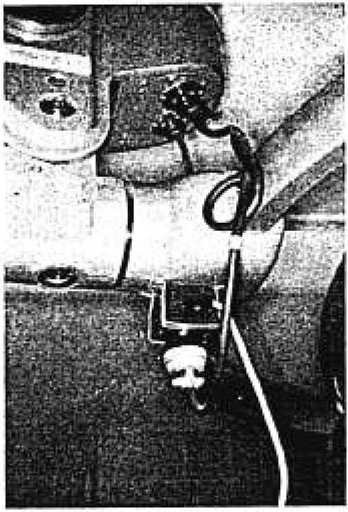
Drs. William L. Berson and T. V. Richey of San Diego, California, believe that headlights for tonsillectomies, with their explosive hazards, present a problem. No headlight is approved officially for use in hazardous locations. The commonly used ones have a connection with an extension cord into a safety-plug in the operating room. Some have connections with a step-down transformer, have a switch to turn on or off and also have the hazard of a loose, flickering bulb. In an attempt to solve these problems, a Welch-Allyn office headlight unit was obtained and fastened to a Castle operating room light. The transformer is fastened to the overhead light support (approximately seven feet from the floor) and it is connected to the electrical circuit there so that it can be activated from the wall switch. The cord is plugged into the transformer and leads directly to the light, enabling the surgeon to test the light away from the anesthesia machine.

Thus they have eliminated three sources of electrical sparks and possible explosions. The remaining possibility is the flickering of the six volt bulb during surgery. This probably presents minimal danger, particularly with the surgeon standing—putting the light above the five foot level.

The names and addresses of manufacturers of the equipment described in this section can be obtained from Anesthesiology, 3 Penn Center Plaza, Philadelphia 2, Pa.



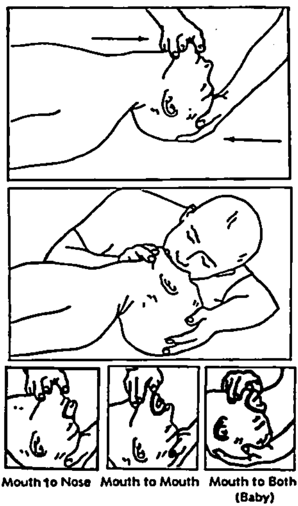
Headlight for tonsillectomy.



Transformer for headlight is attached to overhead light support.

## Rescue Breathing Card

Dr. James O. Elam of the Roswell Park Memorial Institute, Buffalo, New York, has the card illustrated below available for distribution. This card is designed to assist in the promotion of Rescue Breathing to lay audiences.




**_Mouth-To-Nose_**

**and**

**Mouth-to-Mouth**

**Rescue Breathing**

VICTIM ON HIS BACK IMMEDIATELY

| | |
|---|---|
| CLEAR THROAT | of water, mucus, toys, coins, or food. |
| TILT HEAD BACK | as far as possible. |
| PULL CHIN | to keep his tongue out of air passage. |
| BLOW | air through nose or mouth (or both) until his chest rises. |
| LISTEN | for snoring and gurgling - signs of throat obstruction. |
| REPEAT | 10 - 20 times per minute. |

**Continue Rescue Breathing Until He Breathes For Himself.**

For literature, films, training suggestions; Write Health Research, Inc., 666 N. Elm Street, Buffalo 3, New York.

Rescue Breathing Card, showing both sides.