Current Comment

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GADGETS

Halothane Analyzer

Mr. Alfred Robinson and Drs. J. S. Denson and Frank W. Summers in Los Angeles describe the development and application of a clinical instrument for the specific measurement of halothane (Fluothane) concentration, based on the ultraviolet absorption of this molecule. Previously reported methods of analysis, such as gas chromatography and infrared spectrophotometry, are too cumbersome and expensive for routine clinical use in the operating room. Kalow described an ultraviolet absorption method for halothane analysis in 1957.*

Theoretical considerations of the halothane molecule predict ultraviolet absorption in the region of 2500 Å. The ultraviolet absorption spectrum of halothane was determined with a Cary Model 14 spectrophotometer. The beginning of the ultraviolet absorption edge for halothane was found to be 2700 Å. From further studies, the only other volatile or gaseous anesthetic agent found to have a similar absorption spectrum was trichloroethylene at 2625 Å. (table 1). Nitrogen, oxygen, carbon dioxide, helium, and water vapor all show absorption below 2000 Å., and, therefore, would not interfere with analysis of halothane.

A source of ultraviolet radiation suitable for analysis in the absorption spectrum of halothane was sought. It was noted that the position of the mercury emission line was at 2537 Å. Most of the radiation from a standard mercury resonance germicidal lamp, such as the General Electric G4T4, is at 2537 Å. This lamp is sturdy, relatively inexpensive, and readily obtainable in many electrical supply houses. The ultraviolet absorbency of halothane and trichloroethylene at 2537 Å. was determined to be 0.7 and 1.25 per atmosphere, respectively (fig. 1).

Based on the above data, a simple photometer prototype instrument was constructed for the continuous analysis of halothane (figs. 2 and 3). A G4T4 mercury resonance lamp was used as a source of 2537 Å. wavelength ultraviolet light. Radiation from this source passes through a Pyrex analysis cell to a photoelectric tube. The current from the phototube is proportional to the ultraviolet energy passing through the sampling cell and received by the phototube. Since mercury arc light sources may be somewhat unstable, a second phototube is used to measure emission of the source. A small constant voltage transformer adds stability to the entire circuit by eliminating minor fluctuations in powerline voltage. With this photometer circuit, the difference between the currents in the comparison phototube is a measure of the halothane in the sampling cell. This difference is kept so small that the difference approximation to Beer's Law will be valid. The instrument design is essentially an application of Beer's Law, which states that the relation between the concentration of an absorbing molecule, the length of path, and the proportion of the energy (in this case ultraviolet), absorbed, is expressed by $I = Ioe\text{-}bcx$, where Io and I are the intensities of the energy before and after absorption, x is the path length, c is the concentration, b is the absorbency expressed consistent with the units used, and e is the base of natural logarithms. If the ratio of I to Io is kept above 0.8, the difference approximation to Beer's Law $Io\text{-}I = bcx$ will be accurate within less than 1 per cent.

The only electronics required are impedance matching between the small currents in the phototube and the current required for a milliamp meter. This matching is accomplished with a simple cathode follower using a reasonably low grid current tube. Initial zero balance of the meter and circuit is accomplished by adjusting the size of the aperture between the source and the com-

* Kalow, W.: Canad. Anesth. J. 4: 384, 1957.

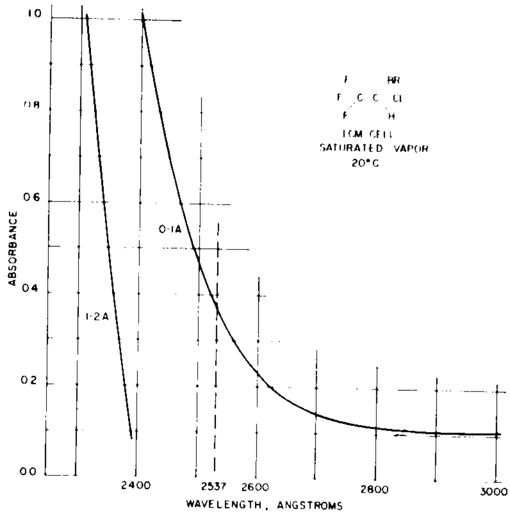
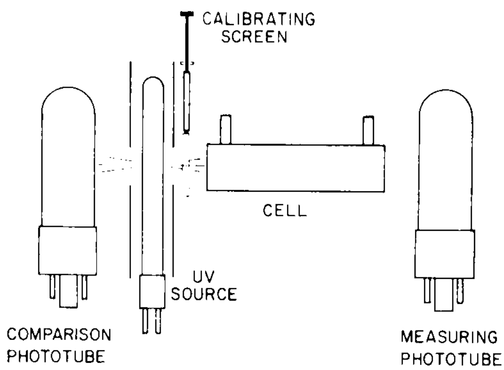


FIG. 1. Ultraviolet absorption spectrum of halothane.



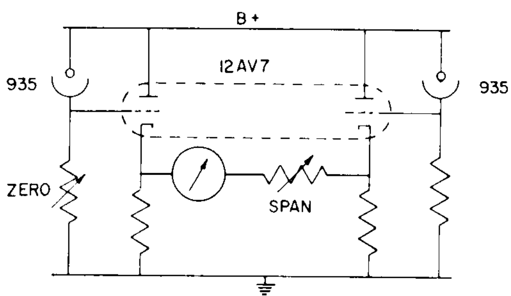


FIG. 2. Circuit diagram—halothane analyzer.

parison phototube. Subsequent adjustment of the analyzer zero calibration is effected by varying the cathode load of the comparison phototube. The meter span adjustment is made by varying a resistor in series with the meter.

Beer's Law states that the portion of the total energy removed by a given concentration of gas (halothane) is defined by the gas cell length and the absorbency of the gas (halothane). Therefore, calibration can be effected using a neutral density plate or screen. The halothane equivalent of the calibration screen was established by comparing the deflections caused by the screen with known concentrations of halothane. Halothane concentrations were determined for calibration purposes by temperature-vapor pressure relations. The calibration screen was arranged for insertion into the sample cell beam to give the equivalent absorption of 2 per cent halothane. The calibration could be checked at any time by flowing air through the cell and resetting the meter zero. Then, with air still in the cell, the calibration screen is inserted and the span set to cause the meter to read the known equivalent of the calibrating screen. The analyzer response to halothane has been linear from 0 to 2.5 per cent full scale. Adjustment of the controls to extend the range to 5 per cent halothane introduced a few per cent error at the center of the scale.

The entire electronics were designed to minimize the effect of powerline voltage power fluctuations. Additional stability was provided by the constant voltage power transformer.

The milliamp meter scale was calibrated to read halothane concentration from 0 to 2.5 per cent with 0.1 per cent increment markings.

An initial 15 minute warm-up period is necessary to establish temperature equilibrium within the analyzer case. Drift after the warm-up period has been found to be negligible. The prototypes were constructed for continuous operation and can be left on for months without affecting the response of the analyzer.

In use, a sample is drawn through the analyzer cell by any source of suction. A small "fish bowl" type suction pump was incorporated in a second prototype for convenience. Response to any change in halothane concentration begins almost immediately. The time required to reach a steady state is dependent upon the cell volume and the rate at which the gas sample is drawn through it.

The response is complete by the time two cell volumes have flushed the cell. In the prototype the cell volume is 15 cc. With this volume approximately 100 cc./minute is required for a complete response in 20 seconds; at a flow rate of 30 cc./minute a gradual smooth response will be noticed immediately with equilibrium to the new concentration in approximately one minute. Lower flow rates can be used if longer response times can be tolerated.

Since the analyzer is essentially a molecule counter, any difference in pressure between the anesthesia circuit and the cell would introduce a proportional error. Therefore, the pressure drop in the cell was kept to less than one-half centimeter of water at 100 cc./minute. This maintained the pressure in the cell close to that in the anesthesia system.

Gas samples taken from anesthesia rebreathing circuits may be saturated with water vapor above the ambient conditions. Fortunately, enough heat is provided from the electronic components to raise the temperature of the cell above the dew point and prevent condensation of moisture on the analyzer cell windows.

Halothane in the intense radiation from a mercury resonance lamp decomposes in the presence of oxygen. Decomposition products included bromine and possible hydrogen chloride. While the reaction is not sufficiently rapid to effect analysis, the production of even small quantities of these irritating decomposition products prevents returning the sample to the system.

With adequate calibration, the analyzer can be used for continuous monitoring of trichloroethylene concentration. Here, too, decomposition products do not allow return of the sample to the breathing circuit.

TABLE 1. Agents

	Start of UV Absorption Edge	Absorptivity per Atmos.
Gases		
Cyclopropane	None above 2000 Å.	at 2537 Å.
Ethyl chloride	2325	
Nitrous oxide	2250	
Vapors, saturated at 20° C.		
Chloroform	2350 Å.	
Ethyl ether	2300	
Fluoromar	2250	
Fluothane (halothane)	2700	0.7
Penthrane	2150	
Trilene	2325	1.25
Vinethene	2475	

Curves run on Cary Model 14 spectrophotometer

FIG. 3. Front view—halothane analyzer.

The sampling tube may be placed anywhere monitoring of concentration is desirable, depending upon clinical techniques and flow rates. Monitoring at the mouth piece or rebreathing bag has been most useful. Concentrations of halothane delivered directly from the anesthesia machine or vaporizer are subject to surprising variation with movements of the machine, or "back-pressure" from positive pressure respiration. The latter effect is most pronounced with low flow rates or closed circuit.

Further work will be necessary to refine the mechanics of the prototypes, but the instrument has been found to be rugged and reliable in clinical situations.

Modification of Laryngoscope Blade

Dr. John C. Snow of the Massachusetts Eye and Ear Infirmary in Boston notes that the standard laryngoscope blades possess certain disadvantages in difficult intubations. The Macintosh blade is less useful than the Wis-Foregger or Miller blade. With the Wis-Foregger blade it is sometimes impossible to raise the visualized epiglottis. He has had greater success with the Miller blade, but in a few cases lack of space to pass the catheter through makes it difficult or impossible to intubate the visualized vocal cords.

In order to overcome these obstacles a new blade was designed, measuring 162 mm. in length, 15 mm. in width, and 15 mm. in height. The blade is curved 1 inch from the distal end and is provided with a rounded peak for raising the epiglottis. A semicircular groove with its concavity to the right provides a pathway for visualizing the larynx, permits passage of the catheter, and prevents obstruction of the view from bulging of the tongue or protrusion of a tooth into the lumen of the laryngoscope. Intubation is easier and more successful with this blade, in conjunction with a Sanders catheter, than with any other blade. Smaller size makes it very useful in infants and children.

This new blade, he believes, will facilitate intubation without trauma, not only where there is normal anatomic relationship of the upper respiratory passages, but especially, where the patient possesses anatomic variations or pathologic conditions which render difficult or impossible endotracheal intubation with the laryngoscope now available.