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A Mechanical Respirator as an Adjunct to Closed System Anesthesia.*

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The average operating room makes no provision for mechanically maintaining artificial respiration in patients during operation. In the absence of adequate pulmonary ventilation, other resuscitative measures are generally of little value in advanced respiratory or cardiac failure.[1] Such accidents are sufficiently common in the operating room to warrant a carefully organized plan for resuscitation and especially to include in this plan a method of artificial respiration for the surgical patient.

During the past 2 years a mechanical respirator, of a type commonly used in physiological laboratories for the intermittent insufflation of compressed air down a tracheal catheter, has been kept available on the operating floors of the University Hospitals. During this period of time the respirator has been successfully used in 4 cases of acute cardio-respiratory failure and might have been successful in several other cases if the artificial respiration could have been instituted more promptly. This fact aroused the interest of the author in developing a simple, dependable mechanical respirator as an integral part of the commonly used anesthesia machines.

Since the introduction of carbon dioxide absorbing technic and the use of a tight fitting face mask, creating a closed lung-bag system, the simplest effective method of artificial pulmonary ventilation in the event of inadequate spontaneous respirations is by rhythmic manual compression of the rebreathing bag. Utilizing this principle, the following apparatus was constructed.† (Fig. 1.)

The rebreathing bag of the anesthesia machine is enclosed in a rigid airtight container, B, made of pyralin, a nonbreakable plastic, and it is attached to the soda-lime canister A, in this case, of a Heidbrink anesthesia machine. Air under pressure, from any source 8, is intermittently injected into the space between the rigid container

* Aided by a grant from the Alumnæ Association of the University Hospitals School of Anesthesia, Cleveland, Ohio.

1 Mautz, Frederick R., PROC. SOC. EXP. BIOL. AND MED., 1937, **36**, 634.

† This apparatus was built by Mr. Morris Dann of the Department of Pharmacology of the Western Reserve University School of Medicine. The injector unit C was designed and has been built since 1928 by Mr. Dann.

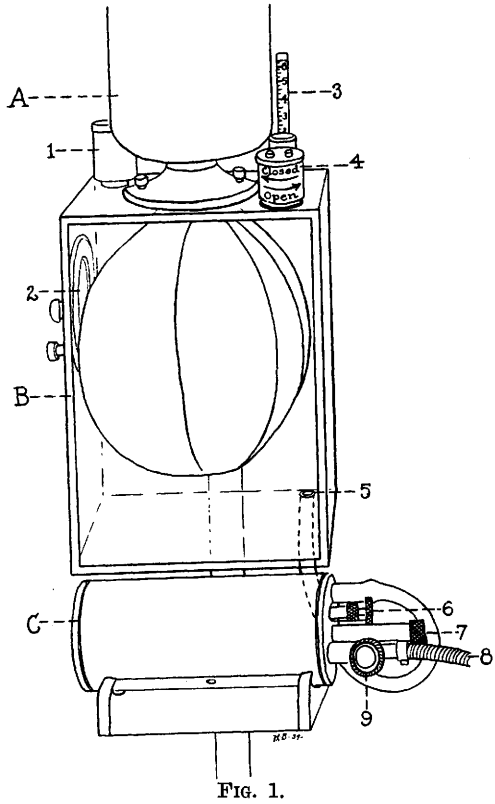

FIG. 1.

and the rebreathing bag through inlet 5 which can be controlled as to rate and volume by valves 9 and 6. Between injections the space around the bag is automatically opened to the atmosphere through the exhaust valve 7. A mercury manometer, 3, measures the pressure developed around the rebreathing bag. A safety pop-off valve, 1, prevents the development of excessive pressures. A removable window, 2, gives easy access to the rebreathing bag. A hand controlled exhaust valve, 4, makes it possible to open the space surrounding the bag to the atmosphere and thus completely eliminate the compressing effect of the injector, even though it be in operation. This valve acts to engage or disengage the respirator mechanism at will and if just slightly opened it gives a delicate control of peak pressures developed during the air injection. This control makes it possible to bring the respirator into use in a fraction of a second without any change in equipment. The pneumatic control of bag compression is extremely flexible and easy to regulate.

This respirator attachment has been used clinically on a number of

patients both with chest intact and also in the presence of an open pneumothorax. With chest intact the intermittent pulmonary inflations are accepted without a struggle providing the patient's respirations are only moderately depressed and even though the inflations are not synchronous with spontaneous respirations. The air volume of the rebreathing bag and pyralin container acts as a buffer for any transfer of force from a source of compressed air to the lung. In the presence of a free airway and a tight fitting face mask no tracheal catheter is necessary; however, it may be desirable in many situations to have an intratracheal catheter in place, since if there is obstruction air might be injected into the stomach. However, with a free airway and pressures not in excess of 15 mm Hg this did not occur in our cases.

This apparatus would seem of particular value in open pneumothorax. We have had an opportunity to use the respirator in several patients with open pneumothorax and found a very satisfactory, readily controlled expansion of the lung, with the maximal pressure not exceeding 10 mm Hg, less pressure being required in the presence of open pneumothorax than with the chest intact to produce a given exchange.

With this arrangement the surgeon can produce a bilateral open pneumothorax and yet maintain any desired degree of pulmonary ventilation. In open pneumothorax there was no difficulty due to failure of the lung to collapse between inflations. This is a strong argument against the need of suction, as is used in some commercial resuscitators. In the presence of fluid in the air passages this should be removed by means of catheter suction. Under such circumstances there might be a distinct hazard to positive pressure insufflation in spreading infection to normal lung, but of course in respiratory failure even this would not contraindicate the use of such a respirator.

Simultaneously with this study Crafoord[2] in Sweden was using intermittent pulmonary insufflation in a large series of pneumonectomies. The mechanical arrangement for accomplishing this was different but in principle the arrangement is essentially that incorporated in this simplified apparatus. There are opportunities for further mechanical development of this principle so as to make such a respirator available in operating rooms that do not have compressed air lines. The present apparatus would run several hours on a large cylinder of oxygen or compressed air.

2 Crafoord, C., *Acta chir. Scandinav.* (supp. 54), 1938, **81**, 1.