oxygen, divinyl ether (Vinethene) in concentrations of 4–12 per cent, chloroform in concentrations of 0.5–3.0 per cent, and trichloroethylene (Trilene) in concentrations of 0.5–3 per cent.

The experimental methods have been described in detail in our previous publication. Control tracings were obtained for each animal, the test drugs applied intravenously or by inhalation and the effects on the evoked potentials in midbrain and thalamus recorded. In some instances, a relaxant and a volatile agent were observed sequentially in the same animal; however, no two relaxants were studied in the same animal.

The muscle relaxants were studied in 32 animals and were found to have no consistent effect on the amplitude or the conduction latency in either the periaqueductal midbrain reticular formation or the posteroventrolateral thalamic nucleus, provided that hypotension, hypothermia and hypoxia were avoided. The volatile agents were studied in nineteen animals and were found to depress both the midbrain and thalamic potentials, particularly the midbrain, in a manner similar to the gaseous agents. In the concentrations studied, the effect was most striking with ethyl ether and chloroform, somewhat less with divinyl ether and least with trichloroethylene. Cardiac arrhythmias and hypotension were a frequent problem with chloroform and, to a lesser extent, with trichloroethylene.

The results indicate that the volatile anesthetics depress the evoked potentials studied in the central nervous system of the cat while the muscle relaxants, even in extremely large intravenous doses, had no such effect.

The Design of Circle Absorbers. JAMES O. ELAM, M.D., Department of Anesthesiology, Roswell Park Memorial Institute, Buffalo, New York.

SEVERAL factors determine the optimal dimensions and features of an efficient, low-resistant carbon dioxide absorber.

Convenient Service Interval.—The period of service before the absorber will require a recharge with fresh absorbent should be appropriate to the anticipated schedule of maximal usage, for example we assume continuous or intermittent use of the absorber in a closed circle for eight hours.

Patient's Respiratory Parameters.—The average-to-maximal expected tidal volume for adults is 0.5 to 1.0 liter. Carbon dioxide output rates range from 12 to 18 liters per hour. Thus, during the eight hours of use, the average-to-maximal expected load in absorption would be about 100 to 150 liters of carbon dioxide.

Capacity and Apparent Density of Absorbent.—In a well-designed lime compartment, free from channeling, 100 g. of soda lime (either Indicating Soda Lime or Sodisorb) or Baralyme absorb about 15 liters of carbon dioxide before the exit gas exceeds one per cent. Therefore, about 870 g. of absorbent are required for the eight hour performance. This amount of lime fills a compartment of one liter volume.

Void Space of Absorbent in Relation to Tidal Volume.—As the pores in the lime granules are filled with water, only the voids or spaces between the granules relate to the accommodation of the patient's expired volume. The void space of lime is 47 per cent of its total volume. Thus, the one liter compartment filled with lime will accommodate a tidal volume of 470 cc.

However, as the lime becomes converted to carbonate, spaces between inert granules contribute no exposure to absorbing surfaces and the effective void space recedes during use of the adsorbent at a rate of about 60 cc. per hour. If the recommendations of Adriani and Rovenstine are to be followed literally, the patient's tidal volume exceeds the void space as soon as absorption begins. The problem of keeping the void space of the lime equal to the patient's tidal volume suggests the addition of a reserve absorber equal in size to the one in primary use. Then, as the void space of the first absorber approaches zero, the second reserve absorber can provide an effective void space equal to the patient's tidal volume. This and other rationale suggest the advantage of a two-chambered lime compartment with each chamber of about a liter in volume.

Resistance to Airflow.—The specific resistance, K, of 4–8 mesh absorbent is of the order of 1 mm. of water per liter per minute. The resistance, R, to airflow of an absorber packed with absorbent will depend upon the velocity, $\dot{V}$, of airflow and upon the length, L, and effective cross sectional area, A, of the absorber. This relationship may be expressed by the equation:

$$R = \frac{K L \dot{V}}{A}.$$

For an absorber with a lime compartment of 2 liters ($L \times A$), the resistance R is less than 1 cm. of water at 60 liters flow per minute, if the length of the combined chambers is less than 18 centimeters and if the diameter is greater than 12 centimeters.

Elimination of Channelling.—Unless this step is taken, most of the foregoing considerations become meaningless. The more complex the shape of the lime compartment, the more difficult becomes the task of distributing the airflow uniformly through all the absorbent bed. The simple cylindrical shape has advantages both in this regard and in the machining incident to fabrication. A small space at the top of the lime compartment is worthwhile to serve as a distributor. Otherwise, airflow, introduced from the expiratory circuit, tends to favor certain paths and by-pass absorbent at the top of the compartment.

Where the absorbent granules cannot interdigitate with other granules at the plane surfaces along the wall of the compartment, a lesser resistance to airflow in these areas results. This preferential pathway of flow must be diverted to avoid bypassing the central mass of absorbent. This is easily accomplished by the use of annular rings at intervals along the wall from top to bottom. Unless these baffles are employed, the estimates of lime depletion from color change in its indicator are sacrificed and a transparent absorber offers little advantage.

Other Recommended Features.—The provision of a space at the bottom of the absorber between lime and the bag or inspiratory circuit is important particularly during closed system use. This space which serves as a condenser and collector for water spares the dependent layers of the lime from becoming waterlogged and prevents the formation of a hard cake in the absorbent.

Transparency of the lime compartment walls permits rational predictable use of the absorber without carbon dioxide leakage at any time. The scheme of counter current extraction implies that, at the time of servicing the absorber, partially used lime is advanced toward the zone of greatest load (where expired air enters) and fresh absorbent is added to make final contact with expired air, removing the last traces of carbon dioxide from the gas stream. This cycling of the two chambers of absorbent insures complete removal of carbon dioxide not only at the start but throughout the period of use.

Variations in design featuring airflow from the bottom of the absorbent bed to the top offer no advantages and present several unnecessary problems.

Symmetrical design of the upper and lower halves of the two-chambered absorber makes for simplicity in design, convenience in servicing, and insures that enough moisture is retained in the absorbent to insure efficient performance in carbon dioxide absorption.

Studies on Ventilation and Circulation During Surgery Using a Volume Displacement Ventilator.

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Respiratory and cardio-circulatory studies were made during surgical anesthesia using a calibrated volume displacement ventilator designed by one of the authors (B. E.). This apparatus possesses the following characteristics: a calibrated and adjustable volume displacement bellows to permit accurate tidal exchange of gases; a manually