A SIMPLE IMPROVEMENT IN THE EMO VAPORIZER

BY

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SUMMARY

The brass-cylindered rotor of the EMO not infrequently "freezes" in the machine's aluminium rotor well. A one-piece Teflon rotor has been fabricated. As Teflon is self-lubricating, the modified rotor should never bind. Being of one-piece construction, the settings will never change.

The EMO (Epstein, Macintosh, Oxford) ether vaporizer has received worldwide acceptance as a simple thermo-compensated anaesthetic apparatus. Equipped with a Penlon bellows and a non-rebreathing valve, safe ether-air or methoxyflurane-air anaesthesia can be administered with this machine in almost any geographical location.

An extensive bibliography of clinical papers related to the use of this apparatus is not indicated in this communication. Mention of references to its use, or anticipated use, in disaster areas or war theatres (Khandekar and Rama Rao, 1965; MacKay, 1965; O'Connor, 1961) is indicated, as such use demands a machine that is resistant to rust and dust, corrosion, or inactivation of moving parts. Although the EMO may have a reputation for reliability in Great Britain, the rotor tends to "freeze" in some of the units when used in the United States (Elam, J., 1967, personal communication; Rendell-Baker, L., 1965, personal communication; Stetson, J. B., 1963, personal experience), Viet Nam (Brown, A., 1966, personal communication), and other countries (Stetson et al., 1966). The author has modified the rotor in an attempt to eliminate the possibility of binding or "freezing".

The main, and practically only, mechanical moving part in the EMO is the rotor (fig. 1). It is perhaps best described as a variable vapour-mixing chamber. By turning the control pointer of the EMO, the rotor is also turned. As the rotor turns, a greater or lesser amount of ether (or methoxyflurane) vapour is allowed to enter the mixing chamber.

Fig. 1
Cross-section schematic of the EMO. The rotor walls in the factory machine are of brass as shown in fig. 2. In this illustration, the concentration control pointer is at 5%. (Modified from, Ghose, R. (1964), *Ethiop. med. J.*, 2, No. 3.)
DESCRIPTION OF ROTORS

The rotor rests in a well cut into the aluminium main casting of the vaporizer. The rotor appears to be cut from brass tubing and mounted on a lightweight alloy metal disc. It must be very difficult to manufacture perfectly circular rotors. A second lightweight metal piece is locked to the top of the rotor unit by a brass locking unit (fig. 2). A steel rod runs through the brass locking unit and rests on a ball bearing set in the bottom of the aluminium well.

When placed in the well, the brass rotor rubs on aluminium. The manufacturer advises pure petroleum jelly as lubricant. This produces a bearing surface of two soft metals lubricated by a material that is soluble in most anaesthetics. To adjust the rotor properly, it is set in the well, the concentration control pointer placed over the rotor (held in place by spring dowels shown in figure 3), and the pointer placed at the figure “1” of the “10%” mark. Gap sizes are then checked with a special tool (fig. 4). Vertical adjustment is effected by screw A which is locked by nut B. This moves the steel rod that rests on the ball bearing. Angular adjustment is provided by slackening three steel Allen screws C and D. Screw C is a clamp only; those marked D have coned ends and by slackening one slightly and tightening the other, fine adjustments of the pointer can be obtained. In practice, it has been found that the spring dowels offer some play, so fine movements of the pointer do not always result in movement of the rotor. When the rotor becomes bound due to loss of lubricant, corrosion, dust, lacquers, or other causes, the steel Allen screws cut the soft metal (aluminium or aluminium alloy) disc that carries the brass rotor. The top soft-metal unit will then no longer be in proper relationship to the soft-metal disc holding the brass rotor. As the steel Allen screws soon cut channels, a tremendous amount of play develops in the pointer.

A simple solution was obtained by fabrication of a one-piece Teflon rotor (performed by Mr. Alexander McInnes, Research Instrumentation Laboratory, Indiana University Medical Center). The rotor is cut 0.001 inch oversize in diameter. The necessary air and vapour channels are vented into a solid piece of Teflon (fig. 5). As the Teflon rotor rotates in the bottom of the well, no ball bearing is necessary. For final manufacture, the cylindrical unit can be placed in the well and the correct location of the vapour channel (in terms of vertical adjustment) scribed with a cutting tool.

The interior is viewed through the outlet channel. In fig. 1, the outlet channel is on the left side of the rotor. The vapour channel (lower right of rotor, fig. 1) in the rotor of the actual machine also acts as the air dilutor inlet. In the schematic diagram, the air dilutor inlet appears in the upper right part of the rotor as a separate port or channel. This is only true when the machine is on the “20 Vol. %” mark and a 1/2-inch port in the rotor faces the air dilutor inlet. The large spring on the right of the figure fits into the top of the unit under the concentration control pointer. It supplies a constant pressure on the rotor, the steel rotating shaft, and ball bearing (not shown). Spring dowels hold the two-piece rotor in proper position in the concentration control pointer. This spring has been omitted in fig. 1.
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The concentration control pointer demonstrating location of spring dowels (E) shown in fig. 2. Screws C and D are steel Allen screws. Screw A and nut B lock the steel rotating shaft at proper height in the factory rotor unit. The steel rotating shaft can be seen inside the rotor in fig. 2.

A second method of fabrication is to cut the vapour channel with the rotor oversize in length. The rotor can then be placed in the well, the extent of over-length error measured, and that length of Teflon faced off the bottom of the rotor on a lathe. After vertical adjustment, the rotor is placed in the well for angular adjustment. The channels are aligned so all gaps are proper width. The pointer is slipped over the one-piece rotor pointing to the “1” of the “10%” marking. Scribe marks are placed on the rotor to indicate the proper location of the dowels. The dowel channels are then cut. After cutting dowel channels, steel rather than spring dowels are used to eliminate play. The new unit is self-lubricating, has no play, and being of one-piece construction, should not change calibration.

When venting the channels, cuts were not directed at right-angles to the wall of the unit (that is, toward the centre axis of the cylinder). As the walls of the Teflon rotor are thicker than the walls of the brass rotor, cuts are directed toward the expiratory port to give a channel that is wider at the inside wall of the Teflon rotor. With the original unit, removal of the rotor, especially when there was binding, was difficult. Leather, lead, or aluminium strips were necessary to prevent plier marks on the soft metal of the unit. Locking nut B for screw A had limited access. With the new Teflon unit, a simple spring tool fits into the top of the unit. The ends of the tool fit in holes bored in the unit and the rotor lifts out with a twisting motion. Actually, with the new rotor, there should be little necessity to remove the rotor.

When the pointer is on 20%, there is one hole in the rotor facing the air dilution inlet (size \( \frac{7}{16} \) inch). With the Teflon rotor, due to its thicker wall, the hole will probably allow less diluting air to enter the unit. On the half-dozen EMO inhalers tested with a gas chromatograph, 20 per
cent ether vapour has never been obtained (15 per cent ether vapour strength is common on a 20 per cent setting). Although it was anticipated that the thicker wall of the Teflon rotor would reduce the diluting air stream and increase the accuracy of the rotor when on the "20%" mark, results were confusing. During gas chromatographic studies, at 15°C the improved rotor delivered more methoxyflurane vapour than two standard factory units tested. This was again true at 25°C with a 10 l./min linear flow of air. At a linear airflow of 14 l./min, the factory-rotor-equipped machines supplied slightly more methoxyflurane vapour than the improved unit! At 35°C the factory units supplied more methoxyflurane vapour. The improved unit did show a smaller variation with temperature change. Why this result was found is unknown.

The proposed modification has been criticized (Sugg, B. R., 1966, personal communication) for removal of the original adjustment system.

The basic reason for the rectangular ports in the rotor is that it is possible to adjust the calibration of the high and low ends of the scale individually, the former by setting the angular position of the rotor and the latter by adjusting its vertical position. It is necessary to have this form of adjustment to deal with the variations in characteristics which resolve during production and also to meet the specialized requirements for calibration under unusual conditions; for example, at low flows for work with children, and at high flows for veterinary use.

The author feels that although the modified rotor cannot be changed once calibrated, certainly one cannot want less than zero per cent vapour for paediatric use, and the new rotors can go to zero. During veterinary use in large animals, a tremendous amount of volatile agent must be vaporized. Even with thermocompensation, the EMO cannot provide enough vapour for prolonged large animal operations unless it is set in a hot water bath. The water in the unit's water jacket is rapidly cooled as the large tidal volumes vaporize substantial amounts of agent. It is possible to set two vaporizers in tandem and thereby increase vapour strength.

The rotor was cut from solid Teflon and no attempt was made to fabricate a Teflon liner for the well or rotor. The coefficients of expansion of Teflon and aluminium are such that the oversize (0.001 inch) rotor should function satisfactorily at any temperature within human tolerance for surgical operations. Use of a liner would involve several coefficients of expansion and raise the danger of slipping unless pinned to the well.
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wall or rotor. Although a solid Teflon rotor would be more expensive to fabricate in Great Britain than in the United States, it is hoped the reduced number of steps for fabrication and fitting would offset the increased cost for materials.

REFERENCES


BOOK REVIEW

The editors of the “Anaesthesiology and Resuscitation” series are issuing as books the main subjects dealt with at the Meeting of the German, Swiss and Austrian Societies of Anaesthesia, held in Zurich in September 1965. This volume, on anaesthesia in emergency situations, consists mainly of individual papers. After a survey of medico-legal aspects a variety of subjects are covered, such as neurosurgery, barbiturate poisoning, shock, infusion and transfusion problems, pulmonary oedema, anaesthesia in patients who cannot be properly prepared, equipment of special emergency ambulances and the time- and life-saving use of helicopters for evacuation to hospitals. Almost all contributions have an English summary and most give bibliographies.

While many of the problems discussed are approached as they would be in English-speaking countries there are some different techniques which seem to be widely applied on the Continent: 40 per cent Sorbit is given for reduction of intracranial pressure, often in 10 per cent Rheomacrodex. Alkalization, which in cases of severe haemorrhage is attempted routinely by some though not accepted by others, is often achieved by THAM (trishydroxymethylaminomethane, Trispuffer), sometimes also infused in Rheomacrodex. Experiments in cats, brought into normovolaemic or hypovolaemic shock after burns, have shown that this substance reduces the vascular resistance in the kidneys. A formula for calculation of dosage in relation to body weight and base excess is given.

Papers of special interest include the experience that while the e.e.g. after cerebral trauma has little immediate value, its deterioration after initial improvement gives an almost hopeless prognosis. It should thus help to determine the chances of continued artificial respiration and nutrition. Though many authors use halothane in extreme emergency situations, one team of cardiologists, after experiments with dogs, maintains that it damages the metabolism of the myocardium, as shown by lengthening of the systole, enlarged ventricles, and reduction of the speed at which the maximal rise of intraventricular pressure is achieved. This effect is slight with 0.5 per cent halothane but considerable with 2 per cent. A case history of a young man, saved after rupture of the pericardium with subluxation of the heart, tears of one phrenic nerve and in liver and mesentery, rupture of spleen, and fractures of skull and leg, makes fascinating reading.

One Panel Discussion deals with anaesthesia in disasters like mine explosions or train derailments, with the emphasis on administrative problems, while the second considers special problems in cases of “acute abdomen”.

It would be of help to the English reader if in further issues generic names of drugs could be given together with brand names. Print, figures and lay-out are of the same good quality as in previous numbers of this series.

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