halothane in the "aqueous" part of the blood rise high enough to interfere with this continuous movement of halothane from the oil droplets.

Again, according to the physical law of partial pressures and to the pressure gradient, the aqueous-dissolved halothane must appear in vapor phase in the lungs, and also move into the tissues of the body. Now the halothane is present in three phases (oil dissolved, aqueous, and gaseous).

Because of the small amount of halothane used, the "aqueous" blood level cannot be maintained high enough for anesthesia if the gaseous phase is lost by respiration. Therefore, the subject must be on a closed carbon dioxide absorbing system to maintain anesthesia with the dosages used. Apparently some equilibrium is reached between the rebreathed vapor phase and the aqueous phase in the blood. This is evidenced by the rapid awaking of the animals when the closed system was discontinued.

If this animal work is repeated by other investigators, it is hoped that measurements can be made of the amount of halothane in the aqueous phase of the blood with the oil droplets separated, and of the amount of halothane in the vapor phase in the lungs. We were not equipped to do these measurements.

Summary. This method of intravenous injection of known amounts of halothane provided a potent, but easily controlled anesthesia in dogs. The anesthesia could be lightened quickly, by changing from the closed rebreathing system to a nonrebreathing system. We believe that this method merits repetition in animals and with other oil-soluble agents (10 per cent ether-Lipomul mixture is easily prepared), and if satisfactory, a cautious trial in patients.

Lipomul and partial financial support was provided by the Upjohn Company. Halothane (Fluothane) was provided by Ayerst Laboratories. This study was presented at the Annual meeting of The American Society of Anesthesiologists, Inc., New York, New York, October 6 1960.

GADGETS

Alarm Device for Respirators

Dr. Karol Hoffmann, M.D. of the Baltimore City Hospitals notes that with the use of any positive pressure respirator complications must be recognized promptly if death from interrupted ventilation is to be prevented. Moment to moment observation of each patient by trained personnel although desirable, is not always possible. The constant monitoring of ventilation in a respirator center therefore had to be improvised.

An alarm system was devised, primarily for use with fixed volume piston respirators, to detect changes in the mean pressure between the nonrebreathing valve and the tracheotomy tube.

The following complications lead to a *decrease* in the mean pressure at the tracheotomy tube: (1) power failure; (2) mechanical failure of respirator; (3) obstruction of connecting tube; (4) leakage, *e.g.*, accidental disconnection of tubings, excessive leakage around tracheotomy tube, leaking valve.

The following complications lead to an *increase* in the mean tracheotomy tube pressure: (1) partial or complete airway obstruction at the tracheotomy tube or in the bronchial tree, for instance due to secretions; (2) decreased lung-thorax compliance; (3) accidental increase in stroke volume in fixed volume respirators or in pressure of pressure sensitive respirators.

Description of the "Vent-Alarm." The basis of this alarm system lies in the transformation of pressure changes within the breathing tubing into movements of a bellows, which in turn triggers an electrical alarm circuit. The "Vent-Alarm" is connected via a plastic tubing to a 13 gauge needle inserted into the tubing between the nonrebreathing valve and the tracheotomy tube, as close as possible to the nonrebreathing valve (in order also to permit recognition of a kink in the tube leading to the tracheotomy). The "Vent-Alarm" consists of 2 components:

A Pressure Sensitive Bellows with a Delaying Mechanism: The bellows expands with increased pressure. The delaying mechanism includes a one-way valve to permit unrestricted pressure transfer into but not out of the bellows and an adjustable needle valve to retard the air escape and thus the pressure drop in the bellows with each respiratory cycle. If the duration of the pressure drop at the tracheotomy tube exceeds a preset time interval (should be set for 2 to 3 respiratory cycles) sufficient air leakage occurs through the adjustable needle valve to trigger the alarm through microswitch no. 1.

A movable rod is attached to the mobile end of the bellows. The motion of the bellows produces an axial motion of the rod. The motion of the rod is opposed by a hinged lever, attracted by an adjustable magnet. When the pressure in the bellows exceeds the attracting force of the magnet, further axial motion of the rod occurs, which closes the alarm circuit at microswitch no. 2. Varying the angle of the magnet in relation to the iron plate permits adjustment of the attracting force. The attracting force is calibrated empirically on a scale in terms of airway pressure.

Electrical Alarm Circuit: Either of 2 levers fixed to the movable rod may close the alarm circuit. Microswitch no. 1 is activated when the pressure transmitted to the bellows within the preset time interval approaches atmospheric pressure (*i.e.*, decrease of mean pressure). Microswitch no. 2 is activated when the pressure rises and exceeds the preset value. A 6-volt dry battery provides power for a light and a bell. A switch is used which can be set for "off," "light only," or "light and bell."

Use with "Fixed Volume" Respirators. The "Vent-Alarm" has been in continuous use for 6 weeks with the Moerch piston respirator. When some of the previously mentioned complications occurred, the device never failed to signal promptly. There was no false alarm provided the device was adjusted correctly to the patient's pressure requirements and deliberate air leakage (*e.g.*, the minimal leak at the tracheotomy cuff to permit the patient to talk). The needle valve and the lever for changing the attracting force of the magnet had to be adjusted for each patient. When higher inflation pressures became necessary (for instance when pulmonary complications occurred) the peak triggering pressure had to be increased. Increased airway resistance due to excessive bronchial secretions triggered the alarm system several times and thus made prompt tracheo-bronchial suctioning possible. A significant increase in lung-thorax compliance and a decrease in airway resistance, an advantage rather than a complication, would also trigger the alarm system, but was never seen if tracheobronchial suctioning preceded the setting of the alarm. When properly adjusted, significant leaks which impaired ventilation triggered the alarm, but small and constant leaks did not trigger the alarm.

Use with "Flow Sensitive" and "Pressure Sensitive" Respirators. We have used the alarm system only occasionally with the "flow sensitive" Bennett respirator. Significant leakage (*e.g.*, deflated cuff, accidental disconnection of tracheotomy adaptor) or power failure promptly triggered the alarm. Obstruction in the patient's tracheotomy tube or bronchi produced some pressure rise which however was usually insufficient to trigger the alarm.

The alarm has not been used with "pressure sensitive" respirators (Bird, MSA, Emerson). Dr. Hoffmann expects, however, the same performance of the alarm as with the "flow sensitive" respirator, *i.e.*, signaling of a pressure drop (leaks and power failure), but not

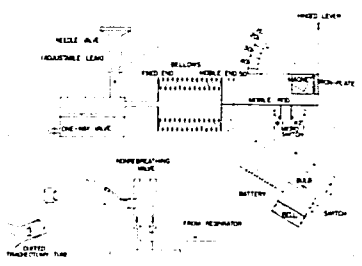
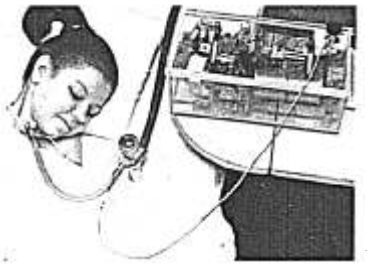


Diagram of alarm device.



Alarm device connected to respirator tubing.

of a pressure rise and therefore no signaling with bronchial obstruction.

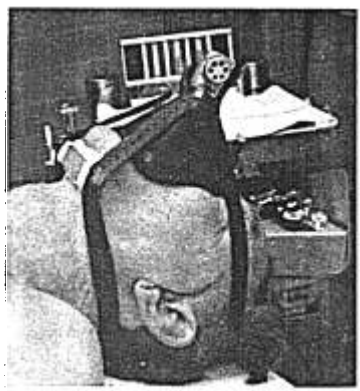
An increase in pulmonary and airway resistance during the use of "pressure sensitive" respirators leads to a decrease in tidal volume, while the peak pressure remains about the same. With "flow sensitive" and "pressure sensitive" respirators the alarm should be connected as closely as possible to the tracheotomy tube (in contrast to the fixed volume respirator) in order to permit signaling also when there is an obstruction in the tube leading to the tracheotomy.

Summary. The "Vent-Alarm" is recommended for use with fixed volume respirators. If used with "flow sensitive" and "pressure sensitive" respirators the most commonly seen failures, namely accidental disconnection and power failure will be signaled because of a decrease in mean pressure. Obstruction between the tracheotomy tube and the alveoli however will not be signaled, because it does not cause a pressure rise.

Chin Holder

Dr. Edwin M. Fuller of Derby, Connecticut, has found an inexpensive "chin holder" (as illustrated) useful for many years. Four wooden tongue depressors are taped together with one-inch adhesive. Two 2×2 or 3×3 sponges are used as padding. A more "deluxe" model can be made using sponge rubber for padding with a washable cover. An oral airway is usually in place, and for the edentulous patient, moistened "tape pads" may be used to fill out the cheeks to give an airtight fit to the mask.

This gadget should not be used in order to remove the anesthetist from contact with the patient. Dr. Fuller assumes the anesthetist will be assisting the patient's respirations with one hand and the "holder" will merely free the other hand *from time to time* to check and record vital signs, etc.



Inexpensive chin holder.

Simple Esophageal Stethoscope

Dr. Robert E. Ploss of Berkeley, California, reports that a simple esophageal stethoscope can be made from a Bardex 24 or 26 French Foley type catheter with either a 75 or 100 cc. balloon (no. 113-75 or 113-100). These catheters have a thick rubber fluted ovoid balloon that is very resistant to repeated cleaning with detergents. They have a very long life. The main catheter channel is plugged, and the stethoscope connection made to the balloon.

Expedient for Leaking Cuff

Dr. Robert E. Ploss of Berkeley, California, reports also that emergency inflation of a leaking endotracheal tube cuff can be accomplished by use of an air displacement rig made from two 1,000 cc. bottles and used intravenous tubings. The same problem can be solved by a balanced escape "Y" line from a room air pressure source. Either system can be practical when replacement of the tube or packing of the pharynx is impossible or impractical.

Manufacturers of the equipment described in this column may be obtained from ANESTHESIOLOGY, J. B. Lippincott Co., East Washington Square, Philadelphia 5, Pa.

CORRESPONDENCE

Monitoring During Anesthesia

To the Editor.—Since the condition and hence the requirements of the anesthetized patient tend to change from moment to moment in response to changes in depth of anesthesia, pulmonary ventilation, blood volume, cardiovascular tone, body temperature, position and many other factors, it is essential that the anesthesiologist constantly reevaluate the physiological status of his patient. To do this the anesthesiologist has traditionally relied upon three of his senses: touch, sight and hearing, and a few primitive accessory instruments, including a watch, a sphygmomanometer, and stethoscope. Anesthesia modifies and often masks vital signs, and in particular normal responses to stress. Traditional methods of observation frequently detect trouble late or after the patient is already in jeopardy. Additional sources of information are required to provide earlier warning of incipient danger.

Many new devices intended to monitor physiological functions have become available to the clinical anesthetist in recent years. Some of these have been outgrowths of development in the physiological research laboratory, others owe their origin to the new science of astronautics, and still others represent the frantic inventions of harried clinicians, seeking to ease the burdens of their responsibility. Almost all of these inventions have received reasonable clinical trials. Only a few have gained acceptance of any significant magnitude. It seems worthwile to consider some of the reasons for these failures and to contemplate solutions to problems of design of clinical monitors based on the demands imposed by patient care in the operating room.

The usefulness of the information transmitted to the anesthesiologist by a physiological monitor is determined by several factors: how representative of the parent function is the parameter being detected, *e.g.*, digital pulse volume versus cardiac output; the success with which the transducer or detection device samples the behavior of the patient, and nothing else; the fidelity and effectivenesss with which the display system projects the function toward the anesthesiologist; the intelligence of the physician in translating the signals of the monitor; and finally the willingness of the physician to make use of the instrument and rely upon its output. A study of the natural history of representative monitors in the operating room revealed commonly recurring causes for failure determined by all of these factors. The last two deserve special consideration. It is relatively easy for the physician to reject an instrument with the explanation that it is not trustworthy, that it presents useless information or that it is inconvenient to use. Engineers are competent to design equipment to perform according to clearly stated specifications. They are not competent to define the specifications appropriate to the monitoring of physiological functions of anesthetized patients being cared for in an operating room in a form convenient and intelligible to an anesthetist because they have had no experience with these things. The physician must learn how to make his needs known to the engineer.

Few anesthesiologists possess the skills necessary to define their needs. In order to improve their ability to assist in the design