THE PRODUCTION OF STANDARD ATMOSPHERES OF VOLATILE ANAESTHETIC AGENTS BY A DIFFUSION DILUTION CELL

R. S. BARRATT, R. L. JONES AND J. M. THOMPSON

SUMMARY

The diffusion of a vapour into a gas provides a useful method for the preparation of standard atmospheres of the vapour. The construction and use of the apparatus for preparing these standards are described and the relevance of the method to research in anaesthetic practice is discussed.

In anaesthetic research there are several investigations which may require the use of a constant concentration of a volatile anaesthetic agent in a gas stream. For example, studies of air pollution in theatres, tests of anaesthetic equipment and measurements of partition data require standard atmospheres. In addition, the calibration and the assessment of the efficiency of humidifiers similarly require accurate mixtures of water vapour in air. In all instances the gas mixture should be prepared accurately and reproducibly by techniques that are simple to use.

The production of synthetic mixtures of gases of known composition involves the use of procedures that are less accurate than those for liquids because gases cannot be weighed easily and volumes may change during handling. Nevertheless, a number of methods are available for the preparation of gas mixtures with reasonable accuracy and such methods may generally be classified as static or dynamic. Static methods involve preparing and storing the mixture in a closed vessel such as a cylinder or a plastic bag. However, losses of sample on the walls of the vessel can cause errors and, in addition, only a limited volume of the standard mixture is available.

Dynamic systems can produce much larger volumes and there are less serious absorption losses because an equilibrium exists between the walls of the system and the flowing gas stream. One example of a dynamic system is flow mixing, in which the gas stream from a vaporizer, for example, is mixed with a diluent stream to give the desired concentration. A popular calibration method for pollution studies involves the use of permeation tubes. O'Keefe and Ortman (1966) have examined permeation tubes for several organic compounds including halothane.

A particularly useful dynamic method for preparing mixtures of vapours in gases involves diffusion of the vapour from tubes of precisely known dimensions. To our knowledge, this elegant method has not been used hitherto for anaesthetic vapours, although it has the advantage that it is an absolute standardization method.

The diffusion of vapour along a tube has been investigated for a long time and Altshuller and Cohen (1960) cite the work of Stefan in 1871. Since then other workers have determined diffusion data by the technique (Lee and Wilke, 1954; Gilliland, 1934; Gilliland and Sherwood, 1934). Fortuin (1956) developed the method for the production of low concentrations of a number of vapours and described the theoretical background to the technique. This method was also used by McKelvey and Hoelscher (1957). Altshuller and Cohen (1960) and Altshuller and Clemons (1962) applied diffusion cells to the preparation of standard mixtures of hydrocarbons and demonstrated the utility of the technique for air pollution studies. The response of a flame ionization detector was examined by Desty, Geach and Goldup (1960), who prepared their standards using this type of apparatus. Goldup and Westaway (1966) introduced trace amounts of water into a gas stream by a diffusion apparatus which was subsequently modified by Savitsky and Siggia (1972), to enable more rapid changes in concentration to be obtained. The application described in this present paper used apparatus based on the work of Savitsky and Siggia (1972).

APPARATUS

The design of the equipment was similar to that described by Savitsky and Siggia (1972) and is illustrated in figure 1. The component of interest is

R. S. BARRATT, B.SC., PH.D., A.R.I.C., Department of Chemistry, University of Birmingham, Birmingham B15 2TT. R. L. JONES; J. M. THOMPSON, M.SC., PH.D., Department of Anaesthetics, University of Birmingham, Queen Elizabeth Hospital, Birmingham B15 2TH.
The diffusion dilution apparatus. AA precision bore capillary tube; BB 8 mm o.d., 6 mm i.d. glass tubing; C screw-type tap; D water circulating pump; E thermometer; F screw connection; G sintered glass delivery tube.

introduced as a liquid into a precision bore capillary tube, AA (Jencons Scientific Ltd, Hemel Hempstead, Herts), maintained at a constant temperature (± 0.1 °C) in a water-jacket attached to a circulating water-bath (Grant Instruments Cambridge Ltd). Ground-glass joints (Quick-fit B60/46) were used in the construction of the gas chamber and in its junction with the water-jacket, while gas and water connections were made through threaded glass assemblies, F (Sovirel System, V. A. Howe & Co. Ltd, London). The diffusion tube, AA, was supported by connections made with these screw joints, F, and was fitted at one end with a “torion” valve, C (Sovirel System, V. A. Howe & Co. Ltd, London). The whole apparatus was supported securely on a rigid framework and measurements of the meniscus position in the capillary tube were made with a cathetometer. Stability of both this and the diffusion apparatus was essential. The gas diluent for the cell was oxygen-free nitrogen (British Oxygen Company Ltd), the flow of which was stabilized by a miniature line regulator after the two-stage regulator on the cylinder. A combination precision needle valve and flowmeter (Meterate Flowmeter, Glass Precision Engineering Ltd, Hemel Hempstead, Herts) has also been used. Flow rates were checked with a soap film flowmeter.

Measurements of the vapour concentrations were made using a Hewlett Packard Model 5713 gas chromatograph. This instrument incorporates a pulsed electron capture detector (63Ni, 15 mCi source) which is ideal for the determination of low concentrations of halogenated anaesthetic agents. Separations were carried out on either of two chromatographic columns. The first (10 ft × ½ in o.d. glass) was packed with 10% (W/W) di(2-ethylhexyl)sebacate on Universal support, 80–100 mesh (Jones Chromatography, Colliery Road, Llanbradach, Glamorgan), and was maintained at 105 °C. This column was suitable for the separation of halothane, trichloroethylene and methoxyflurane. The second column (15 ft × ½ in o.d. glass) was packed with 10% (W/W) silicone fluid, DC560, on Universal support, 80–100 mesh, and was maintained at 90 °C. This column did not resolve methoxyflurane from trichloroethylene, but gave more rapid elutions of halothane and trichloroethylene than on the first column. In all cases the carrier-gas was 5% methane in argon at 60 ml/min and the detector was maintained at 200 °C. Gas samples were introduced into the chromatograph with a gas-sampling valve (10 µl sample) which was installed upstream of the injection port. This installation caused some peak broadening owing to the relatively large dead volume between the injection site and the column, but this broadening was minimized on the silicone fluid column.

The output of the diffusion cell was connected to the gas sampling valve through a nylon tube; no adsorption errors were observed as a result of this method.

PRACTICAL CONSIDERATIONS

The apparatus incorporates a number of modifications to that described by Savitsky and Siggia (1972). The relatively large volume of liquid anaesthetic agent contained in the U-tube outside the glass water-jacket was susceptible to fluctuations in the ambient temperature which in turn caused the meniscus position to vary. Immersing the U-tube, BB, in a water-bath at the same temperature as the water-jacket eliminated this effect. Variations in the meniscus position were also observed if a glass tap was fitted in the U-tube; this effect was a result of the ability of the anaesthetic agents to flow past the tap. The use of a “torion minitap” (V. A. Howe &
Co. Ltd, London) or a "Rotaflo" stopcock (Jobling, Stone, Staffs) eliminated this problem.

Adjustment of the meniscus position may be made more rapidly when the U-tube is replaced by a capillary tube integral with a glass syringe. Such a device is illustrated in figure 5 and will be described later in this paper.

Finally, it is imperative to ensure that the capillary arm of the U-tube is made long enough for the cell to be assembled.

**DISCUSSION**

The basic principle of operation of the diffusion cell is simple. The liquid, the vapour of which is to be the contaminant of the gaseous phase, is contained in the capillary tube at a constant temperature and is allowed to evaporate slowly into the flowing gas stream; the driving force is the concentration gradient of the vapour in the tube (Altshuller and Cohen, 1960). If the rate of diffusion of the vapour and the flow-rate of the gas stream are known, the concentration of the vapour in the gas can be calculated. Diffusion rates can be determined by weighing the capillary tube before and after a given time period to give the weight of vapour discharged. However, it is far more convenient to measure the change in position of the liquid meniscus in the capillary.

Desty, Geach and Goldup (1960) derived an expression for the determination of the diffusion rate knowing the diffusion coefficient, \( D \):

\[
S = (DMPA/RT) \ln \left( \frac{P}{P - \rho} \right)
\]

where

- \( S \) is the rate of diffusion of vapour out of the capillary tube (g sec\(^{-1}\)),
- \( M \) is the molecular weight of the vapour,
- \( R \) is the gas constant (erg deg\(^{-1}\) mole\(^{-1}\)),
- \( T \) is the absolute temperature of the capillary tube (°K),
- \( A \) is the cross-sectional area of the diffusion tube (cm\(^2\)),
- \( l \) is the length of the diffusional path: the distance between meniscus and the end of the capillary tube (cm),
- \( P \) is the pressure in the diffusion cell: at the open end of the capillary,
- \( \rho \) is the partial pressure of vapour at temperature \( T \).

The authors showed that the rate of diffusion could be determined experimentally also and this method is now illustrated for halothane, although it is equally applicable to other volatile anaesthetic agents.

The method involves observing the change in the liquid level over a period of several days and the variation of the square of the diffusional path length is plotted as a function of time, \( t \). This should give a straight line at a constant temperature as shown in figure 2, and the gradient of this line, \( X \), is given by the equation:

\[
X = \frac{2DMP}{RT\rho} \ln \left( \frac{P}{P - \rho} \right)
\]

where \( \rho \) is the density of the liquid at temperature \( T \).

Thus the rate of diffusion at a given instant can be calculated when \( X, \rho, A \) and \( l \) are known. The bore of the capillary tube can be obtained from measurements of the length of a weighed amount of mercury in the tube.

Once the gradient of the \( l^2 \) versus \( t \) line has been determined by either Gaussian or linear regression analysis, the rate of diffusion of vapour for different positions of the liquid meniscus can be calculated from equation (3). Some typical values for halothane...
are presented in table I and these data allow the concentrations of vapour in the gas stream to be determined. Figure 3 shows the variations of halothane concentration in the gas flowing out of the cell as functions of the meniscus position at different temperatures. These concentrations were calculated for a gas flow rate of 20 ml/min, but obviously different flow rates can be used to give the desired vapour concentration. Altshuller and Cohen (1960) suggest that flow rates above 1-2 litre/min may cause

### Table I. Rates of diffusion of halothane for different diffusion path lengths

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient ($X$) of $l^2$ versus $t$ line (cm$^3$/sec)*</td>
<td>$3.33 \times 10^{-4}$</td>
<td>$4.33 \times 10^{-4}$</td>
<td>$6.44 \times 10^{-4}$</td>
<td>$8.62 \times 10^{-4}$</td>
<td>$1.44 \times 10^{-3}$</td>
</tr>
<tr>
<td>$\rho_T$ (gm/ml)</td>
<td>1.857</td>
<td>1.843</td>
<td>1.829</td>
<td>1.815</td>
<td>1.801</td>
</tr>
<tr>
<td>$A = \pi(0.0646)^2$</td>
<td>$1.311 \times 10^{-2}$</td>
<td>$1.311 \times 10^{-2}$</td>
<td>$1.311 \times 10^{-2}$</td>
<td>$1.311 \times 10^{-2}$</td>
<td>$1.311 \times 10^{-2}$</td>
</tr>
<tr>
<td>$(XAP_T)/2$</td>
<td>$4.06 \times 10^{-6}$</td>
<td>$5.23 \times 10^{-6}$</td>
<td>$7.72 \times 10^{-6}$</td>
<td>$1.03 \times 10^{-5}$</td>
<td>$1.71 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rate of diffusion (g/sec)</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>$l = 2$ cm</td>
<td>$2.03 \times 10^{-5}$</td>
<td>$2.62 \times 10^{-5}$</td>
<td>$3.86 \times 10^{-5}$</td>
<td>$5.13 \times 10^{-5}$</td>
<td>$0.853 \times 10^{-5}$</td>
</tr>
<tr>
<td>4</td>
<td>$1.01 \times 10^{-5}$</td>
<td>$1.31 \times 10^{-5}$</td>
<td>$1.93 \times 10^{-5}$</td>
<td>$2.56 \times 10^{-5}$</td>
<td>$0.426 \times 10^{-5}$</td>
</tr>
<tr>
<td>6</td>
<td>$0.676 \times 10^{-5}$</td>
<td>$0.872 \times 10^{-5}$</td>
<td>$1.286 \times 10^{-5}$</td>
<td>$1.71 \times 10^{-5}$</td>
<td>$0.284 \times 10^{-5}$</td>
</tr>
<tr>
<td>8</td>
<td>$0.507 \times 10^{-5}$</td>
<td>$0.654 \times 10^{-5}$</td>
<td>$0.964 \times 10^{-5}$</td>
<td>$1.28 \times 10^{-5}$</td>
<td>$0.213 \times 10^{-5}$</td>
</tr>
<tr>
<td>10</td>
<td>$0.406 \times 10^{-5}$</td>
<td>$0.523 \times 10^{-5}$</td>
<td>$0.772 \times 10^{-5}$</td>
<td>$1.03 \times 10^{-5}$</td>
<td>$0.171 \times 10^{-5}$</td>
</tr>
<tr>
<td>12</td>
<td>$0.338 \times 10^{-5}$</td>
<td>$0.436 \times 10^{-5}$</td>
<td>$0.643 \times 10^{-5}$</td>
<td>$0.883 \times 10^{-6}$</td>
<td>$0.142 \times 10^{-5}$</td>
</tr>
<tr>
<td>14</td>
<td>$0.290 \times 10^{-5}$</td>
<td>$0.374 \times 10^{-5}$</td>
<td>$0.551 \times 10^{-5}$</td>
<td>$0.737 \times 10^{-6}$</td>
<td>$0.122 \times 10^{-5}$</td>
</tr>
<tr>
<td>16</td>
<td>$0.234 \times 10^{-5}$</td>
<td>$0.327 \times 10^{-5}$</td>
<td>$0.482 \times 10^{-5}$</td>
<td>$0.664 \times 10^{-6}$</td>
<td>$0.107 \times 10^{-5}$</td>
</tr>
<tr>
<td>18</td>
<td>$0.225 \times 10^{-5}$</td>
<td>$0.291 \times 10^{-5}$</td>
<td>$0.429 \times 10^{-5}$</td>
<td>$0.547 \times 10^{-6}$</td>
<td>$0.095 \times 10^{-5}$</td>
</tr>
<tr>
<td>20</td>
<td>$0.203 \times 10^{-5}$</td>
<td>$0.262 \times 10^{-5}$</td>
<td>$0.386 \times 10^{-5}$</td>
<td>$0.501 \times 10^{-6}$</td>
<td>$0.085 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

* Values of $X$ derived by Gaussian analysis. † Assuming constant radius, irrespective of temperature.

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![Fig. 3. Calibration curve calculated from experimental data with halothane in the diffusion apparatus. Capillary tube diameter 0.1292 cm; air flow rate 20 ml/min.](https://academic.oup.com/bja/article-abstract/47/11/1177/258949?by_guest)
Table II. Typical values for the slope of the $I^2$ versus $t$ line for anaesthetic agents under different experimental conditions

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>I*</th>
<th>I†</th>
<th>I*</th>
<th>I*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube</td>
<td>A</td>
<td>B</td>
<td>C+ syringe</td>
<td>A</td>
</tr>
<tr>
<td>Bore (cm)†</td>
<td>0.1292</td>
<td>0.1944</td>
<td>0.2025</td>
<td>0.1292</td>
</tr>
<tr>
<td>Flow rate (ml/min)</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Anaesthetic agent</td>
<td>Halothane</td>
<td>Halothane</td>
<td>Halothane</td>
<td>Trilene</td>
</tr>
<tr>
<td></td>
<td>Methoxyflurane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>$3.38 \times 10^{-4}$</td>
<td>$3.48 \times 10^{-4}$</td>
<td>$3.43 \times 10^{-4}$</td>
<td>$6.58 \times 10^{-4}$</td>
</tr>
<tr>
<td>30</td>
<td>$4.57 \times 10^{-4}$</td>
<td>$4.38 \times 10^{-4}$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>35</td>
<td>$6.41 \times 10^{-4}$</td>
<td>$6.39 \times 10^{-4}$</td>
<td>—</td>
<td>$1.07 \times 10^{-4}$</td>
</tr>
<tr>
<td>40</td>
<td>$8.86 \times 10^{-4}$</td>
<td>$9.02 \times 10^{-4}$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>45</td>
<td>—</td>
<td>$1.35 \times 10^{-3}$</td>
<td>$1.46 \times 10^{-3}$</td>
<td>—</td>
</tr>
<tr>
<td>50</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>$2.98 \times 10^{-4}$</td>
</tr>
<tr>
<td>60</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>$1.79 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

* Gaussian analysis of data. † Analysis of data by linear regression programme. ‡ Measured at 20 °C.

different laboratories using different sets of apparatus. Thus the method seems reliable for use in collaborative studies. Repeated analysis of the gradient of a single $I^2$ versus $t$ line gave a coefficient of variation of about ±3%. It is important to note that slight differences in the measured gradient have an insignificant effect on the final vapour concentration.

In this respect it may be useful to examine how variations in the parameters of equation (3) affect the value obtained for $S$, the mass rate of diffusion. The gradient of the $I^2$ versus $t$ line is influenced by the temperature of the liquid; a drift of 0.1 °C in the temperature setting, at 35 °C, would produce a change of $5 \times 10^{-6}$ cm$^2$ S$^{-1}$ in a measured gradient of $6.44 \times 10^{-4}$ cm$^2$ S$^{-1}$. This is a change of the order of 0.8% in $X$. Where the temperature fluctuates by ±0.1 °C, rather than drifting in a particular direction, this makes merely for an uncertainty in the measured gradient as described earlier. The uncertainties in the liquid density value are of two types: (i) those arising from temperature fluctuations and the errors in temperature measurement in the experiment and (ii) those arising from the uncertainty in the best available published values of the density as a function of temperature. Errors in the meniscus height and capillary cross-sectional area can be made very small by accurate measurements with a vernier cathometer for length measurements and an accurate balance for weighing the mercury used in area measurement. The overall error equation for $S$ based on equation (3) is

$$\frac{\Delta S}{S} = \sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta \rho}{\rho}\right)^2 + \left(\frac{\Delta A}{A}\right)^2 + \left(\frac{\Delta l}{l}\right)^2}$$

The concentration of vapour required for a particular application can now be obtained by various manipulations once the initial calibration is complete. The variable parameters at a given temperature are the length of the diffusion path, the flow rate of the diluent gas and the bore of the capillary tube. In addition, the cell temperature can be changed, but this requires calibration at the new temperature. Of these parameters the diffusion path length is the most convenient to change and it was for this purpose that Savitsky and Siggia (1972) produced their design. Lee and Wilke (1954) showed that the vaporization rate of nitrobenzene into air reached 99.92% of the steady-state rate in 15 min and this suggests that equilibrium is reached quite rapidly. However, it is normal practice to leave the cell working continually so that the assumption of steady-state diffusion is valid. After changing the diffusion path length, Savitsky and Siggia (1972) demonstrated that the return to an equilibrium state occurs in a reasonable time for water in the diffusion tube, and the present work has shown that similar behaviour occurs for halothane as shown in figure 4. The equilibrium is reached soon after changing the meniscus level and the output of the cell agrees with the theoretical value derived from the analysis of an equivalent amount of halothane injected into the gas chromatograph as a solution in n-hexane. The fluctuations about the concentration level "A" may be the result of inadequate temperature control but it is also possible that the effect arises from turbulence owing to the relatively high flow rate (400 ml/min) and the short diffusion path length.

Now, despite the advantages of the present design of the apparatus, it is difficult to set the meniscus level to a desired position. Figure 5 illustrates a modification to the diffusion tube to facilitate this adjustment. The bottom of the capillary tube is
Fig. 4. The re-establishment of equilibrium after a change in the diffusion path length. Capillary tube diameter 0.1292 cm; air flow rate 400 ml/min; temp. 25 °C. A response to $9.1 \times 10^{-10}$ g of halothane equivalent to a diffusion path length 6.759 cm. B diffusion path length changed. C response to $3.3 \times 10^{-10}$ g halothane equivalent to a diffusion path length 17.888 cm.

Fig. 5. Modified diffusion tube. A precision bore capillary tube; B screw connection; C mercury seal; D anaesthetic liquid; E syringe; F screw; G fixed bracket; H rotating hand wheel.

joined to a glass syringe which contains mercury, C, to prevent leakage of the anaesthetic liquid, D, past the plunger, E. The syringe plunger can be moved by small increments using the screw, F, and large disc, H, or alternatively a micrometer device (for example, Agla micrometer syringe system) may be used. In this way it is possible to make fine adjustments to the meniscus position. With this system there is little anaesthetic agent outside the main water-jacket so that temperature control is much easier than for the previous system. Some data obtained with the device are included in table II (column 3).

The complete calibration system when used in conjunction with the analyser system gave a coefficient of variation of ± 2.6% on 25 analyses and this is perfectly acceptable considering that manual integration was used for the chromatographic analyses. The precision in resetting the thermostat is a limiting factor in the repeatability of the system on start-up.

APPLICATIONS OF THE TECHNIQUE

The diffusion cell is obviously suitable for the preparation of standard atmospheres of many volatile anaesthetic agents. We have used such a cell for the production of low concentrations of halothane, trichloroethylene and methoxyflurane in air as calibration standards in studies of operating theatre pollution by these volatile anaesthetics. Similar concentrations may be required in the examination of contamination or leakage of anaesthetic equipment (Robinson, Thompson and Barratt, 1974), a matter that must be considered with regard to the controversial subject of postoperative jaundice following
STANDARD ATMOSPHERES OF VOLATILE AGENTS

However, the wide range of concentrations that can be produced makes the technique equally suitable for preparing standards to calibrate anaesthetic vaporizers. Similarly, the efficiency of humidifiers may need to be established (Hayes and Robinson, 1970) and water vapour standards can be prepared in a diffusion cell (Goldup and Westaway, 1966; Savitsky and Siggia, 1972).

Blood-gas partition data can also be determined by exposing blood to an atmosphere containing the known concentration of anaesthetic produced by the cell. Preliminary studies of this aspect have been made with the apparatus illustrated in figure 6.

![Blood equilibration vessel](image)

**Fig. 6.** Blood equilibration vessel. A sintered glass delivery tube; B mercury seal; C magnetic stirrer follower; D magnetic stirrer; E silicone rubber septum.

Blood is contained in the glass vessel which is surrounded by a water-jacket to produce a constant temperature environment. The gas stream is admitted to the chamber through a sintered glass tube, A, while the blood is agitated gently by a magnetic stirrer, C and D. Samples of blood can be withdrawn from the apparatus by a syringe through the septum, E, which is isolated from the blood by a mercury seal, B. In this way, loss of anaesthetic agent into the silicone rubber septum is avoided. A typical partition coefficient of 2.34 was obtained for blood with a red cell count of $3.4 \times 10^6$ mm$^{-3}$ after being exposed for 3 hr to air containing halothane at a concentration of $1.2 \times 10^{-3}$ g/litre at 37°C.

In conclusion, it can be said that a diffusion dilution apparatus offers many advantages for use in work in anaesthetic research, enabling preparation of absolute standard atmospheres of volatile anaesthetic agents and of water over a wide concentration range in a reliable, convenient and reproducible manner.

**ACKNOWLEDGEMENTS**

The authors are grateful to the Medical Research Council, the Birmingham Regional Hospital Board and Imperial Chemical Industries (Pharmaceutical Division) for financial support. The authors also wish to express their appreciation to Professor J. S. Robinson (Anaesthetics Department), Professor R. Belcher (Chemistry Department) and Dr W. I. Stephen (Chemistry Department) for their interest in this work.

**REFERENCES**


La diffusion d'une vapeur en un gaz constitue une méthode utile pour la préparation des atmosphères standards de la vapeur. Les méthodes de construction et d'emploi de l'appareil pour la préparation de ces standards sont décrites dans cet article et on y traite de l'applicabilité de cette méthode pour procéder à des recherches sur les pratiques courantes en matière d'anesthésie.

DIE HERSTELLUNG VON STANDARD-ATMOSPHÄREN FLÜCHTIGER NARKOSEMITTEL DURCH EIN DIFFUSIONS-VERDÜNNUNGSGERÄT

ZUSAMMENFASSUNG

LA PRODUCCION DE ATMOSFERAS NORMALES DE AGENTES ANESTESICOS VOLATILES POR MEDIO DE UNA CELULA DE DIFUSION POR DILUCION

SUMARIO
La difusión de un vapor en un gas proporciona un método útil para la preparación de atmósferas normales del vapor. Se describen la construcción y el uso del aparato para la preparación de esos medios y se analiza la utilidad del método para la investigación en prácticas de anestesia.