A SURVEY OF WASTE ANAESTHETIC GASES IN HOSPITAL OPERATING THEATRES, DENTAL AND VETERINARY SURGERIES

J Crea PhD C Grygorcewicz PhD

Industrial Hygiene Section
Occupational Health & Radiation Control Branch
Public & Environmental Health Division
South Australian Health Commission
Hines House 61 Hindmarsh Square Adelaide S.A. 5000
Telephone 218 3465

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PREFACE

In the mid seventies a considerable volume of literature on health effects of trace concentration of anaesthetic gases and vapours to the health of operating theatre personnel, were published in the United States, United Kingdom and Europe. The health hazards were defined as foetal wastage and abnormality, mutagenesis, liver disease and deterioration in skilled performance of personnel. These claims were based mainly on epidemiological studies and to a lesser extent on animal research.

In Australia, the National Health and Medical Research Council (NH&MRC) acknowledged the existence of possible hazards to personnel in operating theatres. In 1977, the NH&MRC established a Working Party on the Hazards of Exposure to Anaesthetic Agents, in collaboration with the Hospital and Allied Services Advisory Council (HASAC).

The terms of reference for the Working Party were to:
"Investigate and advise HASAC and the NH&MRC through the Medicine Advisory Committee, on:

* the hazards to staff working in operating theatres and other areas subject to atmospheric pollution by anaesthetic gases; and

* action which should be taken to safeguard such staff from those hazards."

In carrying out the above terms of reference, the extent of waste anaesthetic gas pollution was examined by monitoring in hospital operating theatres, dental and veterinary surgeries over a period of two years, from 1978 to 1979, in South Australia.

In conjunction with the monitoring, the effectiveness of various scavenging systems was assessed together with recommendations for controlling waste emissions.

The data collected from this survey was used by the NH&MRC to establish "target values" in Australia. The target values are based on what can be achieved by good work practice and not on health effects. The "target concentrations" are 25ppm nitrous oxide, and 0.5ppm halogenated anaesthetic agents.

SUMMARY

Evidence suggests that chronic exposure to trace concentrations of anaesthetic vapours and gases constitute a health hazard to operating room personnel.

The South Australian Health Commission through the Operating Theatre Pollution Advisory Committee, initiated a monitoring programme in order to:

- assess the occupational exposure to waste anaesthetic vapours and gases in hospital operating theatres, veterinary and dental surgeries in South Australia and
- recommend "Control measures" for the control of occupational exposure to waste anaesthetic agents to the lowest achievable concentration until enough information is gathered to set a TLV (Threshold Limit Value). The "achievable concentrations" adopted by South Australian Health Commission are:

    * Nitrous Oxide 25 ppm
    * Halothane (and other Halogenated anaesthetic agents). 0.5 ppm

A total of 40 hospitals (comprising of 155 operating theatres and labour wards), 26 veterinary surgeries and 25 dental surgeries were monitored at least once.

The most common administered inhalation anaesthetic agents are nitrous oxide and halothane (2-bromo-2-chloro-1,1,1-trifluoroethane). Therefore the measurements of pollution levels are based mainly on these substances. Measurements were taken at the breathing zone of the person administering the anaesthetics, as it was considered that this person would be exposed to the highest concentrations, due to his proximity to the source of the emission.

The concentration of these agents were measured using Wilks Infrared-direct-reading Analysers.

In the Hospital Operating Theatres, breathing zone concentration of anaesthetic agents ranged from 0.2 ppm - 26 ppm halothane and 10 ppm - 1100 ppm nitrous oxide, depending on the extent of control measures adopted.

In Dental Surgeries, nitrous oxide concentration during the use of relative analgesia, ranged from 180 ppm - 1800 ppm in the breathing zone of the dentist under poor control measures (i.e., no scavenging and poor ventilation in the room). Under scavenging conditions the nitrous oxide concentration was between 12 ppm and 180 ppm (using Brown Scavenging Mask). Another scavenging system produced higher environmental concentrations.

In the Veterinary Surgeries the concentration of waste anaesthetic agents in the breathing zone of the surgeon, under no scavenging conditions, ranged from 0.3 ppm to 17 ppm halothane, and 200 ppm to > 300 ppm nitrous oxide. The higher concentrations were measured in large animal practices. With scavenging (only 5 of the 26 surgeries) the halothane concentration ranged from 0.4 ppm to 2 ppm.

Realising that our knowledge of the health hazards associated with waste anaesthetic agents may not be complete at this stage, the philosophy of good occupational hygiene practice should be adopted i.e., minimize the risk to exposed personnel. A systematic and practical approach to the problem as outlined will reduce the exposure to waste anaesthetic agents to below the "target concentration" of 25 ppm nitrous oxide and 0.5 ppm halothane. The correct approach is based on the following measures:

1. An efficient scavenging system.
2. Regular maintenance of the scavenging and anaesthetic equipment.
3. Co-operation from the anaesthetist in the application of efficient techniques.
4. Effective room ventilation.
5. Air monitoring programme.

The study demonstrated that the most obvious causes of room air contamination are related to <u>work practice</u> and attitudes of the persons directly involved in administering the anaesthetic agents. Therefore a much more concerted effort is required in the application of good work practices from these persons if anaesthetic pollution levels are to be maintained within "achievable levels."

RECOMMENDATIONS

1. Scavenging equipment should be installed and used in operating theatres and surgeries which administer anaesthetic agents.

2. A member of staff should be made responsible for the regular maintenance of the scavenging equipment and anaesthetic machine, in accordance with the "Manual for the Control of Anaesthetic Gas Contamination in the Operating Theatre".

3. A greater awareness on health hazards associated with anaesthetic pollution, should be undertaken by <u>all</u> staff involved with anaesthetics, by introducing more extensive education programmes.

4. A more extensive survey should be conducted in order to determine the time weighted average exposure by <u>all</u> personnel exposed to waste anaesthetic agents.

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CHAPTER 1

HEALTH HAZARDS IN THE OPERATING THEATRE

1.1 Introduction

In the past few years there has been considerable concern about the health hazards associated with the exposure to waste anaesthetic gases.

The alleged health risks are infertility, foeto-toxicity, teragenicity, carcinogenicity, hepatic renal disease and central nervous system (C.N.S.) lesions. (Ref. 1-13).

Evaluation of the potential hazards has been carried out by both epidemiological and animal experimental research. Nitrous oxide and halothane are the anaesthetic agents predominantly used.

A brief summary of the current studies on anaesthetic pollution.

1.2 Animal Studies

Early animal studies indicated the possibility of teratogenic effects due to inhalation of anaesthetic dose concentrations administered to pregnant animals during the gestation period.[14,15,16]

These studies reported increased foetal death rates and congenital abnormalities. Further, animal experiments have shown the embryotoxicity of trace concentrations of nitrous oxide[17] and a decreased survival rate on exposure to trace concentrations of fluroxene.[18]

Animal studies also indicate hepatic and renal damage following chronic exposure to subanaesthetic concentrations (i.e. concentrations in the vicinity of those to which operating theatre personnel may be exposed).[18,19,20]

Potential organ toxicity of inhalation anaesthetic doses is also well documented in man.[21-28]

It has also been shown that in animals exposed to low concentrations of halothane (8-12 ppm for 8 hours per day, 5 days per week) during their development significant behavioural abnormalities and C.N.S. damages occurred.[26]

Lane et al. (1979)[46] has shown that exposure of pregnant rats to high concentrations of nitrous oxide on the nineth day of gestation causes foetal resorption (16%, cf control 3%), foetal malformation (15%, cf control 1%) and skeletal anomalies (37% cf 12% control).

In summary there is convincing evidence from animal experiments that organ toxicity, fetotoxicity and carcinogenicity are caused by exposure to high anaesthetic concentrations, however, experiments at sub-anaesthetic concentrations are not as numerous nor as convincing.

1.3 Human Studies

Over the past 10 to 15 years, epidemiological studies of workers exposed to waste anaesthetic gases, tend to support the animal evidence of foetal wastage, congenital abnormalities and hepatic and renal disease. Major surveys carried out in Europe,[4,6,7] the United Kingdom[3,8] and United States,[1,2,5,10,12,13] have provided supportive statistical evidence, without however, demonstrating a cause-effect relationship.

The epidemiological evidence is based on retrospective surveys, which are often criticized because of the use of questionnaires which tend to promote recall bias in the exposed respondents. The response rates are also low (as low as 50%), hence the evidence is not ideal in the statistical sense.

The major studies concluded that the risk of spontaneous abortion and congenital abnormalities in offspring to female workers associated with anaesthetic practice is increased, and suggest that the first trimester of pregnancy is the most critical period.[1-7,30]

Some studies have also observed a high incidence of congenital abnormalities in children of exposed males (e.g. anaesthetists and dentists).[1,8,13,30]

There are several reports of anaesthetists developing an increased incidence of hepatic and renal disease following exposure to low concentrations of anaesthetic gases.[1,7,13]

The American Society of Anaesthetist's study[1] suggests that there is increased incidence of spontaneous abortion, congenital abnormalities, cancer, hepatic and renal disease in female operating theatre personnel.

The study on dentists[13] by Cohen et al. (1980) which entailed 61,000 study subjects, is possibly the most significant retrospective study. It is the final report of the preliminary study (1975) which was responsible for the N.H. & M.R.C.'s conclusion that "anaesthetic agents may be the causative factor."

The findings of this study were as follows:

(1) increase in liver disease was 1.7 fold, kidney disease was 1.2 fold, and neurological disease was 1.9 fold, in male dentists who were heavily exposed to anaesthetics;

(2) increase of spontaneous abortion (1.5 fold) in the wives of the male dentists;

(3) increase of spontaneous abortion (2.3 fold) in the chairside assistants. There was also an increase in liver disease (1.6 fold) and kidney disease (1.7 fold) among the female assistants.

There was no convincing increase in the risk of congenital malformations in children of dentists exposed to anaesthetic agents.

Response rate for this study was only 74%, therefore some bias could have occurred.

Several studies have reported an increase in the incidence of cancer in female anaesthetists.[1,9,10] However, recent in-vitro mutagenicity studies of halogenated ether anaesthetics have been negative except for fluroxene.[11]

Studies also indicate that acute exposure of anaesthetic gases effects the central nervous system. Vaisman [6] in a survey of the complaints of 303 female anaesthetists reported headaches, fatigue and irritability. Bruce et al.[31,32,33] showed that motor skills, perception and memory can be impaired in operating theatre staff. Although Smith and Shirley[34] (1977) could not reproduce these results, further work by Bruce et al.[35] (1976) reinforced their original findings and have demonstrated that nitrous oxide and halothane, in concentrations as low as 50 ppm and 1.0 ppm respectively, caused measurable decrease in performance in psychological tests in healthy volunteers. These effects were absent in subjects exposed to 25 ppm nitrous oxide and 0.5 ppm halothane. Fink and Cullen[36] suggest that stress may play an important role in the considered health hazards in operating theatres.

Vessey[37] (1978) reviewed the eight controlled epidemiological studies carried out to that time, and concluded that there was "reasonably convincing evidence of a moderate increase in the risk of spontaneous abortion among exposed females, although it is possible that even this result is attributable to reporting bias. There is no convincing evidence of any other hazard."

Also recent research studies have shown a significant increase in the rate of drug metabolism in anaesthetists.[38] There is strong evidence that the metabolism of fluorinated anaesthetics is responsible for direct renal toxicity[19], and increasing evidence points to anaesthetic metabolism as a mechanism of toxicity.[39,27] To date this evidence is more convincing at anaesthetic doses.

1.4 Summary of Current Evidence

Summing up the evidence available at the present time, a firm conclusion on the possible hazard to personnel exposed to trace concentrations of anaesthetic gases in the atmosphere of the work place cannot yet be reached. However, many overseas investigations are still in progress.

Although a conclusive cause-effect relationship could take many years to establish, one must conclude that a serious health hazard may exist from the vast amount of information published, and the health hazards discussed above can be attributed, at least in part, to exposure to waste anaesthetic gases. The evidence from the dental survey by Cohen et al.[13] (1980) strongly suggests a dose-response relationship and comes closer to establishing cause-effect. In this study, the exposed and unexposed dentists had a similar working environment and the only different factor was the use of inhalation anaesthetic. The main criticism of previous epidemiological studies apart from the doubtful validity of the retrospective study has been the large number of variables between the exposed and unexposed subjects, thus casting doubts on the validity of the study.

On the basis of the available animal and human data, the only occupational hazard associated with anaesthetic gases for which there is reasonably convincing evidence is an increased risk of spontaneous abortion. The other reported hazards may be actual, but, the evidence is inadequate to be regarded as conclusive. Serious consideration must also be given to other factors found in the operating theatre environment, such as stress, radiation, other toxic materials and viral and bacterial infections.

1.5 The Australian Situation

In Australia, the National Health and Medical Research Council (N.H. & M.R.C.) acknowledged existence of a possible hazard to workers in operating theatres, and took action to consider the "Australian situation" by establishing a working party in 1977. The working party comprised of consultants to the N.H. & M.R.C. and the Hospital and Allied Services Advisory Committee (HASAC).

The working party had two terms of reference, namely:

(1) to define the hazards to staff employed in the operating theatre and other work areas subject to atmospheric pollution by waste anaesthetic gases and vapours, and
(2) what action should be taken to safeguard them from such hazards.

Following the investigations by the working party the following conclusions and recommendations were made by the N.H. & M.R.C.[40]

(1) "It is ethically, scientifically and economically justifiable to instal in operating rooms, scavenging equipment of proper construction and reasonably uniform design as soon as possible

(2) A monitoring programme, appropriate to the case load and size of the institution, should also be adopted.

(3) Pregnant women should be informed that there may be a hazard to their pregnancy in the operating theatre environment, and be entitled to opt for alternative employment elsewhere in the Hospital.

(4) Dental surgeries in which anaesthetic gases and vapours are regularly used should also be scavenged.

(5) The levels of these agents shown to be present in recovery areas adjacent to scavenged theatres do not appear to constitute a significant hazard."

The findings of the N.H. & M.R.C. working party led to the South Australian Health Commission setting an Advisory Committee (Operating Theatre Pollution Advisory Committee) to produce a "Manual" for the control of anaesthetic gas contamination in the operating theatre. The Committee consisted of Professor Michael Cousins, the Head of the Department of Anaesthesia and Intensive Care, Flinders Medical Centre, and member of the N.H. & M.R.C. working party, specialist anaesthetists, scientists, members from the Health Commission, Public Buildings Department, and equipment officer from the Hospitals Department.

The manual[41] is now in use in all South Australian Hospitals and veterinary surgeries that use anaesthetic agents. This manual discusses the factors contributing to anaesthetic gas pollution in the operating theatre work area, presents a variety of methods for the detection and elimination of leaks, and points out the requirements for monitoring trace gas leaks in all exposure situations.

A similar manual was produced by the Industrial Hygiene Section of the Health Commission for dental surgeons who used nitrous oxide for relative analgesia.

CHAPTER 2

ANAESTHETIC POLLUTION SURVEY

2.1 Introduction

During 1978–79, a waste anaesthetic gas monitoring programme was initiated in this state in order to assess the occupational hazards in the hospital operating theatres, veterinary and dental surgeries. All hospitals were visited at least once by Mr. Colin Sandison, the administrative officer of the Operating Theatre Pollution Advisory Committee (OTPAC), on an educational programme, to advise about the need for the reduction of anaesthetic gas pollution in operating theatres. This initial educational programme was followed by a monitoring programme which involved measurements of the waste anaesthetic gases in the breathing zones of the operating theatre staff. Similar measurements were made in veterinary and dental surgeries.

2.2 Method of Measurement

The most commonly administered inhalation anaesthetic agents are nitrous oxide and halothane (2-bromo-2-chloro-1,1,1-trifluoroethane), therefore the measurements of pollution levels are based namely on these substances.

Measurements were conducted mainly in the breathing zone of the anaesthetist, the dentist and the veterinary surgeon, as it was considered that these would be exposed to the highest concentrations, due to their proximity to the sources of emission.

The concentration of nitrous oxide and halothane were measured using Wilks Miran Portable Infrared Analysers, because it allowed continuous monitoring whereby the sampling and analysis is nearly a simultaneous operation. The exposed personnel are then given immediate indication of their exposure and the efficiency of any antipollution control system. The Infrared Analysers are also very useful in detecting low and high pressure leaks in the anaesthetic machine, and therefore immediate action can be taken to rectify the problem.

The Infrared Analysers used for this survey were as follows:

MIRAN-101-N_2O Analyser

This is a specific gas analyser. It contains a fixed filter which sets the optical wavelength to a specific value (4.45 microns(u) for N_2O), has a fixed pathlength and is factory linearised and calibrated in parts per million (ppm) of nitrous oxide. The two scale ranges are set at 0–30 ppm and 0–300 ppm.

MIRAN–103–Halothane Analyser

The 103 range has the flexibility of interchangeable filters and meters scale sets for measuring a wide variety of gases. The Miran 103–Halothane analyser with a wavelength of 8.4 microns and pathlength of 13.5 metres, was set up to measure halothane in the range 0–10 ppm and 0–100 ppm.

MIRAN–1A Gas Analyser

It is a single beam, variable wavelength spectrophotometer, which can automatically or manually scan the infrared spectrum from 2.5 to 14.5 microns. The gas cell which is 5.6 litres in capacity, has variable optical pathlength of from 0.75 to 21.75 metres.

Reference 47 contains a study on the evaluation of these infrared analysers for monitoring waste anaesthetic concentrations, and includes sensitivity and reliability measurements, and calibration curves.

The Miran 101 and 103 were the analysers mainly used to monitor the anaesthetic agents in the hospitals operating theatres and veterinary surgeries. In the dental surgeries the Miran 1A was used to measure the nitrous oxide concentrations because of its higher concentration range.

The possibility of interference in gas analysis by Infrared spectroscopy must be considered. Carbon dioxide presents a strong absorption peak at 4.43 u, which is close to the nitrous oxide peak at 4.45 u. Moreover, water vapour has an absorption plateau that embraces the peaks from both the nitrous oxide and carbon dioxide. Therefore, the analytical errors attributable to carbon dioxide and water vapour were avoided by sampling away from the expired air stream of the personnel. Representative "breathing zone samples" were therefore measured a few centimetres from the side of the person's face.

Another interference problem was encountered with the Miran 103 – halothane analyser which has a fixed wavelength of 8.4 microns. At this wavelength ethanol and isopropanol, which are used as cleaning agents in the operating theatre, interfere with the measurements of halothane. Nitrous oxide was also found to interfere with the halothane measurement. All halothane measurements with the Miran 103, were corrected for any interfering gas or vapour.

Furthermore, the presence of other inhalation agents (e.g. ethrane, methoxyflurane) will lead to higher than expected halothane readings.

2.3 Sources of Anaesthetic Pollution

The main source of anaesthetic gas contamination in the hospital operating theatre, veterinary and dental surgery is leakage associated with the anaesthetic equipment and with the work practices of the person administering the anaesthesia. These pollution sources are discussed in detail in the following manuals;

"A Manual for the Control of Anaesthetic Gas Contamination in the Operating Theatre."[41], and

"A Manual for the Control of Anaesthetic Gas Contamination in the Dental Surgery."[42]

The main sources of anaesthetic pollution are summarised below:

2.3.1 Exhale Valve or Ventilator Waste Gas Outlet

The anaesthetic machine is adjusted to deliver more anaesthetic gases than the patient can absorb; these excess gases escape from the exhale value or ventilator waste gas outlet into the operating room, generally at a rate of up to several litres/minute.

This is the major source of anaesthetic pollution in the absence of scavenging.

2.3.2 Low Pressure Leaks

Leaks resulting from faulty, loose or worn fittings (e.g. connections and tubing) in the anaesthetic or Relative Analgesia (RA) machine, between the rotameter and patient.

2.3.3 High Pressure Leaks

These leaks may result from faulty joints and seals in the fittings between the source of nitrous oxide and the rotameter. Leaks from this area are responsible for elevated nitrous oxide levels even before anaesthesia is commenced.

2.3.4 Technique Errors

These include:

* turning the N_2O or halothane supply before the patient is connected to the circuit;

* using too high fresh gas flows, and high ventilation pressure while mechanically ventilating the patient;

* poor mask fit;

* faulty cuff or lack of pressure in the cuff;

* at the end of an anaesthetic, the breathing system is disconnected from the patient before the excess exhaled anaesthetic gases are flushed out with pure oxygen.

Such poor techniques in anaesthetic practice are responsible for the main contribution of the residual pollution after satisfactory scavenging has been installed.

2.3.5 Patients

* Dental surgery

  Because the only means of scavenging is from the nasal mask, potentially high nitrous oxide concentration leaks can result if the patient breathes through the mouth or is involved in conversation or laughter. Furthermore, the gas escaping from the patient's mouth is very close to the breathing zone of the dentist.

* Hospital - Recovery Rooms

  Exhalation of patients recovering from anaesthesia is a possible source of anaesthetic pollution. Significant levels are detected only within 20 to 30 cm of the patient's face, and then only for short duration provided the room is air conditioned.

2.3.6 Spillage of halothane (or any other inhalation anaesthetic) while filling vapourisers.

2.3.7 The scavenging system, if improperly installed or maintained, may be a source of gas leakage.

Methods for leak detections, correction, long term maintenance of the high and low pressure portions of the anaesthetic machine, and suggestions for minimizing pollution due to technique errors are outlined in the two "Manuals" mentioned above.

2.4 Occupational Health Standard for Nitrous Oxide and Halothane

When the Operating Theatre Pollution Advisory Committee delivered its report, it recommended the adoption of the NIOSH[43] recommendations, based on lowest achievable concentrations,

i.e. Nitrous Oxide 25 ppm
Halogenated Anaesthetics 0.5 ppm

As there is still inadequate data available on the dose-response relationship for worker exposed to waste anaesthetic gases, the N.H. & M.R.C. has not set or adopted a Threshold Limit Value for the two gases, instead it recommends a 'target concentration' based on what can be achieved by good practice. The target concentrations are those initially proposed by NIOSH i.e. as above.

2.5 Methods of Anaesthetic Pollution Control

The concentration of waste anaesthetic gases and vapours, whether in the hospital operating theatre, veterinary or dental surgery, can only be reduced to below the achievable concentration levels (25 ppm N_2O and 0.5 halothane), by a combination of four methods:

2.5.1 Scavenging System

Most of the contaminant gases are released through the exhale valve and ventilator in the anaesthetic machine, or the relief valve of the nasal mask in the dental surgery. This effluent can be collected and disposed from the working environment, by commercially available equipment. Such collection and disposal is called scavenging.

A scavenging system consists of three major components:

* Collecting Device (scavenging adaptor over exhale valve or ventilator) to collect waste gases from the breathing circuit and conduct it to a disposal route.

* The Disposal Route

  The waste gases can be disposed by two routes:

- Passive route: The collected gases are fed into the exhaust of a non-recirculating air conditioning system (100% fresh air intake).

  With recirculating air conditioning systems (e.g. ducted or wall air-conditioner) the above elimination route would contaminate all rooms on the common manifold.

  The collected gases can also be passively eliminated by ducting the collected gases to the open air. In this case the gases are removed by creating a pressure gradient between the patient's lungs and the outside atmosphere, along a low resistance pathway.

- Active: The collected gases are removed by a suction system which is attached to a central or independant evacuation system. (Note: there are regulations against disposal of flammable agents into a central vacuum system).

  In the redesigning of existing operating theatres or in the design of a new operating theatre the OTPAC recommends a separate or "dedicated" anaesthetic gas evacuation system, with high volume (30-40 litres/min) flow (not necessarily high vacuum), conveying the waste gases to a point outside the building where no possibility of personnel exposure exists.

* Interface

  An "interface" provides a means of physically separating the patient circuit and the disposal system, which will eliminate the possibility that either positive or negative pressures could be applied to the patient's lungs.

  A critical assessment of the commercially available scavenging anaesthetic gas devices for use with the anaesthetic procedure in hospitals and veterinary surgeries, was made at Flinders Medical Centre and published in the Journal of Anaesthesia and Intensive Care[44].

  Scavenging systems encountered in the monitoring survey are discussed in Appendix C.

2.5.2 Ventilation[41,42,45]

The air conditioning system is very important in waste gas scavenging. No anaesthetic machine is 100% leakproof, and the only way of efficiently reducing any residual gases resulting from anaesthetic machine leakage, technique errors or scavenging malfunction is via an air conditioning system.

The air conditioning system which should be used in this purpose is a non-recirculating system in which 100% of the intake air is exhausted to the outside atmosphere. This is the air conditioning system which we found in the South Australian hospitals visited.

With recirculating air-conditioning systems, the waste gases will be recirculated back into the operating room and other areas.

In the dental and veterinary surgeries the type of air conditioning system that exists is a recirculating type. Because a non-recirculating air conditioning system is expensive to operate, we have recommended the use of exhaust fans located as close as possible to the source of waste gas emissions, and directed so that the fan carries the waste gases away from the breathing zone of personnel.[42] This system is both economical and effective in exhausting contaminated air from the surgery with minimal spread throughout the rest of the building.

2.5.3 Techniques of the Anaesthetist

Anaesthetic gas pollution resulting from errors in technique, (summarised earlier in the report - "Sources of Anaesthetic Pollution") are the principal contributors to high anaesthetic gas concentrations in the operating room. Reduction of trace anaesthetic levels by variation in the anaesthetic technique is discussed in detail in the "Manual for the Control of Anaesthetic Gas Contamination in the Operating Theatre".[41] This is of course applicable to both hospitals and veterinary surgeries since the anaesthetic procedure can be regarded as similar.

In the dental surgeries surveyed, which administer relative analgesia (R.A.), the suggestions outlined in the "Manual"[41] are also applicable to the dentist.

2.5.4 Maintenance of Anaesthetic Equipment

The anaesthetic and R.A. machines, and the patient circuit, have a large number of joints which are potential sites for leakage. Some waste anaesthetic gases are expected to leak from these joints at a slow rate even if the anaesthetic equipment is in good order. Concentrations of waste gases resulting from these slow leak rates are controlled by effective non-recirculating air conditioning or exhaust ventilation in the dental and veterinary surgeries, and no build-up of waste gases in the room occurs.

However, this leak rate is difficult to control to an absolute minimum unless regular "in-house" maintenance is carried out, as well as the scheduled testing by the manufacturer's representatives. The two "Manuals" [41,42] outline maintenance procedures to control traces of gas leakage from the high and low pressure portions of the anaesthetic (and R.A.) machine.

2.6 Air Monitoring Programme

The main aim of the monitoring programme is to prove the success of the adopted waste gas control measures, such as scavenging, the co-operation of the anaesthetist, effective ventilation and equipment maintenance.

Air sampling, where possible, was performed:

* before the implementation of a control programme;
* after the implementation of a control programme and
* upon request by the concerned institutions.

2.6.1 Without Gas Scavenging Equipment

Anaesthetic gas concentrations in the operating rooms, and dental surgeries without anaesthetic gas scavenging equipment were found to be influenced by a number of factors, such as:

* The concentrations and fresh-gas flow rates of anaesthetic gases e.g. the lower the fresh flow the less spillage will occur, and therefore the lower the airborne gas concentrations.

* The type of anaesthetic breathing system
  e.g. the dentists use an open breathing system, whereby the gas machine delivers fresh gases (5-10 l/min) to the nasal mask (i.e. rebreathing of gases does not occur).

  Because of the high fresh gas flow required to maintain relative analgesia by this system, the dentist and his assistants are exposed to higher concentrations of anaesthetic agents than anaesthetists and staff in operating theatre conditions, which use mainly a semi-closed circle system and lower fresh gas flows (2-7 l/min).

  The closed circle (rebreathing) system, as found in many veterinary surgeries, uses lower gas flows than the circle-system, and therefore lower airborne anaesthetic gas concentrations are experienced.

Ayre's T-piece apparatus has its greatest application in paediatric and small animal veterinary anaesthesia, since circuit resistance and dead space are minimal. Gases from the anaesthetic machine flow into a "T", where they are inhaled through one branch and exhaled through the other. All exhaled gases and excess fresh gases leave the system through the tail of the bag. Rebreathing is reduced by a high fresh gas flow of gases (5-15 l/min) for padiatrics and 1-3 l/min for small animals).

* Method of anaesthetic administration

  e.g. The anaesthetic pollution concentration levels are higher with a mask than an endotracheal tube.

* Ventilation in the room

  e.g. The lack of a suitable number of air changes (general room ventilation) within the operating theatre will result in a build-up of anaesthetic pollution within the theatre. This will be more pronounced with operations of long duration.

* High and low pressure leaks in the anaesthetic (or R.A.) machine

  This was discussed in an earlier section.

Under the conditions mentioned above, overseas studies reported the following average concentrations of nitrous oxide and halothane under UNSCAVENGED conditions[43]:

Operating theatres
Nitrous oxide : 100 - 1000 ppm with a mean of about 500 ppm
Halothane : 2 - 14 ppm with a mean of about 10 ppm

Dentists
Nitrous oxide 1000 - 6000 ppm

Veterinary personnel (using T-piece)
Nitrous oxide 300 ppm
Halothane 7 ppm.

2.6.2 With Gas Scavenging Equipment

Using an effective scavenging system, together with other control measures already discussed, overseas studies[43] demonstrated that the TWA concentrations of nitrous oxide and halothane in the breathing zone of theatre personnel, was controlled at 19 ppm and 0.24 ppm respectively. In the dental surgeries, using a scavenging nasal mask (see appendix C), nitrous oxide exposure was reported[43,46] to average 14 ppm in the dentist's breathing zone. In veterinary surgeries[43], the anaesthetic gases were reduced to 7.8 ppm N_2O and 0.35 ppm halothane.

The results to follow, which were obtained in our monitoring survey show similar range of concentrations in the unscavenged and scavenged operating theatres, veterinary and dental surgeries.

CHAPTER 3

RESULTS AND DISCUSSIONS

3.1 Introduction

During the period 1978 to 1981, anaesthetic pollution monitoring was conducted in 40 hospitals comprising of 155 operating theatres and labour wards, 25 dental surgeries and 26 veterinary surgeries.

The measured time weighted average concentrations of the anaesthetic agents under a variety of conditions are listed in the tables A-1, A-2, and A-3 (Appendix A). The time weighted average concentrations were calculated for the exposure period and not for an eight hour equivalent period.

The tabulated results are summarised in bar graph form shown in figures B-1, B-2 and B-3 (Appendix B).

(Appendix D contains a list of all abbreviations used in the tabulated data, i.e. table A-1, A-2 & A-3).

The results shown in tables A-1, A-2, A-3 and figures B-1, B-2, B-3 may be summarised as follows:

3.2 Hospitals

3.2.1 No Scavenging (table A-1, and fig. B-1a and B-1b)

* with no scavenging the concentrations of nitrous oxide and halothane are well above the recommended levels of 25 ppm and 0.5 ppm respectively. The highest concentrations of nitrous oxide and halothane (>300 ppm N_2O and 26 ppm Halothane) are obtained in operating theatres with no scavenging and poor air conditioning. The highest nitrous oxide concentration of 1100 ppm was measured during a paediatric case in an operating theatre with effective air conditioning. Therefore in operating theatres with poor or no air conditioning and no scavenging, the anaesthetist can possibly be expected to experience nitrous oxide concentrations of up to and greater than 1100 ppm.

* The other concentrations (as shown in fig. B-1a, B-1b) are scattered between 20 - 300 ppm nitrous oxide and 0.6 - 8 ppm halothane. These variations can be accounted for by the large number of factors which control the magnitude of anaesthetic pollution in the operating theatre, such as the effectiveness of the air conditioning, technique errors by the

anaesthetist, fresh gas flows, condition of the anaesthetic machine, and the type of breathing circuit used.

3.2.2 Scavenging (table A-1, fig. B-1a, B-1b)

* With scavenging the concentrations of the anaesthetic agents are generally well below the levels measured under no scavenging conditions;

* The scavenging systems (SE, SB, DS - Appendix C) recommended by the "Operating Theatre Pollution Advisory Committee" (OTPAC) seem to be more effective than the non-recommended scavenging system (SA_1-SA_4, SC, Appendix C).

  The proportion of operating theatres monitored which had anaesthetic pollution levels equal to or less than 30 ppm nitrous oxide and 0.5 ppm halothane are as follows:

  With Recommended Scavenging 33% N_2O,
  50% Halothane
  With Non-Recommended Scavenging 20% N_2O,
  28% Halothane

  This difference in performance between the scavenging systems is well illustrated in figure B-1c. This figure also demonstrates that effective air conditioning is also important in the control of anaesthetic pollution.

* A considerable amount of scatter in the measured concentrations of nitrous oxide and halothane is again evident, demonstrating that scavenging alone does not provide sufficient control of anaesthetic pollution in the operating theatre.

3.2.3 Work Practice

The following table summarises some of the "human factors" which contributed to unnecessary anaesthetic pollution in the operating theatres which are equipped with the recommended control procedures i.e. recommended scavenging system and non-recirculation air conditioning.

TABLE 1

WORK PRACTICE CONTRIBUTION TO ANAESTHETIC POLLUTION LEVELS IN OPERATING THEATRES

	WORK PRACTICE	TIME (mins)	CONCENTRATION (ppm)	
			N_2O	Hal
1 a)	Faulty Y-swivel joint in patient circuit.	35	165	1.5
b)	Following replacement of faulty Y-swivel joint.	85	27	0.3
2 a)	Scavenging not connected (forgot !)	15	200	-
b)	After connecting scavenging system.	38	20	-
3 a)	Nitrous oxide gas turned <u>on before</u> fitting mask to patient's face, during <u>induction</u>.	3	1600	-
b)	Average conc. for remaining anaesthetic procedure.	25	240	-
4 a)	Paediatric circuit - not connected to scavenging system (did not know how!)	13	1100 (>2000)*	12 (55)*
b)	After connecting to scavenging system.	22	310	6
5 a)	<u>High</u> fresh gas flows (ventilator used) N_2O/O_2 = 7-4/5-3 l/min.	40	100	
b)	<u>Lower</u> gas flows (ventilator used) N_2O/O_2 = 3/2 l/min.	25	6	
6	Faulty cuff or lack of pressure in the cuff of the endotracheal tube.	-	(>2000)*	
7 a)	Poor mask fit	13	350	6.0
b)	Good mask fit (held with a strap)	43	17	0.3

* The highest concentration measured during the particular sampling period.

3.2.4 Recovery Room

Monitoring conducted in recovery rooms is summarised in Table 2.

TABLE 2

RESULTS OF MONITORING CONDUCTED IN RECOVERY ROOMS

HOSPITAL		CONC. (ppm) N_2O	Hal.	SITE MON.	COMMENTS
H1 (29/6/78)	C1	27 60	0.8 1.2	Env. close to bed 12cm from patient	No A/C, windows opened
H1 (29/9/79)	C2 C2	65 220 15	- - -	Edge of bed 20cm from patient Between beds	No A/C, windows opened 30 min after patient brought in
H17		80	-	B.Z nurse close to patient	Non-recirculating A/C
H18		8 80	- 1.0	Between 2 beds (BH) 50cm from patient	Non-recirculating A/C
H26	C1	50	-	B.Z nurse close to patient	Non-recirculating A/C - fresh patient
	C2	20	0.2	B.Z nurse close to patient	Patient 1hr in recovery
	C3	10	-	Env. close to bed	

From the results presented in the above table, the following conclusions may be drawn:

* The ambient concentration, measured next to the bed at breathing height, is well below the recommended target nitrous oxide concentration level of 25 ppm, provided the recovery room is serviced with an effective non-recirculating air conditioner (e.g. Table A-1, H18, H26).

* With no air conditioning the concentrations of nitrous oxide and halothane are above the recommended levels, and the concentration depends on the time the patient arrives in the recovery area.

  As can be seen in Table A-1, H1, C2, the concentration of nitrous oxide can still be significant 30 minutes after the patient is brought in.

* High concentrations of nitrous oxide are detected in the breathing zone of the nurse in the immediate vicinity of the patient's face. However, these levels are reduced to below recommended concentrations within 1 hour, provided that the room is air conditioned at a high dilution rate.

3.2.5 Labour Wards

The following table summarises the nitrous oxide concentrations measured in Labour wards. The nitrous oxide, which is mixed with oxygen, is administered to the patient on demand. Nitrous oxide concentration was measured as close as possible to the breathing zone of the nurse. Environmental air samples at breathing height were also measured.

TABLE 3

RESULTS OF NITROUS OXIDE CONCENTRATIONS IN LABOUR WARDS

HOSPITAL		CONC. NITROUS OXIDE (ppm)	TIME (mins)	COMMENTS
H2		> 300	-	B.Z Nurse
		80	-	Env.
H17		300	-	B.Z Nurse
H18		580	-	B.Z. Nurse; peak of 3000 ppm N_2O
		> 300	-	Env., Miran 101 used
H26	C1	200	130	B.Z. Nurse, peak of 750 ppm N_2O
	C2	100	75	B.Z. Nurse, peak of 950 ppm N_2O
	C3	300	65	B.Z. Nurse, peak of 1250 N_2O

From table 3, it can be seen that the nitrous oxide concentrations in the breathing zone of the nurse and in ambient air, are well above the recommended level of 25 ppm. These high concentrations are attributed to two factors, namely,

* no scavenging equipment was used, and

* ineffective recirculating air conditioning system. e.g. in H18, the breathing zone concentration took 90 minutes to drop from 580 ppm to 25 ppm N_2O on completion of administering the gas.

3.3 Dental Surgeries

3.3.1 No Scavenging (table A-2, figure B-2)

Because of the open breathing system, and high fresh gas flow rates, large leaks of nitrous oxide are expected from the exhalation valve on the nasal mask. This, together with leaks through the patient's mouth and the close proximity to the patient's head, means that the dentist and the dental assistants are subject to potentially higher nitrous oxide concentrations than those experienced in a hospital operating theatre.

* Under normal, non-scavenging practice using Relative Analgesia (RA), the nitrous oxide concentration in the breathing zone of the dentist ranged from 180 ppm to 1800 ppm (a mean of 700 ppm).

* The majority of the nitrous oxide concentrations in the low range of 180 ppm to about 650 ppm are due to RA administered on children. Hence, the lower flow rate used, and the fact that the rooms were much larger than the "typical" dental rooms, resulted in these lower nitrous oxide concentrations. A more realistic average concentration measured in the smaller 'typical' dental surgery is approximately 900 ppm (an average of all the surgeries except DS 24 and DS 25 in Table A-2).

* Effect of Ventilation

  The importance of room ventilation can be best demonstrated by considering the monitoring performed at the dental surgery, DS 24 (Table A-2). This surgery had limited ventilation, namely a standard refrigerated wall air conditioner and a window close to the dentist's chair.

  These ventilation conditions, although not satisfactory, were not considered inferior to those of the other dental surgeries monitored.

  The following table summarises the time weighted average (TWA) concentrations measured in the dental surgery during relative analgesia, using the normal conventional mask, with the window either opened or closed.

  The TWA concentrations are the results of 23 RA cases on children measured on the 19/9/78, 20/9/78 and 3/10/78, using nitrous oxide gas flows of 1.5 litres/minute.

The environmental concentration was measured with a Miran 101 infrared analyser, approximately 1 metre behind the dentist. Breathing zone samples were measured with a Miran 1A Infrared analyser.

TABLE 4

EFFECT OF VENTILATION ON THE NITROUS OXIDE CONCENTRATION DURING RELATIVE ANALGESIA (NO SCAVENGING)

SESSION	CONCENTRATION OF NITROUS OXIDE (ppm) BREATHING ZONE DENTIST	ENV.	VENTILATION
19/9/78	350	210	Window open.
	590	350	Window closed.
3/10/78	350	200	Window open.
26/9/78	460	300	Window closed.

The data in the table clearly demonstrates that with the <u>window open</u> the environmental and breathing zone concentrations are about 30-40% lower than the values with the <u>window closed</u>.

Hence with more effective and controlled ventilation system the nitrous oxide levels would be expected to be reduced further. The fact that it took 110 minutes for the concentration to drop from about 500 ppm to 25 ppm nitrous oxide at the end of RA administration proves that air movement in the room was not satisfactory. Hence, the longer RA is used, the greater the build-up of nitrous oxide concentration expected, since the gas is not dissipated and removed quickly enough.

A similiar argument would apply to all inadequately ventilated (i.e. most) surgeries monitored.

3.3.2 Scavenging (table A-2, figure B-2)

* Under scavenging conditions using primarily the Brown Scavenging mask with suction flows of 30-45 litres/min., the nitrous oxide concentrations lie mainly between 12 ppm and 180 ppm, with a mean of about 65 ppm.

* The three values which lie outside this range (i.e. 580 ppm, 350 ppm and 1100 ppm) are a result of incorrect use of the scavenging systems:- e.g.

  - The value of 580 ppm in the breathing zone of the dentist is a result of loose mask fit while using the Quantiflex Anti-Pollution System (a leak in excess of 2000 ppm was measured around the seal of the mask). The concentration of 350 ppm nitrous oxide was measured when the Quantiflex System was replaced with the Brown scavenging mask under the same conditions and with the same patient. Although a reduction in the breathing zone level resulted, the major part of this concentration is due to nitrous oxide build-up from the previous session.

  - The value of 1100 ppm nitrous oxide in the breathing zone of the dentist is attributed to inadequate suction flow in the Brown scavenging system used (i.e. 16-18 l/min was used instead of 35-45 l/min.). A leak in excess of 3000 ppm was measured close to the scavenging nasal mask.

Other factors which contributed to this high concentration are factors which were found in most dental surgeries monitored: e.g.

* Inadequate ventilation, therefore a build-up of nitrous oxide occurs in the surgery. (<u>Note</u>: high levels were also measured in the corridor, adjacent rooms and reception area).

* Leakage from an unsuitable rubber adoptor to the RA machine.

3.2.3 **Evaluation of Brown Scavenging Mask**

* <u>Simulated Condition of Operation</u>

  An evaluation of the Brown scavenging mask was made under simulated experimental conditions, in order to define its effectiveness during relative analgesia. [The Brown Mask was the only available scavenging system at the time of testing]. Measurements were carried out under varying conditions of <u>suction flow rates</u>, <u>fresh gas flows</u>, <u>with a patient</u> and without a patient. Figure B-4 is a graphical representation of the experimental results shown in table A-2 dental surgery DS 23.

From table A-2 and figure B-4, the following conclusions may be drawn:

* When no scavenging suction was used the nitrous oxide concentration was greater than 750 ppm. The concentration increasing with increasing fresh gas flowrates.

* With scavenging suction, and without a patient, (this experiment demonstrated the worst possible case of mask fit), the concentrations in the approximate breathing zone of the dentist, were markedly lower, compared with the above experiment (i.e. no scavenging suction).
  Suction flowrate of 10 l/min. produced levels of 60-150 ppm, the increase in concentration being proportional to the nitrous oxide fresh gas flow. Increasing the suction to 30 l/min. reduced the breathing zone concentration to 40 ppm nitrous oxide, for total gas flows of 6 l/min.

  At total fresh gas flows of 12 l/min. (i.e. 3 l/min. N_2O, 9 l/min. O_2), the nitrous oxide concentration was 85 ppm at 30 l/min. scavenger suction flow rate. Increasing the suction flow rate to 50 l/min. did not significantly improve the breathing zone concentration for the whole range of fresh gas flow values tested.

* With a scavenging suction and with a patient, a slight reduction in concentration compared with the above experiment, (i.e. scavenging suction without a patient) was observed at 50 l/min. at a fresh gas flowrate of 12 l/min.

  A further breathing zone reduction was observed at lower fresh gas flowrates (6 l/min.), at both 30 l/min. and 50 l/min. scavenging suction flows, this reduction being attributed to a closely fitted mask.

  From this simple experiment the following conclusions may be made:

  - The mask fit is not very critical since scavenging was still efficient when the mask was not applied to the patient's nose. However, a good face seal will ensure that the nitrous oxide concentration levels are kept to the lowest achievable concentration.

- The nitrous oxide concentration is expected to be less than 50 ppm for total fresh gas flows of 6 l/min. or less, and for flows of 3 l/min. or less of nitrous oxide, if scavenging suction of a minimum of 30 l/min. is used. Under this condition and with effective ventilation the average room concentration of nitrous oxide would be expected to be less than half this value (i.e. < 25 ppm, see table A-2, DS 23). At fresh gas flows greater than 6 l/min., higher scavenging suction should be used.

* Field Test

A further evaluation of the Brown mask was made under normal working conditions. The tests were carried out on children ranging from 3 to 6 years of age (see table A-2, DS 25). The initial tests (8/8/81 and 25/8/81) were conducted with an adult scavenging mask, because of the unavailability of the paediatric mask.

General ventilation in the dental room was provided by opened doors and windows, and a recirculating wall air conditioner.

The following table summarises the time weighted average concentration (TWA) of nitrous oxide in the breathing zone of the dentist, with and without the Brown scavenging mask.

TABLE 5

NITROUS OXIDE CONCENTRATION IN THE BREATHING ZONE OF DENTIST WITH AND WITHOUT SCAVENGING

CONDITION	T.W.A. CONC. OF NITROUS OXIDE (ppm)
Conventional mask (no scav.)	350 (> 3000)*
Brown scavenging mask	50 (400)*

* Value in brackets is the highest recorded concentration during the sampling period.

With the conventional mask, the nitrous oxide concentration in the breathing zone of the dentist ranged from 260–700 ppm, with a mean concentration of 350 ppm. When the scavenging mask was used, with suction flows of of 30–35 l/min., the dentist was exposed to a TWA concentration of 50 ppm. This represents an 85% reduction from the original TWA exposure level.

The exposure levels could be reduced further if mouth breathing by the children, and mask fit could be controlled. Under these controlled conditions, concentrations of about 30 ppm nitrous oxide were obtained in two cases, as seen in table A–2, DS 25.

3.2.4 Conclusion

The nitrous oxide concentration levels can be reduced below 30 ppm, provided scavenging mask is used effectively and all potential leak sources are controlled, and the fresh-gas flows are maintained at the lowest effective setting.

These conditions are well demonstrated in table A–2, DS 5, 2nd visit. A TWA concentration of 80 ppm nitrous oxide was measured in the breathing zone of the dentist because of high fresh gas flows (8 l/min. - adult patient) and poor scavenging mask fit (a leak of about 300 ppm was measured on the side of the nasal mask).

The high fresh gas flows used by the dentist were a result of the scavenging suction being set at greater than 50 l/min. With this high suction, the fresh gases reaching the mask are rapidly extracted, and as a consequence, the patient does not receive an adequate dosage of nitrous oxide. Upon adjusting the suction to 40–45 l/min., and reducing fresh gas flows to 4.5 l/min., the measured nitrous oxide concentration levels ranged from 12 ppm to 18 ppm.

3.4 Veterinary Surgeries

Air sampling was carried out in 26 surgeries, two of which were large animal practice only (i.e. horses, pigs). Halothane was the major vapour anaesthetic used, with methoxyflurane and ethrane being used in a small number of surgeries. Nitrous oxide in combination with a vapour anaesthetic was also used in some surgeries.

3.4.1 No-Scavenging (table A-3, figure B-3)

With no scavenging, the concentration of the anaesthetic agents in the breathing zone of veterinary surgeon varied from 0.3 ppm to 17 ppm halothane, and 20 ppm to greater than 300 ppm nitrous oxide. Methoxyflurane and ethrane concentrations of 0.6 ppm and 24 ppm were also measured in two surgeries. The wide variation in the measured anaesthetic concentrations in the breathing zone of the surgeon is attributed to a number of factors discussed earlier, namely:

* the type of breathing ciruit;
* the amount of fresh-gas flows;
* general ventilation;
* anaesthetic technique

The following table summarises the time weighted average concentrations of halothane using different breathing circuits and fresh gas flow rates (taken from table A-3).

TABLE 6

HALOTHANE CONCENTRATION USING DIFFERENT BREATHING CIRCUITS AND FRESH GAS FLOW-RATES

ANIMAL SIZE	BREATHING CIRCUIT	TWA CONC. HAL. (ppm)	FRESH GAS FLOWS (l/min)
1. Small animals (e.g. cats)	T-piece (non-rebreathing)	13	-
2. a) Mixture of small (cats) and medium (dogs) animals	Closed circuit (rebreathing)	2	0.1-1.0
b) Large animals (pigs)		16	7.5
3. a) Mixture of small and medium animals	Circle-circuit (semi-open system)	3	0.6-0.8
b) Large animals (horses)		13	12.5

From table 6 it can be seen that the use of the T-piece breathing circuit results in the highest breathing zone concentrations of anaesthetic gases, in small to medium animal practices. This technique discharges all exhaled gases to the atmosphere at 1.5 - 3 l/min., hence, high concentration levels are expected.

In the large animal practice there is insufficient data to verify the variation in anaesthetic pollution concentrations due to the type of breathing circuit.

The close circuit (rebreathing) anaesthesia circuit, which is the most commonly used system, produced the lowest airborne concentrations because of the lower fresh gas flows and recirculation of the gases (table 6).

As animal size increases so does the oxygen and anaesthetic flow rates to meet the animal's needs. Consequently, more exhaled gas passes through the exhale value into the room air. This is also well demonstrated in table 6.

The concentration of halothane increases from about 2 - 3 ppm for small to medium size animals with fresh gas flows of 0.1-1 l/min, to 13-16 ppm for large animals with fresh gas flows of 7.5-12.5 l/min.

Recirculating Air Conditioning (dilution ventilation) was used in most of the surgeries monitored. This type of ventilation has little significance in the control of waste anaesthetic gases in the breathing zone of the surgeon or assistants. The greatest sources of leakage from the breathing circuit and anaesthetic machine occurred:

* at the unscavenged exhale values
* around poorly fitted endotracheal tubes and masks
* around seals of bottled vaporizers.

Leak concentrations at these sites are usually in excess of 10 to 60 ppm halothane (depending on the fresh gas flow rates). Since surgical personnel typically stood very close to the anaesthetic machine (i.e. within 1 to 2 metres), and hence close to the source of contamination, dilution ventilation was unable to appreciably reduce high concentrations prior to their passage through the breathing zone of the veterinary personnel.

3.4.2. Scavenging (table A-3, figure B-3)

Scavenging was only used in five of the 26 practices surveyed, but resulted in marked reduction in waste anaesthetic gases concentrations.

Four of the scavenged surgeries used 'inhouse' made scavenging systems (SP, SQ, SR, SS, appendix C, figure 11, 12, 13, 14), while the other practice used system SB (figure 4, appendix C) which is one of the systems recommended by the "Operating Theatre Pollution Advisory Committee" for hospital operating theatres.

From figure B-3 it can be seen that six out of the 14 cases using scavenging devices, resulted in halothane concentrations in the breathing zone of the surgeon on 0.5 ppm or less. Higher than expected halothane levels resulted in the other 8 cases because of the crudeness of the scavenging system (e.g. SP, SS) and leakages from bottle vaporizers.

The most successful "inhouse" made scavenging system was SQ (see figure 12 and appendix C).

The system consists simply of a perspex box which covers the Stephen's anaesthetic machine. The box is exhausted to the outside atmosphere by the use of flexible corrugated ducting and a centrifugal pump. The system was very efficient because it controlled all the major leak sites from the old Stephen's machine, such as exhale valve (> 10 ppm hal), bottle vapourizer (> 10 ppm hal) and CO_2 absorbers (> 10 ppm hal). Using this system, concentrations of 0.4 ppm and 0.5 ppm halothane were obtained in the breathing zone of the surgeon. Lower concentrations could have been achieved if mouth leaks were reduced by placing the animal closer to the opening in front of the perspex box (see figure 12). Without scavenging, a time weighted average concentration of 2.3 ppm halothane was measured.

Veterinarians utilize inhalation anaesthetics for only a small part of their work week. Information gathered from the veterinarians during the survey indicated that about 1 to 15 hours each week are spent by the veterinarians performing surgery with inhalation anaesthetics. The majority of the small practices use inhalation anaesthetics for less than 8 hours per week, whereas the larger surgeries or animal hospitals use inhalation anaesthetics every day for an average of 3 to 4 hours per day. Compared to routine exposure times in human hospital personnel, exposure times in veterinary surgeries or hospitals are small.

Although exposures, when time weighted over a work day, are less than reported in human hospitals, the use of scavenging equipment should be encouraged to maintain exposures as low as possible until more definite evidence concerning possible deleterious effects becomes available. Properly scavenged small to medium animal surgeries can maintain waste halothane concentrations well below 0.5 ppm.

CHAPTER 4

CONCLUSION

The human and animal evidence available to date indicate that a health hazard affecting operating room personnel is probably related to chronic exposure to trace concentrations of waste anaesthetic gases and vapours. Of all the possible ill-effects caused by anaesthetic pollution, the increased risk of spontaneous abortion is the most convincing. The other hazards; congenital abnormalities in offspring among female workers and wives of male workers, hepatic and renal disease, impaired psychological function and effects of the central nervous system due to acute exposure (i.e. nausea, fatigue, irritability etc.), may be actual, but there is not yet sufficient evidence for that inference to be drawn "beyond reasonable doubt".

A "safe" concentration cannot be defined because the information on adverse health effects is incomplete, therefore the most reasonable course to take is to adopt the first commandament philosophy of good occupational hygiene practice and limit personnel exposure to as low as is reasonably practicable. A systematic approach to the problem includes the following:

1. Efficient scavenging system, which is well maintained in accordance with the manufacturer's recommendations.

2. Equipment maintenance to reduce gas leakage.

3. Effective ventilation.

4. Co-operation from the anaesthetist in the application of efficient techniques.

5. Air monitoring programme.

If all these combined conditions are fulfilled, the concentration of waste anaesthetic agents is reduced to less than 25 ppm nitrous oxide and 0.5 ppm halothane in hospital operating theatres and veterinary surgeries, and less than 50 ppm nitrous oxide in dental surgeries. (These values are the recommended achievable concentrations adopted by the N.H. & M.R.C.). These concentrations represent time weighted average concentrations in the breathing zone of the person administering the anaesthetics, who is considered to be the person who is exposed to the highest concentration, as he is the closest to the source of emission.

The monitoring programme highlighted some common problems in the scavenged operating theatres and veterinary and dental surgeries, which have unnecessarily high concentrations of waste anaesthetic gases which negate the effects of scavenging. These include:

1. Low pressure leaks in defective hose fittings and corrugated breathing tubes, defective metal-to-metal joints and exhale valve. Although the anaesthetic circuit cannot be made completely leakproof, every effort should be made to keep these leaks to a minimum by regular checks by the theatre staff, as well as the scheduled testing by the manufacturer's representative (see Ref. 41, section 3).

2. Nitrous oxide was turned on before fitting the mask to the patient's face. Peak concentration of nitrous oxide in the order 1000-3000 ppm have been measured in the breathing zone of the person administering the anaesthetics. This short, peak concentration takes a long time to be eliminated, resulting in unacceptable concentrations for the remainder of the operating session. Therefore, turning on of the nitrous oxide supply or the vaporizer should be avoided until the mask is fitted to the patient's face or the patient is intubated and connected to the circuit, as in operating theatres and veterinary and dental surgeries. In this way all the excess gas enters the scavenging system and unnecessary contamination is avoided (see Ref. 41, section 4).

3. Faulty cuff or lack of pressure in the cuff of the endotracheal tube (hospitals and veterinary surgeries only). This results in a leak through the mouth in excess of 2000 ppm nitrous oxide. The leak is greatest when mechanically ventilating the patient. The pressure in the cuff should be periodically checked during the operating session, since the pressure is difficult to maintain for any length of time.

4. High fresh gas flows and ventilation pressure, while mechanically ventilating the patient (hospital operating theatres) resulted in spillage of waste gases through the exhale value and into scavenging interface (system SB) at a greater rate than the elimination rate of the gases from the interface by the suction system. Hence, some waste gases are "dumped" from the bottom of the interface into the operating theatre atmosphere.

   Leaks of over 2000 ppm nitrous oxide were recorded. Under these conditions the average nitrous oxide concentration in the breathing zone of the anaesthetist was about 100 ppm, compared to 6 ppm when the ventilation pressure and fresh gas flows were reduced. Therefore, as low as practicable gas flows should be adopted if anaesthetic pollution is to be controlled.

5. In some hospital operating theatres, the brass sintered filter in the head of the interface of the scavenging system SB, was blocked with dust and fluff. The sinter could be partially blocked and the pressure gauge on the head of the interface still shows a positive functional reading. Therefore, since inadequate suction takes place through the interface, the waste anaesthetic gases are once again "dumped" into the operating theatre environment.

Hence, it is very important that the sinter is checked and cleaned regularly in accordance with manufacturers' specifications.

6. During some cases of paediatric anaesthesia, scavenging was not undertaken from the bag of the Jackson-Rees T-piece apparatus, in the fear that the suction from the scavenging system would be directed to the bag and hence endangering the patient. This is of course incorrect and shows a lack of understanding on the function of the scavenging system. The main criteria in the design of the scavenging system is to ensure that negative pressure is not directed to the patient circuit.

7. In some dental surgeries using the Brown scavenging nasal mask, high nitrous oxide concentrations were recorded in the breathing zone of the dentist and assistant due to the incorrect regulation of the scavenging suction through the mask. This, once again, demonstrates the lack of understanding on the correct function of the scavenging system by the persons concerned. There is more to effective scavenging than just purchasing and installing the system. The vacuum flow should be set at the optimum flow necessary to prevent any significant leakage of nitrous oxide in the room air. For example, a suction flow rate of 45 litres/minute should be used with fresh gas flows of 4 litres/minute. The suction flow should also be checked on a regular basis.

From the above examples it can be seen that the most obvious cause of room air contamination is related to the work practice and attitudes of the persons directly involved in administering the anaesthetic agents, for example, the anaesthetist or the veterinary surgeon or the dental surgeon, and their respective nursing assistants.

Effective control of the anaesthetic pollution in the operatory environment is not achieved simply by the installation of a scavenging system, but by a COMBINATION of factors, which include, low-leak work practice, regular "in-house" maintenance of the anaesthetic machine and breathing circuit in order to control low and high pressure leaks, and an effective ventilation system, as well as an effective well maintained scavenging system, and air monitoring. To an important extent, the effectiveness of these control measures will depend on the co-operation of the anaesthetist (or the person administering the anaesthetics) and the nursing staff.

It is therefore recommended that all the personnel directly involved with anaesthetics familiarize themselves on anaesthetic pollution and control measures (see Refs. 41 and 42), and conscientiously put them into practice.

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Table A-1
Anaesthetic Pollution Survey - Hospitals

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>H1</u>											
T2, C4	29/6/78	4 : 2 : -	15	0.5*	-	95	B.Z.A.	I., A., C.C.	N.R. 8.5 A.C/H	SA_1	A/c not very efficient. Decay of 250ppm - 30 ppm took 12 mins.
C1		4 : 2 : .5	32	0.9	-	80	B.Z.A.	I., A., C.C.	N.R. 8.5 A.C/H	SA_1	
C2		4 : 2 : .5	32	0.5	-	25	B.Z.A.	I., A., C.C.	N.R. 8.5 A.C/H	SA_1	*Carry over from previous usage.
C3		4 : 2 : -	34	0.5*	-	90	B.Z.A.	I., A., C.C.	N.R. 8.5 A.C/H	SA_1	
R. Rm.)		-	27	0.8	-	-	Env.	-	Windows opened	N.S.	
)		-	60	1.2	-	-	12P	-	Windows Opened	N.S.	Only one patient in recovery room.
T1, C1	25/9/79	3 : 2 :0.5	37	0.2	-	113	B.Z.A.	I., C., C.C.	N.R.	SB	
			22	0.2	-	35	B.Z.A.	I., C., C.C.	N.R.	SB	
T2, C1		4 : 2 : -	25	-	-	75	B.Z.A.	I., C., C.C.	N.R.	SB	
T3, C1		7-4 : 3-2 :1-3	220	13	-	20	B.Z.A.	M., A., C.C.	N.R.	SB	H.P. leak - A/c not as efficient as other theatres.
R. Rm, C1		-	65	-	-	65	E.B.	-	No A/c,Win. open	-	1 patient in recovery room.
		-	220	-	-	25	20P	-	" "	-	
		-	15	-	-	30	B.B.	-	" "	-	
											calibrated
H2											
T4, C1	4/7/78	4 : 2 :.4% Ethrane	85	-	*	50	B.Z.A.	I., C., C.C.	N.R. 14 AC/H	SA_2 -	*Ethrane not measured, since analyser NOT calibrated
C2		4 : 2 : .8 Ethrane	210	-	*	25	B.Z.A.	M., C.,M.C.**	N.R. 14 AC/H	N.S.	** Mapleson A circuit.
T3, C1		4 : 2 : .4 Ethrane	80	-	*	40	B.Z.A.	I., C., C.C.	N.R. 14 AC/H	SA_2	
LWd)		40% N_2O intm	300	-	-		B.Z N&P	Mask	N.R.	N.S.	Inefficient A/c - took 30min for N_2O levels to drop-10ppm few mins after admin. of gas.
)		-	80	-	-		Env	-	-	-	
<u>T3</u>, C1	10/7/81	3 : 1.5 :0.6 Ethrane	45		0.7	15	B.Z.A.	I., C., C.C.	N.R.	SB	
<u>T1</u>, C1		4 : 2.5 :0.5	8	-	0.3	60	B.Z.A.	I., C., C.C.	N.R.	SB	
<u>T3</u>, C2		4 : 2 : .4	45	-	0.7	60	B.Z.A.	I., C., C.C.	N.R.	SB	
<u>H3</u>											
MT, C1	20/1/78	3 : 1.5 : -	50	-	-	75	B.Z.A.	I., A., C.C.	N.R., 19.7AC/H	SA_1	
C2		5 : 2.5 : .5	35	-	-	15	B.Z.A.	M., A., C.C.	N.R., 19.7AC/H	SA_1	

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 : HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
H4	21/7/78										
T1, C1		4 : 1.5 : .25	110	1.1	-	50	B.Z.A.	I., A., C.C.	N.R., 16 AC/H	SA_1	)Very high leaks in)Absorbers and)Vapourisers)(10ppmHAL,)>300ppm N_2O)
C2)		4 : 1.5 : .3	95	1.8	-	16	B.Z.A.	I., A., C.C.	N.R., 16 AC/H	SA_1	))
)			75	1.1	-	6	B.Z.S.	I., A., C.C.	N.R., 16 AC/H	-	)Exh route in)theatres)inefficient
T3, C1		2 : 1 : .5	58	0.9	-	22	B.Z.A.	I., C., C.C.	N.R., 16.8 AC/H	SA_1	
C2)		5 : 2 :1.5-2.5	80	1.5	-	10	B.Z.A.	M., A., P.C.	N.R., 16.8 AC/H	SE	)))
)			18	1.0	-	6	B.Z.A.	I., A., P.C.	N.R., 16.8 AC/H	SE	)Paediatric)
T2, C1		2 :1.5 :1.5	18	0.2	-	18	B.Z.A.	I., C., P.C.	N.R., 22.7AC/H	SE	))
C2		5 : 2 : 2	18	0.3	-	10	B.Z.A.	M., A., P.C.	N.R., 22.7AC/H	SE	)
C3		5-2: 2-1 :.75	32	0.5	-	10	B.Z.A.	I., A., C.C.	N.R., 22-7AC/H	SA_1	
H5	28/7/78										
C1		4 : 2 :0.3	180	1.5	-	56	B.Z.A.	I., C., C.C.	N.R., 18AC/H	SA_1	H.P. leak and high leak from vap (> 10ppm HAL.)
C2		4 : 2 :1.5	50	0.7	-	10	B.Z.A.	M., A., C.C.	N.R., 18AC/H	N.S.	
C3		4 : 2 :1.5-.3	160	1.8	-	58	B.Z.A.	I., C., C.C.	N.R., 18AC/H	SA_1	(Gas 'dumped' from ventilator - i.e. not scavenged.)
H6	1/8/78										
T2, C1		3 : 1.5 : -	170	0.5*	-	15	B.Z.A.	I., C., C.C.	N.R., 15AC/H	SA_2	*Leak from vap.
C2		3 : 1.5 : -	180	0.5*	-	15	B.Z.A.	I., C., C.C.	N.R., 15AC/H	SA_2	In theatre 2 - suction on wall too low (only 16 l/m)
C3		3 : 1.5 : -	175	0.5*	-	20	B.Z.A.	I., C., C.C.	N.R., 15AC/H	SA_2	
C4		3 : 1.5 : -	220	0.6*		22	B.Z.A.	I., C., C.C.	N.R., 15AC/H	SA_2	
T1, C1		5-3 :2-1.5 :0.5	32	.5	-	67	B.Z.A.	I., C., C.C.	N.R., 15AC/H	SA_2	
H7	2/8/78										
T2, C1		6-3 :3-1.5: -	145	-	-	76	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_1	Dumping from exhale valve. GOLDMAN HAL. VAP used.
T3, C1		6 : 2 : 1	140	2.0	-	15	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_1	Leak >>10ppm HAL. (H.P. leak)
C2		6 : 2 : 1	95	1.3	-	13	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_2	
C3		6 : 2 : 1	80	1.0	-	18	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_2	
T1, C1		5 : 2 : .5	300*	6.0	-	30	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_2	Fluotec Vap (*Gas left ON from previous oper.)
C2		5 : 2 : .5	180	3.5	-	30	B.Z.A.	I., C., C.C.	N.R., 20AC/H	SA_2	

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 : HAL (l/m) (l/m) (%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>H8</u>	3/8/78										
C1		4 : 2 :2U*	14	2.0	-	30	B.Z.A.	I., C., C.C.	N.R., 23AC/H	SA_2	*GLASS VAPORIZER - very leaky (>> 10ppm)
C2		4 : 2 :MAX	13	2.4	-	12	B.Z.A.	M., A., C.C.	N.R., 23AC/H	SA_2	
C3		4 : 2 :MAX	23	3.0	-	10	B.Z.A.	M., A., C.C.	N.R., 23AC/H	SA_2	
C4		4 : 2 :MAX	11	3.2	-	6	B.Z.A.	M., A., C.C.	N.R., 23AC/H	SA_2	
<u>H9</u>	7/8/78										
T2, C1		6 : 2 : -	65	2*	-	30	B.Z.A.	I., C., C.C.	N.R., 27AC/H	SA_1	GOLDMAN VAP. *due to leakage.
T1, C1		3 : 1.5: 1	75	1.2	-	35	B.Z.A.	M., C., C.C.	N.R., 25AC/H	SA_1	Portable Fluotec Vap
<u>H10</u>	10/8/78										
C1		4 : 2 :0.5	33	0.5	-	32	B.Z.A.	I., C., C.C.	N.R., 27.8AC/H	SB	Few low press leaks
C2		4 : 2 :0.5	9	0.2	-	20	B.Z.A.	I., C., C.C.	N.R., 27.8AC/H	SB	
C3		4 : 2 :0.5	18	0.2	-	19	B.Z.A.	I., C., C.C.	N.R., 27.8AC/H	SB	
		4 : 2 :0.5	8	0.2	-	15	B.Z.S.	I., C., C.C.	N.R., 27.8AC/H	SB	
C4		4 : 2 : 15	13	0.3	-	12	B.Z.A.	M., C., C.C.	N.R., 27.8AC/H	SB	
<u>H11</u>	15/8/78										
C1		4 : 2 :0.5	22	0.5	-	53	B.Z.A.	I., A., C.C.	Wall A/c	SA_1	Poor A/c - usually off because too noisy.
C2		6 : 3 : 2	300	10	-	35	B.Z.A.	M., C., M.C.*	Wall A/c	N.S.	*Circuit similar to Mapleson type with no scav.
C3		4 : 2 : 2	250	5	-	7	B.Z.A.	M., C., C.C.	Wall A/c	SA_1	Note: Poor EXHAUST SYSTEM.
C4		4 : 2 : 2	270	6	-	18	B.Z.A.	M., C., C.C.	Wall A/c	SA_1	45 min after completion of operation N_2O conc. 140 ppm
<u>H12</u>	25/8/78										
C1		3 : 1.5 :MAX	300	10	-	30	B.Z.A.	I., A., C.C.	Air C.	N.S.	GOLDMAN VAP.
C2		3 : 1.5 :MAX	300	10	-	33	B.Z.A.	I., A., C.C.	Air C.	N.S.	No exhaust.
C3		3 : 2.5 : -	300	4	-	35	B.Z.A.	I., A., C.C.	Air C.	N.S.	
<u>H13</u>	28/8/78										
C1		3 : 2 : -	300	-	-	45	B.Z.A.	I., A., C.C.	Win. A/c	N.S.	
			300	-	-	15	B.Z.S.	I., A., C.C.	Win. A/c	N.S.	
<u>H14</u>	18/9/78										
MT, C1		3 : 1 : 1U	11	0.1	-	20	B.Z.A.	I., A., C.C.	N.R., 20.0AC/H	SA_1	Goldman Vap
			33	0.3	-	55	B.Z.A.	I., C., C.C.	N.R., 20.0AC/H	SA_1	
C2		5-3 :3-0.5:MAX	85	0.8	-	15	B.Z.A.	M., C., C.C.	N.R., 20.0AC/H	SA_1	
<u>H15</u>	11/9/78										
C1		5 : 2 :MAX	300	10(26 (high (scale	-	30	B.Z.A.	I., A., C.C.	Wall A/c	N.S.	Glass jar with metal cap for Halothane Vap.
C2		5 : 2 :MAX	300	10(26)	-	10	B.Z.A.	I., A., C.C.	Wall A/c	N.S.	

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 : HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
H16	6/9/78										
T1, C1		3 : 1.5: 1-1.5	43	0.8	-	19	B.Z.A.	M., C., C.C.	N.R.	SA_2	
C2		5 : 2 : -	45	-	-	58	B.Z.A.	I., A., C.C.	N.R.	SA_2	
C3		6 : 2 : 1	55	1.3	-	27	B.Z.A.	I., A., P.C.	N.R.	SA_3	Paediatrics
C4		3 :1.5 :1-1.5	95	2.0	-	30	B.Z.A.	M. C. C.C.	N.R.	SA_3	
C5		5 : 2 :1.5	35	0.5	-	17	B.Z.A.	I., A., P.C.	N.R.	SA_3	
T2, C1		3 : 2 : 2	47	1.0	-	13	B.Z.A.	M., C., C.C.	N.R.	SA_3	
C2		3 : 2 : 2	46	1.0	-	10	B.Z.A.	M., C., C.C.	N.R.	SA_3	
C3		4 : 2 :4.5-2	32	0.8	-	18	B.Z.A.	I., C., C.C.	N.R.	SA_3	
C4		4 : 2 :2.5	28	0.6	-	19	B.Z.A.	I., C., C.C.	N.R.	SA_3	
C5		3 : 1.5: 2	5	0.3	-	37	B.Z.A.	I., C., B.C.*	N.R.	SA_1**	*BAIN circuit **Scav from Ex valve Bain Circuit.
C6		3 : 1 : 3	25	0.6	-	15	B.Z.A.	I., C., B.C.*	-	SA_1	
C7		4 : 1.5: 2	35	0.9	-	25	B.Z.A.	I., C., P.C.	-	SA_3	Paediatric
C8		3 : 1.0:1.5	11	0.2	-	15	B.Z.A.	I., C., B.C.*	-	SA_1	
H17	12/9/78										
MT, C1 (GYN)		3 : 1.5 : -	65	-	-	20	B.Z.A.	I., A., C.C.	N.R.	SA_4	Poor exhaust.
C2		3 : 1.5 : 2	47	0.7	-	47	B.Z.A.	M., C., C.C.	N.R.	SA_4	
C3		3 : 1.5 : 1	110	0.7	-	23	B.Z.A.	I., C., C.C.	N.R.	SA_4	Few LP leaks.
mT, C1 (GYN)		3 : 1.5 :MOF (MAX)	300	-	-	23	B.Z.A.	I., C., C.C.	Wall A/c	SA_4	(1) bottle vaporiser (2) Poor Exhaust (200ppm N_2O, 30min after completion)
OBT		3 : 1.5 :0.3	280	2.2	-	73	B.Z.A.	I. A. C.C.	N.R. 12AC/H	SA_1	
LWd		70%:30%, -	300	-	-	-	B.Z.N.	Mask	-	N.S.	
R.Rm		-	80	-	-	-	B.Z N.	-	-	N.S.	1 patient - residual coming from GYN theatres.
H18	20/9/78										
T4, C1		4 : 2 :0.5	200	1.4	-	33	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	
T3, C1		4 : 2 : .5	85	0.1	-	100	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	HAL only used for 5 mins.
T6, C1		4 : 2 :0.5	100	0.8	-	78	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	
T2, C1		4 : 2 : -	54	0.1		41	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	HAL leak from Vap. Filling port.
T1, C1		4-3 :2-1.5: -	150	1.5		145	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	
T5, C1		3 :1.5:0.5-0.7	80	0.6		145	B.Z.A.	I., C., C.C.	N.R., 30AC/H	SC	

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
R.Rm, C1		-	8	-	-	-	B.B.	-	-	N.S.	
C2		-	80	1.0	-	-	50P	-	-	N.S.	
I.Rm		-	150-300	-	-	-	B.Z.A.	-	-	N.S.	
L.Wd		-	300	-	-	-	Env.	Mask	-	N.S.	
		-	580	-	-	-	B.Z.N.	Mask	Poor Exh	N.S.	Miran 1 A used for BZ. of nurse. PK valves up to 3000ppm N_2O
H19	20/10/78										
C1		6-4 : 3-2 :1.0	300	7.5	-	100	B.Z.A.	I., C., C.C.	Wall A/c	N.S.	Bottle vap. (took 60min - 30 ppm N_2O)
H20	6/11/78										
C1		5-3 :2.5-1.5:-	130	0.1	-	55	B.Z.A.	I., C., C.C.	Wall A/c	SA_2	
C2		5-4 : 2.5-2:0.5	300	6	-	42	B.Z.A.	M., A., P.C.	Wall A/c	N.S.	No scav. facility for paediatric circuit.
C3		5-3 :2.5-1.5:-	100	0.8*	-	70	B.Z.A.	I., C., C.C.	Wall A/c	SA_2	*Carry over from previous operation.
C4		5-3:2.5-2.5: .5	130	1.5	-	40	B.Z.A.	I., C., C.C.	Wall A/c	SA_2	
H21	7/11/78										
C1		3 : 1 :0.5	53	0.7	-	65	B.Z.A.	I., C., C.C.	Wall A/c	SA_4	
C2		3 : 1 :0.5	300	3.5	-	45	B.Z.A.	I., A., C.C.	Wall A/c	N.S.	Manually ventilated no scav facility.
C3		3 : 1 : -	65	1.0*	-	35	B.Z.A.	I., C., C.C.	Wall A/c	SA_4	*Carry over from previous session.
H22	14/11/78										
C1		6 : 2 :0.5-1	300	6	-	35	B.Z.A.	I., A., C.C.	N.R., 8-12 AC/H	N.S.	Leaky fluotec vap filling port.
C2		5 : 2 : 1	300	6	-	25	B.Z.A.	I., A., P.C.	N.R., 8-12 AC/H	N.S.	)Paediatric Circuit)
C3		5 : 2 :1.5	300	6	-	18	B.Z.A.	I., A., P.C.	N.R., 8-12 AC/H	N.S.	)
H23	29/11/78										
		4-2: 2-1 :0.5	300	3.5	-	26	B.Z.A.	I., A., C.C.	Wall A/c (3AC/H)	N.S.	N_2O levels reached>300 ppm 7min after commencement.
		4-2: 2-1 :1.0	300	8	-	28	B.Z.A.	M., A., C.C.	Wall A/c (3AC/H)	N.S.	At end, it took 15min for levels to drop below 300 ppm.
H24	12/12/78										
T1, C1		3 : 1 :MAX	17	0.3*	-	43	-	M., A., C.C.	N.R.	SA_2	Mask was belted. *leak in vaporisor (GOLDMAN Vap)
C2		3 : 1 :MAX	17	0.5	-	22	-	M., A., C.C.	N.R.	SA_2	
T2, C1		6 : 2 : -	25	0.1	-	42	-	I., C., C.C.	N.R.	SA_2	Goldman Vap
C2		6 : 2 : -	25	0.1	-	25	-	I., C., C.C.	N.R.	SA_2	
T3, C1		4 : 1.5 :MAX	85	0.8	-	95	-	M., A., C.C.	N.R.	SA_2	Large number of low P. leaks.

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
T4, C1		5 : 2 : -	25	0.3	-	35	-	I., C., C.C.	N.R.	SA_2	)Goldman Vap. Leaky)Vap. (> 10 ppm HAL)
C2		5 : 1.5 : -	23	0.3	-	12	-	M., A., C.C.	N.R.	SA_2	))
C3		5 : 1.5 : -	27	0.5	-	8	-	M., A., C.C.	N.R.	SA_2	)
H25	24/1/79										
C1		4-2:2-1:1.5-1.0	200	5	-	60	B.Z.A.	I., C., C.C.	No. A/c	SA_1	)Large number of L.P.)leaks. Scav)system unsuitable,)and poor exhaust.)Hence Levels)build up.
C2		4-2 : 2-1 :2-1	300	10 (15-25)*	-	45	B.Z.A.	I., C., C.C.	No. A/c	SA_1	)))
C3		4-2 : 2-1 :2-1	300	10 (15-25)*	-	45	B.Z.A.	M., A., C.C.	No. A/c	SA_1	*estimated value by extrapolation
H26	27/2/79										
T7, C1		3 : 1.5 : -	38	-	-	75	B.Z.A.	I., C., C.C.	N.R.	SD	
C2		5 : 2 : -	280	-	-	50	B.Z.A.	I., C., P.C.	N.R.	N.S.	Paediatric T-piece with no Scav. facility.
T3, C1		4 : 2 :0.5	29	0.4	-	90	B.Z.A.	I., C., C.C.	N.R.	SD	
T4, C1		6 : 2 :2-1	28	0.5	-	45	B.Z.A.	I., A., M.C.*	N.R.	SD	*M= Mapleson D Circuit.
C2		6-3:3-1.5:-	27	0.2	-	85	B.Z.A.	I., C., C.C.	N.R.	N.S.	
T8, C1		4 :2:0.5-1.5	45	0.5	-	65	B.Z.A.	I., A., C.C.	N.R.	SD	
T1, C1		6-3 :3-1.5:2.5-1.0	50	0.5	-	50	B.Z.A.	M., A., C.C.	N.R.	SD	
T2, C1)))		6-3 :3-1.5:2.5-1.0	165	1.5	-	35	B.Z.A.	I., C., C.C.	N.R.	SD	Large leak from Y swivel in patient circuit.
		6-3 :3-1.5:0.5	27	0.3	-	85	B.Z.A.	I., C., C.C.	N.R.	SD	After swivel was replaced.
Ma. Wd.		9-6 :4.5-2: -	92	-	-	40	B.Z.A.	M., C., M.C.	Win A/c	SD	6 short operations.
Am. H		- : 0.4 : 2U	-	1.2	-	120	B.Z.S.	I., C.,Cl.C.*	Re. Duc	N.S.	*Closed circuit. Bottle Vap. (very leaky, >>10ppm Hal)
R. Rm, C1		-	50	-	-	-	B.Z N.	-	-	N.S.	Measured 20cm from patient's nose FRESH PATIENT
C2		-	20	0.2	-	-	B.Z N.	-	-	N.S.	Patient 1hr in recovery - monitor 20cm from patients nose.
C3		-	10	-	-	-	Env.	-	-	N.S.	
L.Wd., C1		-	200	-	-	130	B.Z.N.	M.	-	N.S.	Peak of 750 ppm N_2O (Miran 1A)
C2		-	100	-	-	75	B.Z.N.	M.	-	N.S.	Peak of 950 ppm N_2O. (Miran 1A)
C3			300	-	-	65	B.Z.N.	M.	-	N.S.	Peak of 1250ppm N_2O (Miran 1A)

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>H27</u>	6/2/79										
T1, C1		5 : 2 : -	25	-	-	50	B.Z.A.	I., C., C.C.	N.R.	SB	Goldman Vap (Miran 103 out of order).
T3, C1)		4 : 2 :0.5	50	-	-	20	B.Z.A.	I., C., C.C.	N.R.	SB	Fluotec MKII vap.
)		4 : 2 :0.5	130	-	-	50	B.Z.Sr	I., C., C.C.	N.R.	SB	Sister close to leaky absorbers.
T2, C1)		6-3: -1.5:2U	35	-	-	70	B.Z.A.	I., C., C.C.	N.R.	SB	Goldman Vap.
<u>H28</u>	2/5/79										
T1, C1		3 : 1.5 : -	55	-	-	8	B.Z.A.	I., A., C.C.	N.R.	SA_1	
C2		4 : 1.5 : -	60	-	-	35	B.Z.A.	I. A. C.C.	N.R.	SA_1	H.P. leak behind machine.
T2, C1		4 : 2 :0.5	300	5	-	37	B.Z.A.	I., C., M.C.*	N.R.	NS	*Mapleson B type circuit.
C2		5 : 2 :1.5	300	3	-	10	B.Z.A.	I., C., M.C.	N.R.	NS	
<u>H29</u>	15/5/79										
T1, C1		4 : 2 : -	18	0.2	-	50	B.Z.A.	I., C., C.C.	N.R.	SB	
T2, C2		4 : 2 :0.5	43	0.5	-	45	B.Z.A.	I., C., C.C.	N.R.	S.B.	
<u>H30</u>	29/5/79										
T1, C1		3 : 2 : -	57	2.0*	-	17	B.A.Z.	M.,C.,C.C.	N.R.	SB	* due to error in filling vaporizer.
C2		3 : 2 : -	48	0.7	-	45	B.A.Z.	I.,C.,C.C.	N.R.	SB	
C1		3 : 1.5: 1	300	10.5	-	60	B.A.Z.	I.,A.,C.C.	N.R.	SB	Scav system <u>not often used</u>. (pump too noisy)
	16/8/79										
T2, C1		4-3 :2-1.5:0.5	120	2	-	35	B.Z.A.	I., C., C.C.	N.R. 6AC/H	SB	Suction on scav system too low (N_2O > 300 ppm bottom of bassoon)
T1, C1		6-4 : 2 : -	125	-	-	20	B.Z.A.	I., C., C.C.	N.R. 6AC/H	SB	
<u>H31</u>	7/6/79	4 :2:0.5-1.0	19	0.3	-	100	B.Z.A.	I., A., C.C.	N.R.	SB	<u>Miran 1A used for N_2O</u>
<u>H32</u>											
<u>GnT</u>	5/6/79										
T1, C1		6-3:3-1.5: -	120	-	-	23	B.Z.A.	I., C., C.C.	N.R.	SB*	*Scav system not connected.
T1, C1			27	-	-	50	B.Z.A.	I., C., C.C.	N.R.	SB	Scav system connected.
T2, C1)		8-3:4-1.5: -	110	-	-	25	B.Z.A.	I., C., C.C.	N.R.	SB	High level due to gas left <u>ON</u> after Induction.
)			28	-	-	37	B.Z.A.	I., C., C.C.	N.R.	SB	
)			32	-	-	14	B.Z S.	I., C., C.C.	N.R.	SB	
T3, C1	6/6/79	6-3 :3-1.5:0.5*	200	-	-	15	B.Z.A.	I., C., C.C.	N.R.	SB	Scav. <u>NOT ON</u> (forgot)
			18	0.3	-	38	B.Z A.	I., C., C.C.	N.R.	SB	Scav <u>ON</u>.
T4, C1)		6-3 :2-1.5:0.5*	130	0.7	-	15	B.Z.A.	I., C., C.C.	N.R.	SB	*HAL used in Induction. High level due to N_2O left <u>ON</u> during induction.

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
			48	0.2	-	38	B.Z.A.	I., C., C.C.	N.R.		
T5, C1)		3 : 1.5: -	110	-	-	10	B.Z.A.	I., C., C.C.	N.R.	SB	N_2O left on during induction.
			35	-	-	70	B.Z.A.	I., C., C.C.	N.R.		
T6, C1)		6-3 :3-1.5: -	200	-	-	10	B.Z.A.	I., C., C.C.	N.R.	SB	N_2O left on during induction.
)			70	-	-	40	B.Z.A.	I., C., C.C.	N.R.		
T7, C1		5 : 2 :1.5-1	260	3.5	-	10	B.Z.A.	M., C., C.C.	N.R.	SB	
(CYI), C2		5 : 2 :2.5-1	200	4.3	-	25	B.Z.A.	M., C., C.C.	N.R.	SB	
C3		6-3 :3-1.5:-	110	-	-	17	B.Z.A.	I., A., C.C.	N.R.	SB	
T8, C1 (CYII)	8/6/79	6-4 :3-2:1-0.5	75	0.7	-	16	B.Z.A.	M. A. C.C.	N.R.	SB	
E.T.1, C1	12/6/79	6-3 :3-1.5:1.0*	85	1.0	-	40	B.Z.A.	I., C., C.C.	N.R.	SB	*1% during induction only separate Ind. room
C2)		7-3 :3-1.5:1.5*	70	1.0	-	9	B.Z.A.	M., A.,C.C.**	N.R.	SB	** during induction leaks of ~3000ppm N_2O
)			28	0.6	-	9	B.Z.A.	I., C., C.C.	N.R.	SB	
C3)		7-3 :3-1.5:1.0*	350	6.0	-	13	B.Z.A.	M., A., C.C.	N.R.	SB	Induction room.
)			90	1.5	-	18	B.Z.A.	I., C., C.C.	N.R.	SB	In theatre.
E.T.2, C1		7-3 :3-1.5:1.0*	28	0.6	-	45	B.Z.A.	I., C., C.C.	N.R.	SB	
C.Th. T1, C1	13/6/79	4-3 :2-1.5:2-.5	55	1.2	-	45	B.Z.A.	I., C., C.C.	N.R.	SB	
			18	0.2	-	55	B.Z.A.	I., C., C.C.	N.R.	SB	Patient transferred to heart machine and N_2O off.
			58	0.3	-	50	B.Z.A.	I., C., C.C.	N.R.	SB	Patient back on anaesthetic machine
E.N.T. T(B), C1	11/6/79	5-3 :2-1.5: -	130	-	-	50	B.Z.A.	I., C., C.C.	N.R. 12AC/H	SB	Contribution from adjoining theatre T(A)
C2			25	-	-	15	B.Z.A.	I., C., C.C.	N.R. 12AC/H	SB	Theatre A was not used.
T(A), C1		5 : 2 : -	350	-	-	7	B.Z.A.	I., C., C.C.	N.R. 12AC/H	SB	Scav system not turned ON.
			150	-	-	26	B.Z.A.	I., C., C.C.	N.R. 12AC/H	SB	Scav system ON.
C.Th. T2, C1)		3 :1.5:1-2:-	40	1.0	-	40	B.Z.A.	I., C., C.C.	N.R.	SB	
			250	2.0	-	70	B.Z.A.	I., C., C.C.	N.R.	SB	Patient on heart machine (+scav sys) BUT N_2O left ON to keep lungs inflated.
			60	0.8	-	30	B.Z.A.	I., C., C.C.	N.R.	SB	Patient back on anaesthetic machine

HOSPITAL	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>NuS</u>											
T(B), C1	20/6/79	6-3 :3-1.5:0.5	155	1.0	-	105	B.Z.A.	I., C., C.C.	Wall A/c(2)	SB	)<u>Miran 101 used for</u>)N_2O
T(A), C1		6-3 :3-1.5: -	155	-	-	85	B.Z.A.	I., C., C.C.	Wall A/c(2)	SB	)H.P. & L.P. leaks.
<u>E.S.S.</u>											
T(B), C1	13/6/79	4-3 :2-1.5: -	70	-	-	240	B.Z.A.	I., C., C.C.	N.R.	SB	
T(A), C1		4 : 2 :0.5	100	1.3	-	40	B.Z.A.	I., C., C.C.	N.R.	SB	Leak >300 ppm N_2O - bottom of bassoon. (blocked sintered filter).
C2		4 : 2 : -	65	-	-	30	B.Z.A.	I., C., C.C.	N.R.	SB	
<u>O.P.T.</u>,											
C1)		6-4 : 2 :0.5	150	3.0	-	10	B.Z.A.	M., A., C.C.	N.R.	SB	During induction.
)			45	1.5	-	50	B.Z.A.	I., C., C.C.	N.R.	SB	Miran 1A used for <u>Hal</u>
<u>O.S.T.</u>	17/7/79										
C1		4-3 :4-1.5: ETH. 2-0.8	110	-	-	13	B.Z.A.	I., A., C.C.	Re	SB	Extractions. (Gas left on during intubation.)
C2			70	-	-	15	B.Z.A.	I., A., C.C.	Re	SB	Extractions. (Gas left on during intubation.)
C3			95	-	-	15	B.Z.A.	I., A., C.C.	Re	SB	Extractions. (Gas left on during intubation.)
<u>X-R.T.</u>											
R31		5-3: 2.5:-	21	-	-	45	B.Z.A.	I., A., C.C.	Re	SB	
R30		3 : 1.5 :0.5	35	0.6	-	28	B.Z.A.	I., A., C.C.	Re	SB	
<u>H33</u>, C1	22/7/79	4.5 :2.5:2-0.5	300	4.5	-	40	B.Z.A.	M., C., P.C.	2 Wall A/c	SA_1	Paediatric
C2)		3 : 1.5 :2-1	130	4.0	-	40	B.Z.A.	I., A., C.C.	2 Wall A/c	SA_1	Using Bag
)			200	5.0	-	10	B.Z.A.	I., C., C.C.	2 Wall A/c	SA_1	Using Ventilator (residual conc. from from previous operation.
C3		3 : 2 :2-1	250	5.5	-	20	B.Z.A.	M., A., C.C.	2 Wall A/c	SA_1	Poor Exhaust - took 32 minutes to drop from 250 - 45 ppm N_2O.
<u>H34</u>	15/8/79										
C1		3 : 1.5 : 2 setting	100	3.5	-	45	B.Z.A.	I., C., C.C.	N.R.	SA_2	Goldman Vap. (leak >10 ppm HAL)
C2		3 : 1.5 : 1-2 setting	75	4.5	-	60	B.Z.A.	I., C., C.C.	N.R.	SA_2	H.P. leak. (Both theatres)
C3		3 : 1.5 :MAX	85	5.0	-	90	B.Z.A.	I., C., C.C.	N.R.	SA_2	H.P. leak. (Both theatres)
<u>H35</u>	15/10/79										
T1, C1		3 :1.5:1-0.5	41	0.5	-	15	B.Z.A.	M., A., C.C.	N.R.	SA_2	
C2		3 :1.5:0.5-1.0	62	1.1	-	135	B.Z.A.	I. C. M.C.*	N.R.	SA_2	*Mapleson D. (Scav from ventilator <u>only</u>).

HOSPITAL		DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Ethrane (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>H36</u>		20/11/79	5 : 2 :1-0.5	300	4.0	-	130	B.Z.A.	I., C., C.C.	N.R.	N.S.	N_2O (est 300-400 ppm) Hal Peak 9.0ppm
<u>H37</u>	C1	9/11/81	3 : 2 :2.5	240	0.5*	-	25	B.Z.A.	I., A., C.C.	N.R.	S.B.	*HAL used for 2min Gases left <u>ON</u> before connecting to patient
<u>H38</u>	C1	10/11/81	4 : 2 : -	210	-	-	50	B.Z.A.	I.,C.,C.C.	N.R.	S.B.	Large mouth leak (>3000ppm N_2O), plus, anaes. machine leaks
			4 : 2 : -	36	-	-	20	B.Z.S.	I.,C.,C.C	N.R.	S.B.	
	C2		4 :1.5-2: -	34	-	-	30	B.Z.A.	I.,C.,C.C	N.R.	S.B.	Intubation 80ppm N_2O
<u>H39</u>		11/11/81										
T3	C1		4-3:3-1.5:1.5	85	-	-	7	B.Z.A.	I., A., P.C.	N.R.	S.B.	Bag-to-interface
	C2		4-3:3-1.5:1.5	130	-	-	11	B.Z.A.	I., A., P.C.	N.R.	S.B.	leakage (>3000ppm
	C3		3 : 1 : -	35	-	-	18	B.Z.A.	I., C., C.C.	N.R.	S.B.	N_2O)
	C4	12/11/81	6 : 2 :1.5-2	18	-	-	8	B.Z.A.	I., C., C.C.	N.R.	S.B.	
T2	C1		6 : 2 :1-1.5	8	-	-	39	B.Z.A.	I., A., C.C.	N.R.	S.B.	
	C2		5-6 : 2 :1.5-2	1100	12	-	13	B.Z.A.	I., A., P.C.	N.R.	N.S.	Leaks >2000ppm N_2O and 55ppm HAL
			5-6 : 2 :1.5.2	310	6	-	22	B.Z.A.	I., A., P.C.	N.R.	S.B.	reduction after scav. connected
	C3		6 : 2 : -	36	-	-	70	B.Z.A.	I., C., C.C.	N.R.	S.B.	
			6 : 2 : -	28	-	-	10	B.Z.A.	I., C., C.C.	N.R.	S.B.	
T1	C1		3-1 :1-.75:1.5	8	0.1	-	30	B.Z.A.	I., C., C.C.	N.R.	S.B.	
	C2		3-1 :1-.75: -	17	-	-	50	B.Z.A.	I., C., C.C.	N.R.	S.B.	
<u>H40</u>	C1	13/11/81	7-4 : 5-3 : -	100	0.2*	-	40	B.Z.A.	I., C., C.C.	N.R.	S.B.	*probably due to leakage in circuit
	C2		4.5-3: 3-2 :1.5	41	2.0	-	75	B.Z.A.	I., C., C.C.	N.R.	S.B.	
	C3		3 : 2 : -	6	-	-	25	B.Z.A.	I., C., C.C.	N.R.	S.B.	

APPENDIX A

Table A-2
Anaesthetic Pollution Survey - Dental Surgeries

DENTAL SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 (l/m) (l/m)	WASTE GAS CONC: N_2O (ppm)	SAMP. TIME (min)	SITE MON.	RATE OF RA per WK (hrs)	VENTILATION	SCAV. SYSTEM	COMMENTS
DS1	21/2/79	3.5 : 3	680	36	B.Z.D.	3-5	Re A/c (NU)	N.S.	Window closed.
			450	5	B.Z.D.		Re A/c (NU)	N.S.	Window open.
DS1 2nd Visit	29/9/81	2.5 : 3	1100	32	B.Z.D.		Re A/c (NU)	SL	Peak 3000ppm (suction flow rate too low, 15-18l/m)
DS2	22/2/79	2 : 3	280	5	B.Z.D.	.5	Re A/c	N.S.	Window open (No A/c inlet vent to surgery).
DS3	29/2/79	3 : 3	1200	26	B.Z.D.	3	W.A/c*	N.S.	No exhaust route, H.P. leak (cylinder) 1200 ppm.
			900	8	B.Z.N.	-	W.A/c*	N.S.	*A/c in corridor.
DS4	2/4/79	3.5 : 3.5	1200	20	B.Z.D.	-	Re A/c	N.S.	No exhaust route.
			180	8	B.Z.D.	-	Re A/c	SL	Suction on Scav system 50l/m.
DS5	6/4/79								
S1)		3-1.5: 3-4.5	550	12	B.Z.D.	30-35	W.A/c	N.S.	A/c OFF - window opened. (NO exhaust route)
)			600	8	B.Z.D.		W.A/c	N.S.	Ac/ OFF - window closed. (NO exhaust route)
S2)		2 : 6	500	10	B.Z.D.		W.A/c	N.S.	A/c ON.
)		4-1.5: 4-4.5	850	20	B.Z.D.		W.A/c	N.S.	A/c OFF.
DS5 2nd Visit	28/9/81								
S_2		6-2 : 2-6	30	25	B.Z.D.		W. A/c	SL	A/c OFF (peak 70ppm) (gas turned ON before connecting mask)
		4-2 : 4-6	80*	24	B.Z.D.		W. A/c	SL	A/c ON (*high level due to poor mask fit) (peak 400ppm)
		4-3 : 4-5	18	12	B.Z.D.		W. A/c	SL	A/c OFF (peak 150ppm) (portable fan on)
		4-1.5: 4-3**	12	10	B.Z.D.		W. A/c	SL	A/c OFF (peak 60ppm) (portable fan on)
		4-1.5: 4-3**	15	8	B.Z.D.		W. A/c	SL	A/c OFF, Portable fan off (peak 100ppm) (**Note. Lower gas flows)
DS6	8/5/79	4 : 1*	300 + 10ppm Tri	22	B.Z.D.	1	No A/c	N.S.	Austox Anaesth Machine - on demand only. HP leak, exhale valve and mouth region. *Trilene also given.
DS7	14/5/79	3 : 3	550	30	B.Z.D.	2	Re A/c	N.S.	1 vent on wall (Air Inlet) - Window closed.
			300	15	B.Z.D.		Re A/c	N.S.	Window open.
DS8	27/6/79	6 : 2*	300 +10ppm HAL	25	B.Z.D.	1-2	Re A/c	N.S.	Gen Anaesth Given Intub (through nose)*1.5% HAL also given.
DS9	13/8/79	3 : 4	1800	30	B.Z.D.	2-3	Air C.(Du)	N.S.	No exhaust route.
DS10	27/8/79	2.5 : 3	1100	30	B.Z.D.		-	N.S.	
DS11	10/9/79	2 : 4	350	30	B.Z.D.	2-3	-	N.S.	
DS12	24/10/79	3 : 3-6	1000	10	B.Z.D.	0.5	Re A/c	N.S.	No exhaust route. (peak of 2200ppm N_2O.
DS13	21/9/79	2.5 : 3	1700	18	B.Z.D.	0.5	Re A/c	N.S.	Peak of 3000 ppm N_2O.

DENTAL SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 (l/m) (l/m)	WASTE GAS CONC: N_2O (ppm)	SAMP. TIME (min)	SITE MON.	RATE OF RA per WK (hrs)	VENTILATION	SCAV. SYSTEM	COMMENTS
DS14	21/9/79	3 : 3	1000	17	B.Z.D.	5-6	No A/c	N.S.	Peak of 2800 ppm N_2O.
DS15	21/9/79	4.5 : 3	1200	25	B.Z.D.	2hrs	Re A/c	N.S.	Peak of 2000 ppm N_2O.
DS16	19/9/79	2-4 : 4-3	1200	22	B.Z.D.	1-15	A/c (Du)	N.S.	Peak of 3000 ppm. "
DS17	16/10/79	3 : 4.5	1100	35	B.Z.D.	1	No A/c	N.S.	Peak of 3000 ppm. "
DS18	27/9/79	2 : 3	1200	15	B.Z.D.	1	P.C.	N.S.	Peak of 3000 ppm. "
DS19	10/10/79	2 : 3	550	30	B.Z.D.	6-7	No A/c	N.S.	Peak of 1200 ppm. "
DS20	5/2/80	1.5 : 6	450	20	B.Z.D.	1	No A/c	N.S.	Peak of 950 ppm. "
DS21, C1 1st Visit	18/7/80	3-2 : 3	600	15	B.Z.D.	15-20	Re A/c. E.F.C.	N.S.	Peak of 1200 ppm "
C2		3-2 : 3	600	20	B.Z.D.		Re A/c. E.F.C.	N.S.	Peak of 1400 ppm "
C3		3-2 : 3	600	15	B.Z.D.		Re A/c. E.F.C.	N.S.	Peak of 2000 ppm N_2O
C4		2 : 4	600	15	B.Z.D.		Re A/c. E.F.C.	N.S.	Peak of 1600 ppm N_2O
2nd Visit C1	30/6/81	3-2 : 3-2	90	60	B.Z.D.	30-36	Re A/c. E.F.C.	SM	Passive set up. (Peak 700ppm).
C2		3-2 : 3-2	580*	30	B.Z.D.	-	Re A/c. E.F.C.	SM	Passive and active set up. (peak 2000 ppm) leak around face seal.
			350	15	B.Z.D.	30-36	Re A/c. E.F.C.	SL	Replace (SM) with (SL) during dental session.
DS22	18/7/80								
C1		5 : 3	800	7	B.ZDN	15	A/c. E.F.C.	N.S.	Peak 1700 ppm N_2O (door opened)
C2		5 : 3	1800	35	B.ZDN		A/c. E.F.C.	N.S.	Peak 3000 ppm N_2O (door shut)
C3		3 : 4	1800	15	B.ZDN		A/c. E.F.C.	N.S.	Peak 3000 ppm N_2O
DS23									
EXPT, C1)	21/11/78	2 : 2	950	10	B.Z.D.	-	Re A/c.	N.S.	)
M. not W)			120	10	60P		11 AC/H		)
)			40	10	B.Z.D.	-	Re A/c	SL	)with 50 and 30 l/m
)			20	10	60P		11 AC/H		)suction.
)			55	10	B.Z.D.	-	Re A/c	SL	)with 20 l/m suction.
)			23	10	60P		11 AC/H		)
)			100	10	B.Z.D.	-	Re A/c	SL	)with 10 l/m suction.
			25	10	60P		11 AC/H		)
C2)		3 : 3	35	10	B.Z.D.	-	Re A/c.	SL	)50 l/m suction.
)			18	10	60P		11 AC/H		)
)			40	10	B.Z.D.	-	Re A/c.	SL	)30 l/m suction.
)			22	10	60P		11 AC/H		)
)			150	10	B.Z.D.	-	Re A/c.	SL	)10 l/m suction.
)			25	10	60P		11 AC/H		)
C3)		1 : 1	750	10	B.Z.D.	-	Re A/c	N.S.	) -
)			80	10	60P		11 AC/H		)
)			40	10	B.Z.D.	-	Re A/c	SL	)30 l/m Suction.
)			20	10	60P		11 AC/H		)
)			60	10	B.Z.D.	-	Re A/c	SL	)10 l/m Suction.
)			22	10	60P		11 AC/H		)
C4)		3 : 9	45	10	B.Z.D.	-	Re A/c	SL	)50 l/m Suction.
)			20	10	60P		11 AC/H		)
)			85	10	B.Z.D.	-	Re A/c	SL	)30 l/m Suction
			20	10	60P		11 AC/H		)

DENTAL SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 (1/m) (1/m)	WASTE GAS CONC: N_2O (ppm)	SAMP. TIME (min)	SITE MON.	RATE OF RA per WK (hrs)	VENTILATION	SCAV. SYSTEM	COMMENTS
M.W. & P.									
C1)		3 : 9	35	10	B.Z.D.	-	Re A/c	SL	)50 1/m Suction.
)			30	10	Env.		11 AC/H		)
)									)
)			95	10	B.Z.D.	-	Re A/c	SL	)30 1/m Suction.
)			85	10	Env.		11 AC/H		
C2)		1.5 : 4.5	30	10	B.Z.D.	-	Re A/c	SL	)50 1/m Suction.
)			30	10	Env.		11 AC/H		
)									)
)			30	10	B.Z.D.	-	Re A/c	SL	)30 1/m Suction.
)			27	10	Env.		11 AC/H		
DS24 EXPT, C1	19/9/78	2 : 3	280	18	B.Z.D.	15-25	Wd. A/c	N.S.	Peak 1100 ppm. Window open.
			190	18	Env.				
(Chd.) C2		1.5 : 2.5	360	15	B.Z.D.	-	2 AC/H	N.S.	Peak 950 ppm. Window open.
			180	15	Env.				
C3		1.5 : 4.5	450	21	B.Z.D.	-	2 AC/H	N.S.	Peak 1300 ppm. Window open.
			260	21	Env.				
C4		1.5 : 2.5	360	16	B.Z.D.	-	2 AC/H	N.S.	Peak 980 ppm. Window open.
			230	16	Env.				
C5		1.5 : 2.5	310	18	B.Z.D.	-	2 AC/H	N.S.	Peak 750 ppm. Window open.
			200	18	Env.				
C6		1.5-2.5:2.5-4.5	530	20	B.Z.D.	-	2 AC/H	N.S.	Peak 1150 ppm. Window closed.
			300	20	Env.				
C7		1.5 : 2.5	720	15	B.Z.D.	-	2 AC/H	N.S.	Peak 1900 ppm. Window closed.
			300	15	Env.				
C8		1.5 : 2.5	570	10	B.Z.D.	-	2 AC/H	N.S.	Peak 1070 ppm. Window closed.
			300	10	Env.				
C9		1.5 : 2.5	530	10	B.Z.D.	-	2 AC/H	N.S.	Peak 950 ppm. Window closed.
			300	10	Env.				
C1	26/9/78	1.5 : 2.5	180	11	B.Z.D.	-	2 AC/H	N.S.	Peak 550 ppm. Window closed.
			150	11	Env.				
C2		1.5 : 2.5	380	18	B.Z.D.	-	2 AC/H	N.S.	Peak 1250 ppm. Window closed.
			280	18	Env.				
C3		1.5 : 2.5	480	14	B.Z.D.	-	2 AC/H	N.S.	Peak 1200 ppm. Window closed.
			300	14	Env.				
C4		1.5 : 2.5	420	18	B.Z.D.	-	2 AC/H	N.S.	Peak 3000 ppm. Window
			300	18	Env.			closed.	
C5		1.5 : 2.5	280	12	B.Z.D.	-	2 AC/H	N.S.	Peak 580 ppm. Window closed.
			240	12	Env.				
C6		1.5 : 2.5	390	14	B.Z.D.	-	2 AC/H	N.S.	Peak 1030 ppm. Window closed.
			300	14	Env.				
C7		1.5-2.5:3.5-4.5	400	11	B.Z.D.	-	2 AC/H	N.S.	Peak 2700 ppm. Window closed.
			300	11	Env.				
C8		1.5 : 3.5	430	35	B.Z.D.	-	2 AC/H	N.S.	Peak 2250 ppm. Window closed.
			300	35	Env.				
C9		0.5-1.5:2.5-3.5	580	26	B.Z.D.	-	2 AC/H	N.S.	Peak 1000 ppm. Window closed.
			300	26	Env.				
C10		1.5 : 2.5	870	20	B.Z.D.	-	2 AC/H	N.S.	Peak 5000 ppm. Window closed.
			300	20	Env.				
C11		1.5-2 : 2.5-4	350	15	B.Z.D.	-	2 AC/H	N.S.	Peak 2120 ppm. Window closed.
			270	15	Env.				

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C1	3/10/78	1.5 : 2.5	210	20	B.Z.D.	-	3 AC/H	N.S.	Peak 1800 ppm. Window open.
			140	20	Env.				
C2		1.5 : 2.5	260	26	B.Z.D.	-	3 AC/H	N.S.	Peak 870 ppm. Window open.
			140	16	Env.				
C3		1.5 : 2.5	450	51	B.Z.D.	-	3 AC/H	N.S.	Peak 1450 ppm. Window open.
			250	51	Env.				
DS25 EXPT (Chd.) C1	15/2/80	1-1.5: 2.5-3	360	25	B.Z.D.	-	W.A/c	N.S.	Peak 1400 ppm.
C2		1-1.5: 2.5-3	230	7	B.Z.N.	-	W.A/c	N.S.	Peak 600 ppm.
C3		1-1.5: 2.5-3	260	27	B.Z.D.	-	W.A/c	N.S.	Peak 900 ppm.
C1	8/8/81	2-1.5: 2-2.5	360	20	B.Z.D.	-	W.A/c	N.S.	Peak 1700 ppm.
C2		2-1.5: 2-2.5	35	30	B.Z.D.	-	W.A/c	SL*	Peak 350 ppm. *Adult mask only available when did test.
C1	25/8/81	2 : 2	31	35	B.Z.D.	-	W.A/c	SL	Peak 350 ppm.
C2		4-1.5: 2-2.5	160	5	B.Z.D.	-	W.A/c	SL*	Peak 400 ppm. (patient exhaled through mouth).
C3		1.5 : 2.5	55	12	B.Z.D.	-	W.A/c	SL*	Peak 400 ppm.
DS25 EXPT. C1	11/9/81	4-1.5: 2-2.5	75	20	B.Z.D.		W. A/c	SL**	**Paediatric mask used peak 450ppm (Exhaled through mouth often)
C2		4-1.5: 2-2.5	70	18	B.Z.D.		W. A/c	SL**	peak 250ppm
C1)	22/9/81	4 : 2	1500	5	B.Z.D.		W. A/c	N.S.	peak>3000ppm (Conventional Mask held away from nose)
)		2 : 2	700	5	B.Z.D.		W. A/c	N.S.	peak > 3000ppm (Scavenging Mask held over nose)
)		1.5 : 2.5	70	17	B.Z.D.		W. A/c	SL**	peak 200 ppm

Table A-3
Anaesthetic Pollution Survey - Veterinary Surgeries

VETERINARY SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m)(%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Other (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
VS1	26/6/78										
C1		2 : 1 :5-1.5	300	15	-	30	B.Z.S.	I,C,*T.P.**	Re A/c	N.S.	*C= Spontaneous ** T-Piece
C2		2 : 1 :5-1.5	300	12	-	25	B.Z.S.	I, C, T.P.	Re A/c	N.S.	
C3		2 : 1 :5-1.5	300	17	-	120	B.Z.S.	I, C, T.P.	Re A/c	N.S.	
VS2	27/7/78										
C1		- : 0.2: 0.5	-	0.3	-	23	B.Z.S.	I,C,Cl.C.*	Ev. C. (Du)	N.S.	*Cl. C. = closed circuit. FAN SETTING ON FULL window always left slightly opened.
C2		- : 0.2 :0.5	-	1.1	-	20	B.Z.S.	I, C, Cl. C.	Ev. C. (Du)	N.S.	FAN OFF.
							B.Z.S.	I, C, Cl. C.	Ev. C. (Du)	N.S.	Komesaroff An. Machine
C3		- : 0.2 :0.5	-	0.8	-	45	B.Z.S.	I, C, Cl. C.	Ev. C. (Du)	N.S.	FAN OFF
VS3	31/7/78										
C1		0.5 :0.25 :MAX*	26	1.8	-	30	B.Z.S.	I, C, Cl. C.	Re A/c	SP	*Goldman Vap.
C2		0.5 :0.25 :MAX*	28	3.5	-	3.5	B.Z.S.	I, C, Cl. C.	Re A/c	SP	
VS4	16/8/78										
C1		0.5 :0.4:2-0.5	200	1.3	-	29	B.Z N.	I, C, Cl. C.	Ev. C* (Du)	N.S.	)*A/c not usually ON)Has exhaust fan in)window. Turned ON.)
		0.5 :0.4:2-0.5	170	1.3	-	10	B.Z S.	I, C, Cl. C.	Ev. C* (Du)	N.S.	)
C2		0.6 :0.4 :0.5	170	1.4	-	11	B.Z.S.	I, C, Cl. C.	Ev. C* (Du)	N.S.	)*A/c not usually)ON. Has exhaust
C3		0.6 : 0.3 :0.5	90	1.1	-	15	B.Z.S.	I, C, Cl. C.	Ev. C* (Du)	N.S.	)fan in window.) Turned ON.
C4		0.6 : 0.4 :1.0	220	2.1	-	30	B.Z.S.	I, C, Cl. C.	Ev. C* (Du)	N.S.	))
		0.6 : 0.4 :1.0	70	1.2	-	15	B.Z.S.	I, C, Cl. C.	Ev. C* (Du)	N.S.	)
VS5	22/11/78										
C1		0.4 : 0.4 : 2	45	1.6	-	25	B.Z.S.	I, A, C.C.*	Re A/c (Du)	N.S.	*Circle circuit. (dog)
C2		0.8 : 0.8 : 2	140	5	-	18	B.Z.S.	M, A, T.P.*	Re A/c (Du)	N.S.	)*T-piece (cat).)Jackson-Rees)assembly.)
C3		0.8 : 0.8 : 2	115	5.5	-	17	B.Z.S.	M, A, T.P.*	Re A/c (Du)	N.S.	)Note: cat induced)with ether in box.)
C4		0.8 : 0.8 : 2	160	5.0	-	28	B.Z.S.	M, A, T.P.*	Re A/c (Du)	N.S.	)
VS6	28/11/78										
C1		- : 0.1 :MAX	-	1.2	-	30	B.Z.S.	I, C, Cl.C.	W. A/c, E.F.Wd.	N.S.	Komesaroff Anaesth. Machine
C2		- : 0.1 :MAX	-	1.1	M.O.F. 0.6	15	B.Z.S.	I, C, Cl.C.	W. A/c, E.F.Wd.	N.S.	A/c & Fan ON. High leaks - mouth of dog and vapour (> 10 ppm HAL).
VS7	30/11/78	- : 0.4 : 6	-	5.0	-	5	B.Z.S.	M, A, Cl. C.	Re. A/c* (Du)	N.S.	Induction
C1		- : 0.4 :6-3	-	2.0	-	25	B.Z.S.	M, A, Cl. C.	E.F.W.	N.S.	Bottle Vap (leaky > 10ppm HAL). * A/C OFF

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C2		- : 0.4 :6-3	-	3.0	-	27	B.Z.S.	M, A, Cl. C.	E.F.W.	N.S.	
											C.I.G.-Midget Anaesth. Machine
C3		- : 0.4 :6-2	-	2.3	-	13	B.Z.S.	I, C, Cl.C.	A/c ON	N.S.	
C4		- : 0.4 :6-2	-	1.7	-	8	B.Z.S.	I, C, Cl.C.	A/c ON	N.S.	
VS8	24/11/78										C.I.G. Midget.
C1		- : 0.4 :6-2	-	1.2	-	5	B.Z.S.	M, A, Cl. C.	Re. A/c* ON (Du)	N.S.	)Cat induced in box)with ether.
C2		- : 0.4 :6-2	-	1.1	-	5	B.Z.S.	M, A, Cl. C.	Re. A/c* ON (Du)	N.S.	)Cat induced in box.))
C3		- : 0.4 :6-2	-	1.6	-	12	B.Z.S.	M, A, Cl. C.	Re. A/c* ON (Du)	N.S.	))
C4		- : 0.4 :6-2	-	2.0	-	15	B.Z.S.	I, C, Cl. C.	Re. A/c* ON (Du)	N.S.	)Dog induced with)5-6% HAL.)
C5		- : 0.4 :6-2	-	2.5	-	9	B.Z.S.	I, C, Cl. C.	Re. A/c* ON	N.S.	)
VS9	23/11/78										Stephens An. Machine
C1		- : 0.4 :6-2	-	0.6	-	11	B.Z.S.	I, A, Cl. C.	W.A/c, E.F.W.	N.S.	Window slightly open
C2		- : 0.4 :6-2	-	1.1	-	8	B.Z.S.	I, A, Cl. C.	W.A/c, E.F.W.	N.S.	Leaks in mouth and Vap (~8ppm).
VS10	1/12/78										CIB Midget An Machine and Stephens bottle Vap. (used).
C1		- : 0.3 :5-6	-	1.2	-	10	B.Z.S.	M, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	)Cats induced with)ether.)
C2		- : 0.3 :5-6	-	1.2	-	11	B.Z.S.	M, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	)))
C3		- : 0.3 :5-6	-	1.2	-	7	B.Z.S.	M, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	))
C4		- : 0.3 :6-2	-	1.3	-	14	B.Z.S.	I, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	)Dogs induced with)5-6% HAL.)
C5		- : 0.3 :6-2	-	1.7	-	9	B.Z.S.	I, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	)))
C6		- : 0.3 :6-2	-	0.8	-	50	B.Z.S.	I, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	))
C7		- : 0.3 :6-2	-	0.8	-	7	B.Z.S.	I, C, Cl. C.	W.A/c (Du) E.F.W.	N.S.	))
VS11	14/12/78	- : 0.2 :1-3	-	1.6	-	105	B.Z.S.	I, C, Cl. C.	W.A/c (Next Rm)	N.S.	Window opened (Poor circulation)
		- : 0.2 :1-3	-	2.0	-	23	B.Z.S.	I, C, Cl. C.	W.A/c (Next Rm)	N.S.	C.I.G.-MIDGET An Machine and Stephens Vap used.
VS12	2/2/79	- :1.0 :1/4U	-	0.6	-	30	B.Z.S.	I, C, Cl. C.	No .A/c E.F.	N.S.	Komesaroff An Machine FAN ON, WINDOW OPEN.
		- :1.0 :1/4U	-	0.9	-	18	B.Z.S.	I, C, Cl. C.	No .A/c E.F.	N.S.	FAN ON, WINDOW SHUT.

VETERINARY SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 : HAL (l/m) (l/m) (%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Other (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
VS13	20/2/79										*A/c usually not on.
C1		- :0.2 :3/8U	-	2.3	-	90	B.Z.S.	I, C, Cl. C.	W. A/c*	N.S.	A/c on for this test STEPHENS ANAEST. MACHINE.
	6/12/79										MIRAN 1A used.
											MIRAN 1A used.
C1		- : 0.2 :1/2 - 3/8U	-	0.5	-	30	B.Z.S.	I, C, Cl. C.	W.A/c**	SQ*	*Scav system made by Surgeon
C2		- : 0.2 :1/2 - 3/8U	-	0.4	-	20	B.Z.S.	I, C, Cl. C.	W.A/c**	SQ*	Vap on MAX for induction. **A/c not used.
VS14	30/1/79										
C1		- :0.6:2-2.5	-	5	-	50	B.Z.S.	M, C, C. C.	No A/c	N.S.	No exhaust.
C2		- :0.6:2-2.5	-	8.5	-	30	B.Z.S.	M, C, C.C.	No A/c	N.S.	C.I.G. Midget An Machine.
VS15	16/2/79										
C1		- : 1.0:3/8U	-	2.5	-	37	B.Z.S.	I,C, Cl.C.	Wd A/c, E.F.*	N.S.	STEPHENS Anaesth Machine. *Next room.
VS16	14/2/79										
C1		- :0.25 : 2	-	0.6	-	18	B.Z.S.	I, C, C.C.	Re A/c (Du) 14AC/H	N.S.	Window slightly opened.
C2		- :0.25 : 2	-	0.6	-	17	B.Z.S.	I, C, C.C.	Re A/c (Du) 14AC/H	N.S.	C.I.G.-MIDGET An Machine.
C3		- : 0.25: 2	-	0.6	-	23	B.Z.S.	I., C., C.C.	Re A/c (Du) 14AC/H	N.S.	(Leaky exhale valve i.e. >10 ppm).
C4		- : 0.25: 2	-	0.7	-	15	B.Z.S.	I., C., C.C.	Re A/c (Du) 14AC/H	N.S.	
VS17	19/3/79										C.I.G.-T.M.41 An Machine.
											MIRAN 1A used
L.T., C1		- : 9.0 : 4	-	15	-	18	B.Z.S.	I, C, C.C.	Re A/c (Du) E.F.W.	N.S.	Circle Circuit - high flow rates, high leaks from mouth (~60ppm) patched breathing bag)(>80 ppm) exhale valve (30 ppm)
C2		- : 9.0 :3.5	-	14	-	55	B.Z.S.	I, C, C.C.	Re A/c (Du) E.F.W.	N.S.	(Oper. on Horse)
		- : 9.0 :3.5	-	11	-	5	EXH* Gr	I., C., C.C.	Re A/c (Du) E.F.W.	N.S.	*Exh Grill give room av. conc.
C3		- : 9.0 :3.5	-	12	-	56	B.Z.S.	I., C., C.C.	Re A/c (Du) E.F.W.	N.S.	(Oper. on Horse)
sT, C1	21/3/79	- : 9.0 :1.5	-	2.8	-	80	B.Z.S.	I., C., C.C.	Re A/c (Du)	N.S.	One Anaesth Machine used in the two theatres.
VS18	29/3/79	- : 1.7 : 2	-	2.5	-	40	B.Z.S.	I., C., C.C.	No A/c. No E.F.	N.S.	A/c in reception area. (MIRAN 1A used)

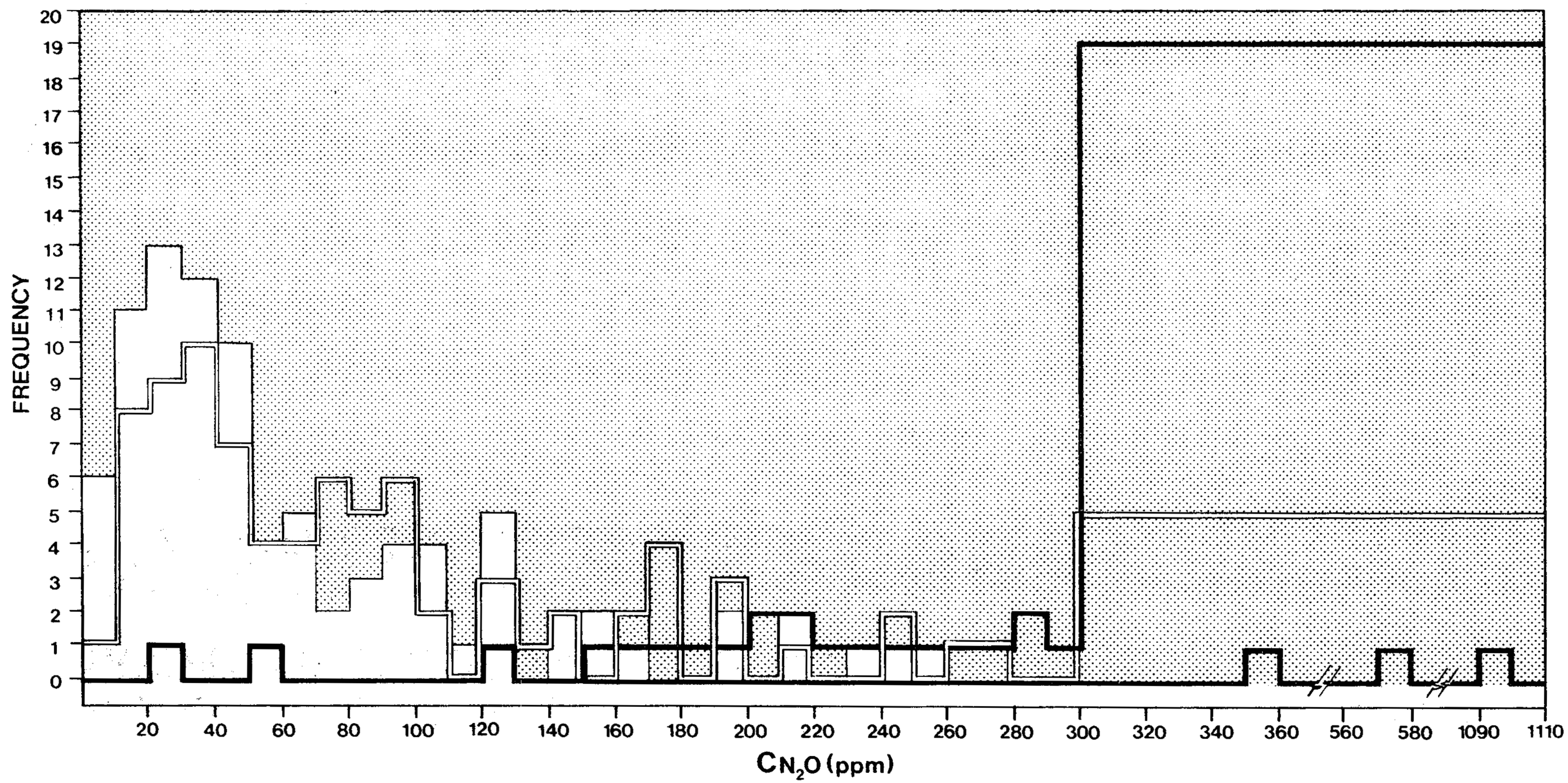
VETERINARY SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m) (%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Other (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
<u>VS19</u>	8/5/79										C.I.G. MIDGED 2 An Machine. Bottle Vap (leaky > 10 ppm)
C1		- :0.2:4-1/2U	-	4.6	-	15	B.Z.S.	I., C., C.C.	W. A/c	N.S.	A/c OFF
C2		- :0.2:4-1/2U	-	2.7	-	15	B.Z.S.	I., C., C.C.	W. A/c	N.S.	A/c OFF
C3		- :0.2:4-1/2U	-	2.1	-	15	B.Z.S.	I., C., C.C.	W. A/c	N.S.	A/c ON
<u>VS20</u>	30/5/79										MIRAN 1A used.
C1		- :0.5-0.8: 2-2.5*	-	3.0	-	25	B.Z.S.	I, C, Cl. C.	No A/c Wd. open	N.S.	C.I.G. BOYLE An machine. Glass Vap)*0.5-0.8 setting on)Vap.)
C2		-1.0: 2.5**	-	5.5	-	35	B.Z.S.	I, C, Cl. C.	No A/c Wd. open	N.S.	)** 0.7 setting on) Vap.)
C3		-0.6: 2.5**	-	3.1	-	13	B.Z.S.	I, C, Cl. C.	No A/c Wd. open	N.S.	))
<u>VS21</u>	24/5/79										MIRAN 1A used. (C.I.G. Midget A.M. Stephens Vap.)
C1		-0.4: 1/2U	-	9.0	-	19	B.Z.S.	I, C, Cl. C.	Ev. C.	N.S.	Window <u>closed</u>.
C2		-0.4: 1/2U	-	5.5	-	15	B.Z.S.	I, C, Cl. C.	Ev. C.	N.S.	Window <u>open</u>.
C3		-0.2: 1/2U	-	5.0	-	19	B.Z.S.	I, C, Cl. C.	Ev. C.	N.S.	Window <u>closed</u>.
<u>VS22</u>	21/7/80										
Room 1 C1		1.0 : 0.7 : 2	25	0.5	-	40	B.Z.S.	I, C, Cl. C.	No A/c, E.F.Wd	SR	Fan on ceiling as well.
C2		1.0 : 0.7 : 2	20	0.8	-	20	B.Z.S.	I, C, Cl. C.	No A/c, E.F.Wd	SR	<u>Boyle An. Machine</u>
C3		1.0 : 0.7 : 2	8	0.5	-	10	B.Z.S.	I, C, Cl. C.	No A/c, E.F.Wd	SR	Moved machine next to Exhaust Fan.
Room 2 C1		- : 0.75: 2U	-	3.0	-	30	B.Z.S.	I, C, Cl. C.	W.A/c, No E.	N.S.	<u>Komesaroff An.Machine</u> Large leak in Vap (> 10ppm).
<u>VS23</u>	17/7/80										
C1		2.0 : 3 :2.5	300	15	-	30	B.Z.S.	<u>M</u>, C, Cl. C.	W.A/c	N.S.	Midget 3 Anaesth Machine used 4.5% HAL Induction.
C2		2.0 : 3 :2.5	300	17	-	60	B.Z.S.	<u>M</u>, C, Cl. C.	W.A/c	N.S.	
<u>VS24</u>	31/7/80										C.I.G. Midget An Machine.
C1		0.4 : 0.3 : 1	50	1.1	-	35	B.Z.S.	M, C, Cl. C.	W.A/c., E.F.W.	N.S.	peak valves 250 ppm N_2O, 5ppm HAL.
C2		0.4 : 0.3 :2.5	45	1.2	-	35	B.Z.S.	M, C, Cl. C.	W.A/c., E.F.W.	N.S.	peak valves 280 ppm N_2O, 6ppm HAL.
2nd Visit	23/9/81										
C1		0.4 :0.3:2-1.5	40	1.3	-	20	B.Z.S.	I,C, C.C.	Ev. C. (Du)	SB	A/c OFF (Exh Fan ON)
C2		0.5 :0.4:2-0.5	65	2.0	-	20	B.Z.S.	I, C, T.P.	Ev. C. (Du)	SB	A/c OFF (Exh Fan ON)
C3		0.6 :0.4: 1.0	55	1.5	-	9	B.Z.S.	I, C, T.P.	Ev. C. (Du)	SB	A/c OFF (Exh Fan ON)
C4		0.6:0.4:0.5-1.5	10	0.5	-	15	B.Z.S.	I, C, T.P.	Ev. C. (Du)	SB	A/c ON (Exh Fan ON)
C5		0.4 :0.5 :1.0	35	0.5	-	35	B.Z.S.	I,C, C.C.	Ev. C. (Du)	SB	A/c ON (Exh Fan ON)

VETERINARY SURGERY	DATE	FRESH GAS FLOW N_2O : O_2 :HAL (l/m) (l/m) (%)	WASTE GAS CONC: N_2O (ppm)	HAL (ppm)	Other (ppm)	SAMP. TIME (min)	SITE MON.	ANAES. PROC.	AIR COND.	SCAV. SYSTEM	COMMENTS
VS25	16/9/80										Anaesth Machine built by H26. Hospital
C1		0.5 : 1 : 4 Ethrane	240	-	24.0	130	B.Z.S.	M, C., C.C.	No A/c. E.F.C.	N.S.	Ethrane Vap. peak values, >300 ppm N_2O, 60 ppm Ethrane.
VS26	29/6/10										
mT, C1		0.25:0.5:4-2.5	28	2	-	40	Env	M, C, Cl. C.	Re A/c.	N.S.	Injecting rats.
			38	4	-	60	B.Z.S.	M, C, Cl. C.	Re A/c.	N.S.	Injecting rats.
C2		0.25: 0.5 : 2	45	4	-	35	B.Z.S.	M, C, Cl. C.	Re A/c.	SS	Operating on rats.
		0.25: 0.5 : 2	40	4	-	30	B.Z.A.	M, C, Cl. C.	Re A/c.	SS	Operating on rats.
MT, C1		0.5 : 1.2 :4-2	100	9	-	35	Env	M, C, Cl. C.	Re A/c.	N.S.	Operating on rats. peak, 35ppm HAL., >300ppm N_2O

ANAESTHETIC POLLUTION SURVEY: HOSPITALS NITROUS OXIDE RESULTS

FIGURE B-1 (a) TAKEN FROM TABLE AI

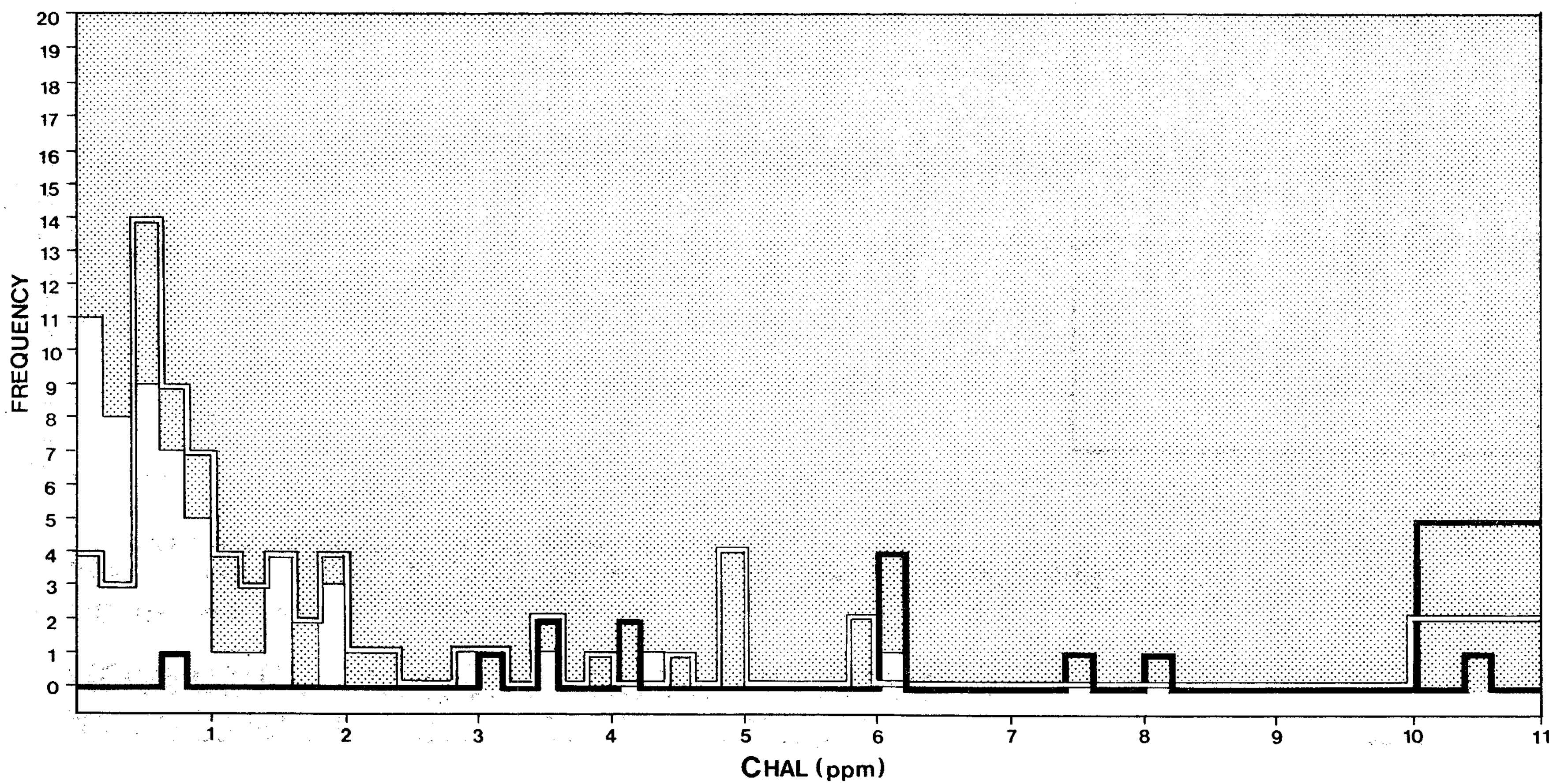
KEY: ▭ RECOMMENDED SCAVENGING SYSTEM; ▬ NO SCAVENGING; ═ NON RECOMMENDED SCAVENGING SYSTEM



ANAESTHETIC POLLUTION SURVEY: HOSPITALS HALOTHANE RESULTS

FIGURE B-1 (b) TAKEN FROM TABLE AI

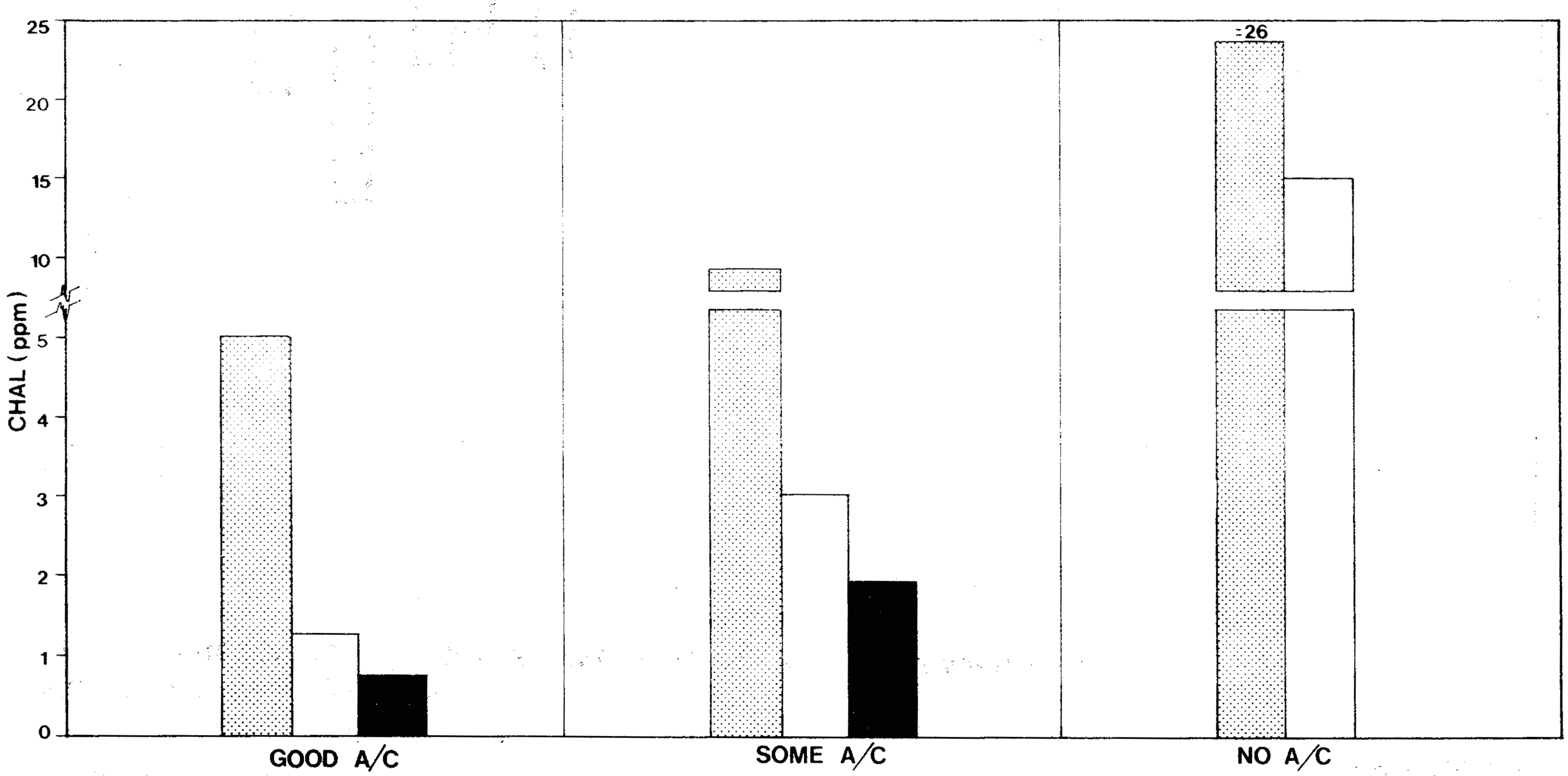
KEY: ▭ RECOMMENDED SCAVENGING SYSTEM; ▬ NO SCAVENGING; ═ NON RECOMMENDED SCAVENGING SYSTEM



ANAESTHETIC POLLUTION SURVEY: HOSPITALS

FIGURE B-1 (c) TAKEN FROM TABLE AI

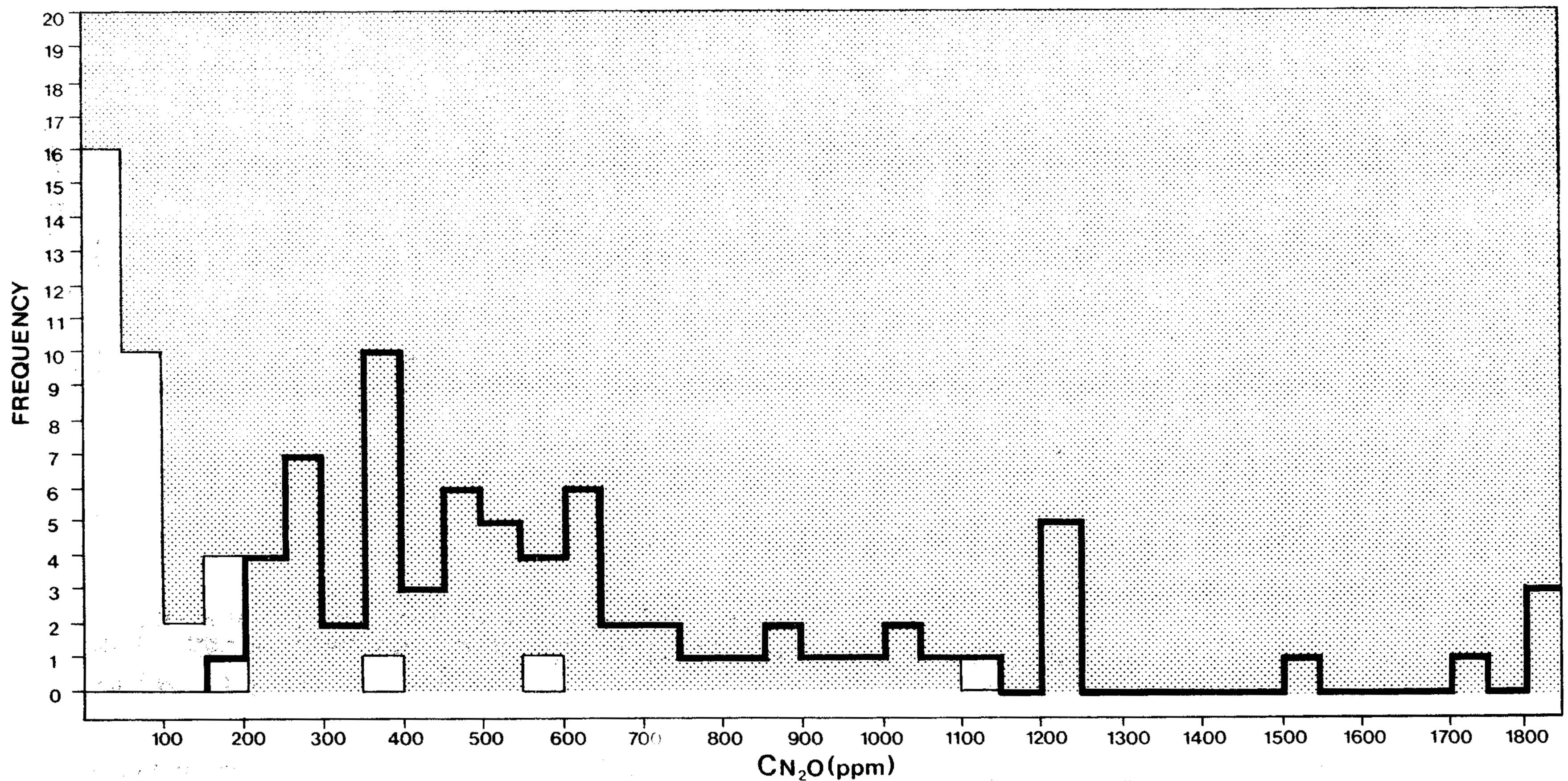
KEY: ■ RECOMMENDED SCAVENGING SYSTEM; ▒ NO SCAVENGING; □ NON RECOMMENDED SCAVENGING SYSTEM



ANAESTHETIC POLLUTION SURVEY : DENTAL SURGERIES

FIGURE B-2 TAKEN FROM TABLE A2

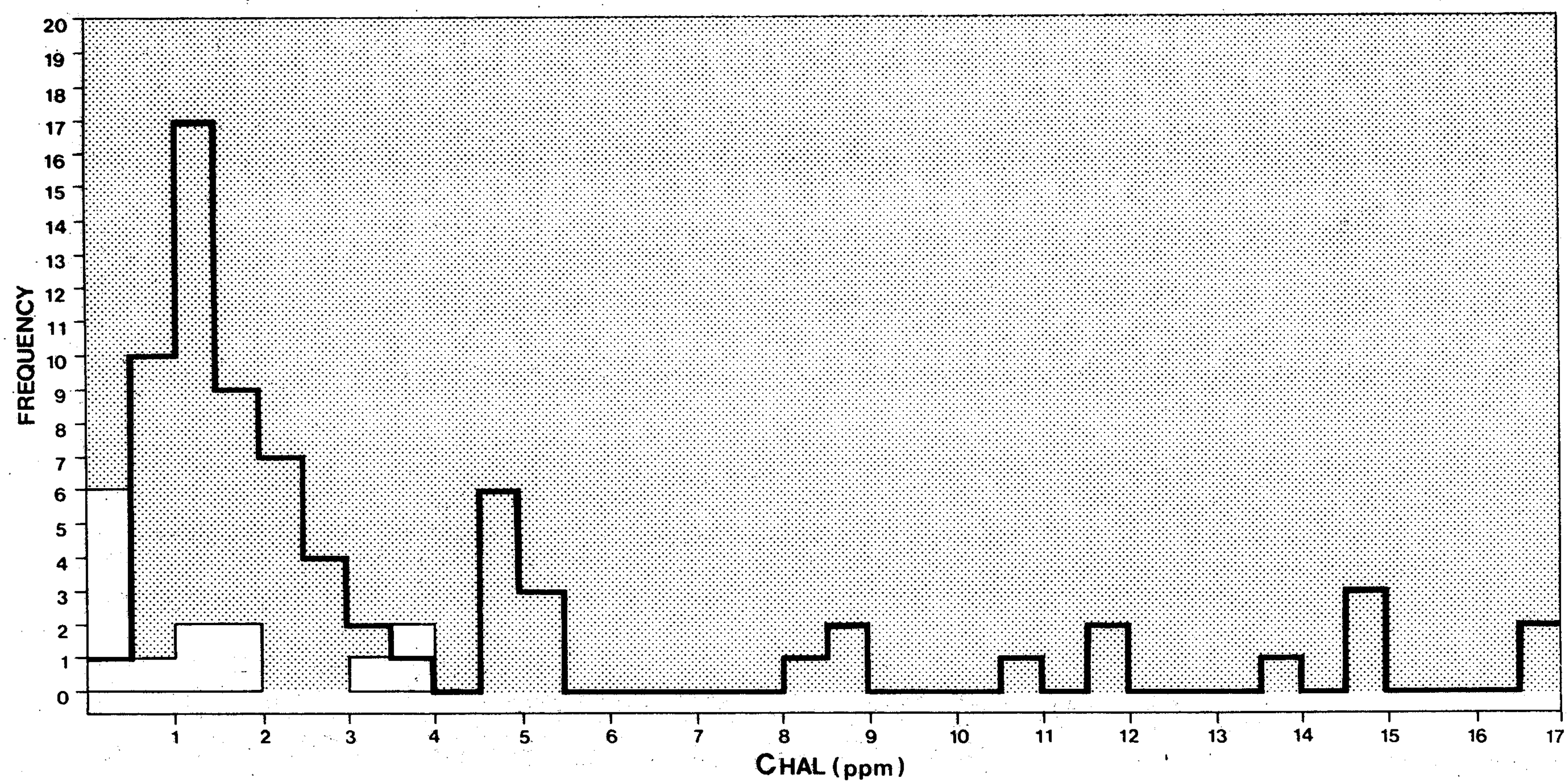
KEY : ▭ RECOMMENDED SCAVENGING SYSTEM ; ▬ NO SCAVENGING



ANAESTHETIC POLLUTION SURVEY : VETERINARY SURGERIES

FIGURE B-3 TAKEN FROM TABLE A3

KEY : ☐ RECOMMENDED SCAVENGING SYSTEM ; ▬ NO SCAVENGING

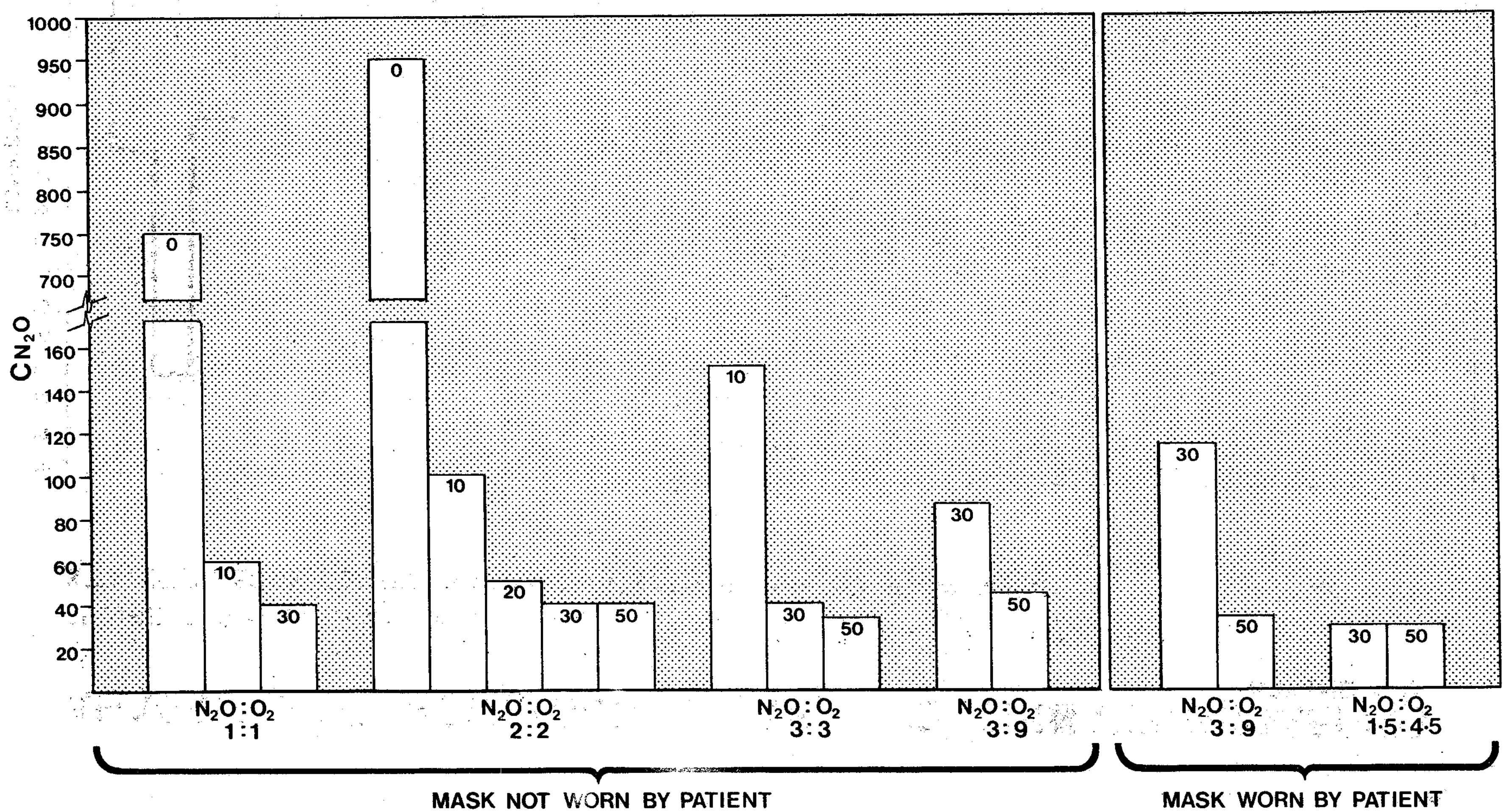


A GRAPHICAL REPRESENTATION OF THE EXPERIMENTAL EVALUATION OF THE BROWN MASK

(TAKEN FROM TABLE 2; DS 23)

FIGURE B-4

KEY: 0: ZERO SUCTION; 10: 10 L/min SUCTION; 20: 20 L/min SUCTION; 30: 30L/min SUCTION; 50: 50L/min SUCTION
(REPRESENTS THE SCAVENGING SUCTION FLOWRATE IN LITRES/minute)



APPENDIX C DESCRIPTION OF SCAVENGING SYSTEMS

HOSPITALS

DESCRIPTION

SYSTEM

SA1 CIG-Medishield Scavenging System MK I (1st system released (See Figure 1)

Original CIG system - adaptor fits over the Exhale Valve of the anaesthetic apparatus or the ventilator. The adaptor is fitted with a wide bore outlet, plus a nipple for connection of standard suction tubing. The wide bore outlet is fitted with a 1.5 metre length of corrugated tubing which acts as a reservoir for waste anaesthetic gases released from the exhale valve.

Waste gases are removed continuously from the reservoir by suction applied to the nipple and vented to the outside atmosphere via a suitable suction system.

Recommended suction air flow is 30 litres/min.

Disadvantage : scavenging can only be applied at either the exhale valve or the ventilator. Therefore when the ventilator is used, considerable leakage occurs from the unscavenged exhale valve (although it is closed).

SA2 Modification of Medishield Scavenging System MK I (See Figure 2)

Similar to system MKI except the suction is divided into 2 sections via a Y piece in order to scavenge from both the Exhale Valve and the Ventilator.

Disadvantage : the suction flowrate, originally about 30l/min, is halved at each site of scavenging. Therefore pollutants are "dumped" into the theatre environment because the suction (of 15 litres/min) cannot cope.

SA3 Medishield Scavenging System MK I - Modified for use with Paediatric Circuit (See Figure 7)

The Interface was provided by a trailing piece of a 22mm corrugated clear tubing. The narrow bore rubber tubing leads from the tail of the paediatric breathing bag to the interface (about 20cm into the corrugated tube).

The other end of the interface is connected to an adaptor which fits over the ventilator or exhale valve. The adaptor is fitted with a nipple for connection of standard suction tubing. The suction tubing in turn is connected to suction system which vents outside the hospital.

SA4 CIG -Medishield Scavenging System MKI Modified to Passive System (See Figure 8)

Using the CIG-Medishield scavenging system, MKI, except that the suction nipple on the adaptor over the exhale valve is blocked, and the reservoir tube is connected to a hole in the wall. The waste gases are removed from the threatre 'passively' relying on the pressure gradient between the patient's lungs and the outside atmosphere to generate flow along a low resistance pathway.

SB CIG-Medishield Scavenging System MKII (See Figure 4)

Consists of the following sections :

1. Gas Capturing Assembly : This is located in the breathing circuit, by means of :

   (a) a shroud to cover the CIG-Medishield range of "DF" Type exhale valves on the circle absorber Units.

   (b) "Heidbrink" type exhale valve fitted to circle absorber unit on the anaesthetic machine.

   (c) Various adaptors attached to the exhale port of the automatic ventilators (e.g. Bird, Bennett, etc.)

2. Interface Assembly : located in between the breathing circuit and the suction disposal unit.

   The unit is constructed of clear polycarbonate having a capacity of two litres, with relief holes at the base, thus preventing suction build-up.

The head, made of high density plastic, has a suction-flow gauge, entry ports for attaching corrogated tubing (19mm) from the expiratory valve on the absorber unit and exhaust part of the ventilator unit, and a nipple for connection to standard suction tubing.

3. <u>Dedicated Evacuation System</u> : The interface is connected to the suction system via the standard gas disposal assembly tube. The system should provide a volume flow of 30-40 litres/min (not necessarily high vacuum), in order to convey the waste gases to a disposable site outside the operating theatre work area in such a manner that occupational re-exposure does not occur.

<u>Note</u> : A 'silencer' is included in the head of the interface, in order to reduce the noise produced by air through the interface.

(Commercially approved system).

<u>SC</u> <u>Drager Rubber Interface</u> (as supplied inb April 1976 to Hospital
(See Figure 3)

Drager active scavenging system based on the venturi principle. It evacuates the surplus anaesthetic gases and vapours away from the operating theatre through a vent pipe of up to 30 metres length to the outside atmosphere or into an exhaust duct. The anaesthetic waste-gas socket is built into a ceiling mounted column and connected with the outlet nozzle of the anaesthetic apparatus by means of a hose and an adaptor. The rubber part of the adaptor which has three relief holes, does NOT include an adequate reservoir facility.

<u>Disadvantage</u> : it lacks an interface reservoir, and therefore considerable 'dumping' of pollutants results through the rubber adaptor.

<u>Note</u> : This system is no longer used.

SD Drager's Universal Antipollution System *(See Figure 5)

The Interface consists of two Sections :

(1) Two standard 22mm tapers which accept hose from the breathing circuit (including ventilator), and the expiratory valve. The latter can be fully closed when the ventilator is included in the circuit.

(2) The collecting and disposal section which includes :

(a) a reservoir bag (capacity 500ml) to accept transient peak flows.

(b) safety gravity loaded valve, to allow venting of excessive pressure in the collecting chamber to atmosphere.

(c) Leaf valve to allow ingress of room air to compensate for the excess of suction over the spill from the expiratory valve or ventilator.

(d) Two entry ports, one connected to a dedicated evacuation system, and the other is connected to the Ventilator.

(Commercially approved system).

* SAUNDERS, J.M., "A Versatile Antipollution Device" Anaesthesia and Intensive Care, Vol V11, No. 1, 1979.

SE Paediatric - Holland Scavenging System (See Figure 6)

Interface - an Underwater Drainage Bottle (Tuta Meraseal) modified to act as an interface for scavenging the Jackson-Rees modification of the Ayre's T-piece.

The conversion is effected by drilling eight one centimetre relief holes, connecting one nipple ('patient') to the tail of the bag and the other nipple to the dedicated scavenging system. Volume of the reservoir is 1.5 litres.

APPENDIX C DESCRIPTION OF SCAVENGING SYSTEMS

DENTAL SURGERIES

DESCRIPTION

SYSTEM

SL Brown Nitrous Oxide Scavenging Mask for Relative Analgesia
(See Figure 9)

Consists of a double mask system. The inner mask is contained within the slightly larger outer mask, and a slight vaccuum is present in the space between masks.

This vacuum, scavenges the waste nitrous oxide exhaled by the patient as well as any leakages around the edges of the inner and outer masks.

Two larger hoses (9.5 mm (I.D.) supply the anaesthetic gases to the inner mask. The two smaller hoses (6.5mm I.D.), open into the space between layers, and are used for scavenging.

SM Quantiflex Dental Anti-Pollution Systems For Relative Analgesia

Passive System (See Figure 10a)

The passive anti-pollution system consists of :

1. a nose piece with an air inlet valve on top. One side of the nose piece is fitted with a clear 22mm inspiratory corrugated tube, with a non-return valve. The other side is fitted with a expiratory tube with a non-return valve. The expiratory tube is directed to the outside atmosphere.

Active System (See Figure 10b)

Similar to the passive system, except that the expiratory tube is connected to an interface. The interface is a clear polycarbonate cylinder with relief holes at the base to prevent suction build up.

The head has a pressure gauge, an entry port for attaching the expiratory tube, and a nipple for connection of standard suction tubing. The suction tubing is connected to a suction line which exhausts to the outside atmosphere.

APPENDIX C DESCRIPTION OF SCAVENGING SYSTEMS

VETERINARY SURGERIES

SYSTEM	DESCRIPTION
SP	Inhouse Made Scavenging System : - Type I (See Figure 11) The exhaled gases pass through a non-return valve via a narrow bore tube into a 22mm corrugated tube which acts as the INTERFACE. The other side of the corrugated tube is connected to a suction system which vents into the outside atmosphere.
SQ	Inhouse Made Scavenging System : Type II (See Figure 12) Consists of : (a) a perspex box covering the anaesthetic machine. (b) a flexible corrugated pipe (10cm I.D.) connected from the top of the box to a pump above the ceiling which vents to the outside atmosphere. (c) a small lid on top of the box provides easy access to the anaesthetic machine. (d) an opening infront of the box facing the animal on the operating table ensures that any leak from the mouth area is readily exhausted.
SR	Passive System (See Figure 13) Corrugated tube fitted over Exhale valve of Komesaroff anaesthetic machine. The corrugated tube is connected to the grill of the Exhaust fan in the window.
SS	Inhouse Made Scavenging Mask (See Figure 14) The mask consisted of a cup-within a cup. The fresh gas was connected to the inner mask. A suction hose is connected on top of the outer mask. The waste gases coming out of the inner mask pass through vents situated on the outside of the outer mask, and finally through the suction system to the outside atmsophere.
SB	CIG - Medishield Scavenging System MK11 (same system which is used in hospital operating theatres - see figure 4).

C.I.G. – Medishield Scavenging System–MK I

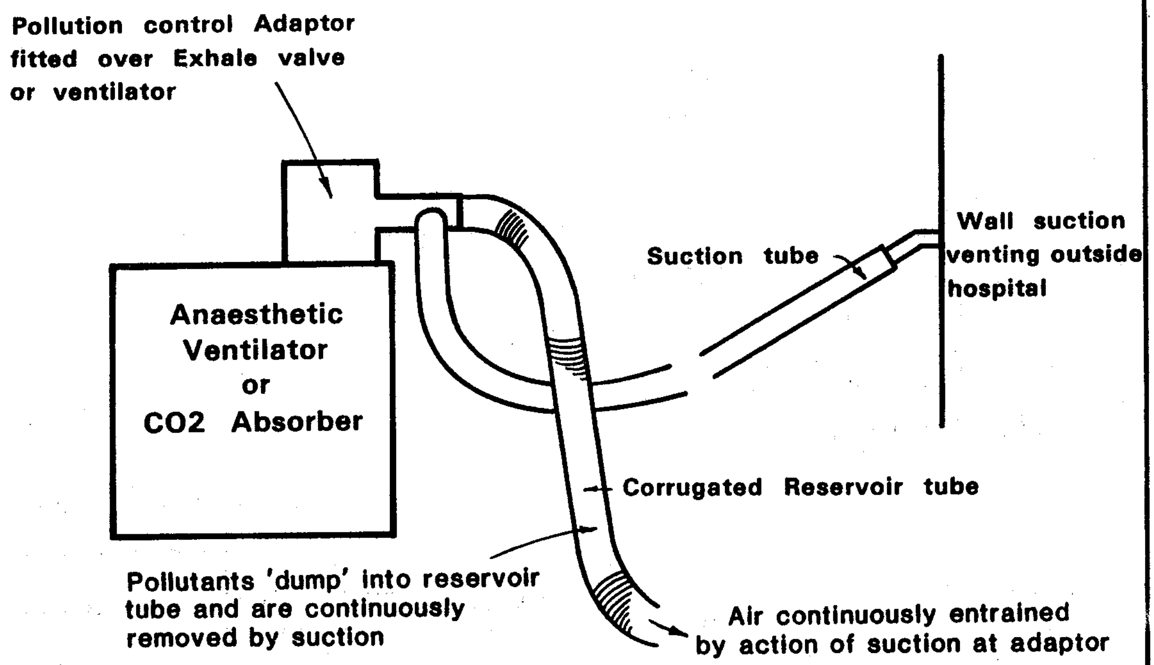


Fig.No. 1

Modification of
C.I.G. Medishield Scavenging System
MK I

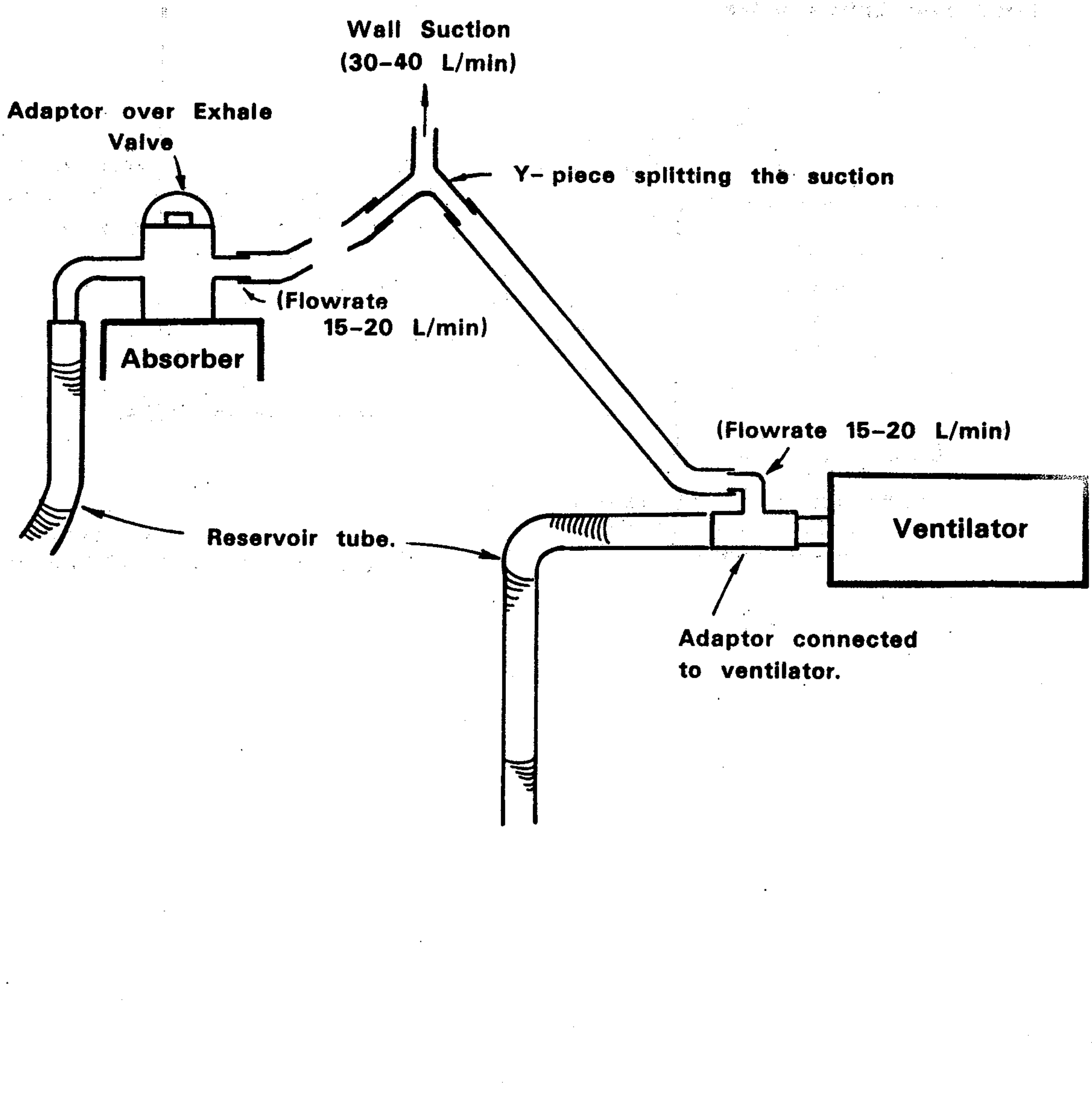


Fig.No. 2

Dräger Rubber Interface.

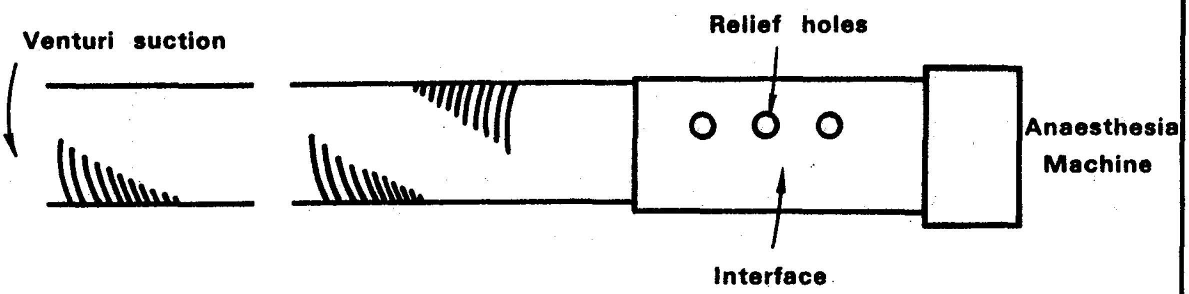
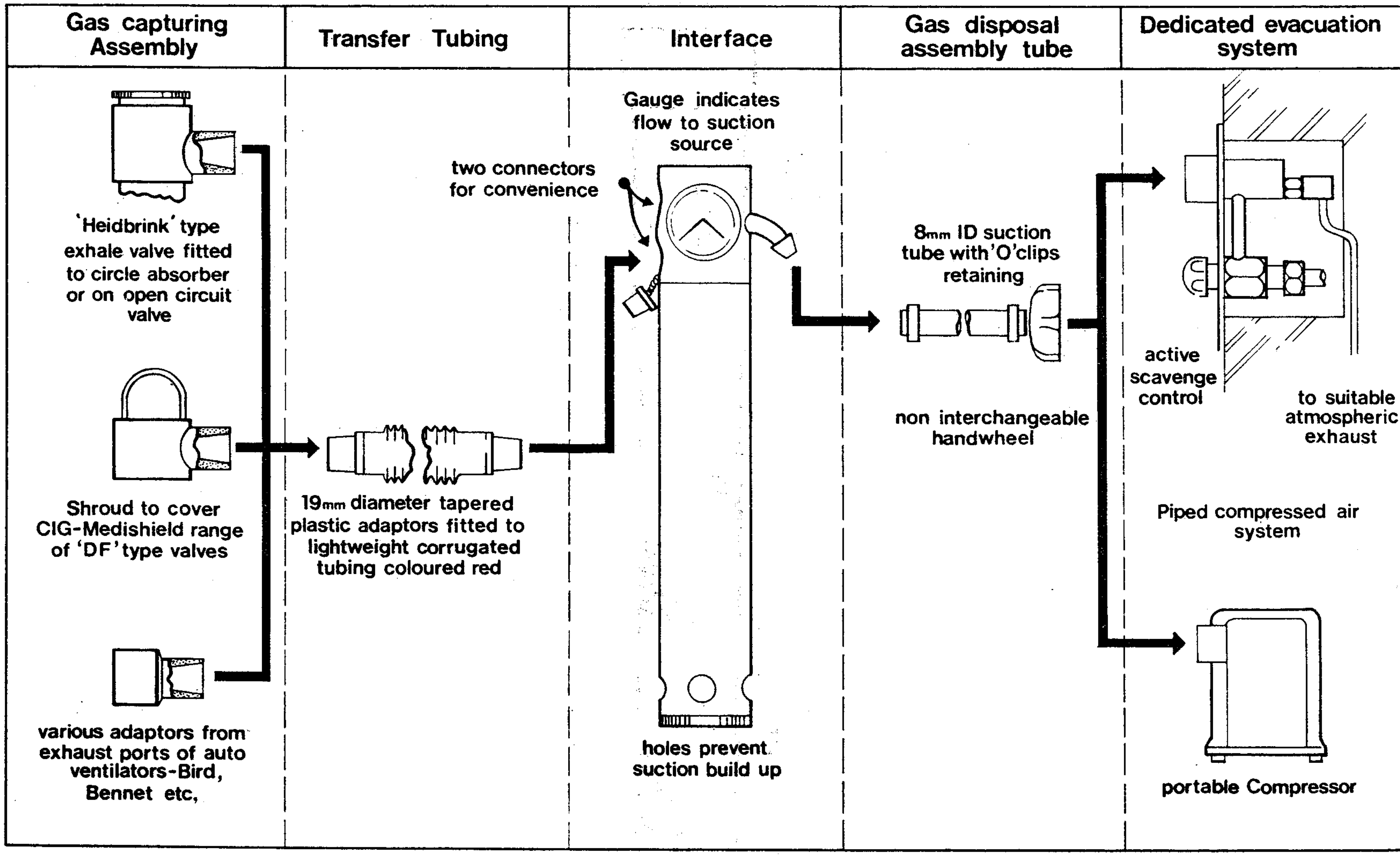


Fig.No. 3

FIGURE 4

CIG MIDISHIELD SCAVENGING SYSTEM MARK II



DRÄGER'S UNIVERSAL ANTIPOLLUTION SYSTEM

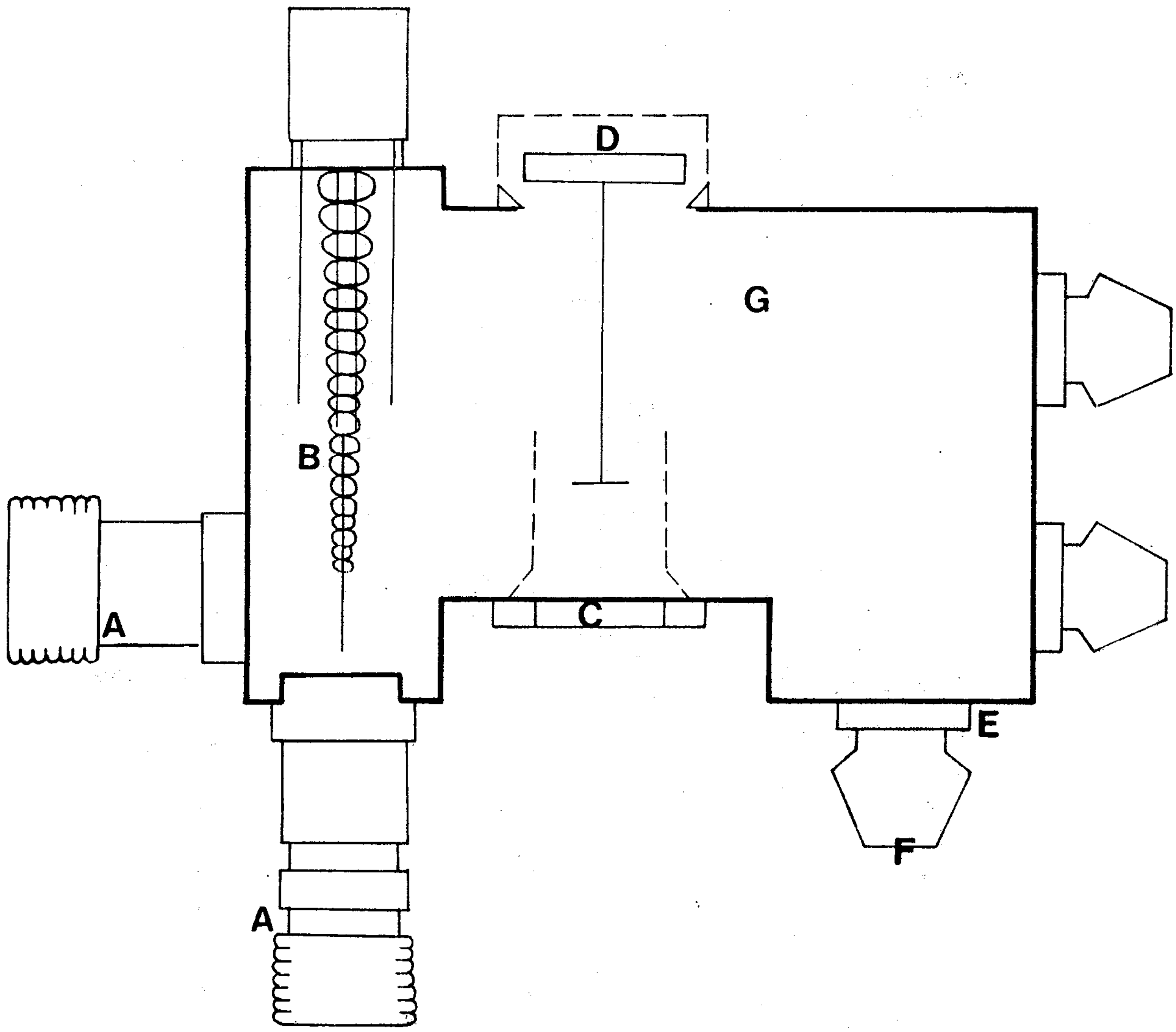


FIGURE 5

A	22 MM MALE AND FEMALE TAPERS	E	DEDICATED SNAP-LOCK CONNECTORS
B	ADJUSTABLE SPRING LOADED PATIENT EXPIRATORY VALVE.	F	SCAVENGING RESERVOIR BAG
C	LEAF VALVE FOR AIR INGRESS	G	CAVITY OF INTERFACE
D	SAFETY GRAVITY LOADED VALVE		

Paediatric–Holland Interface

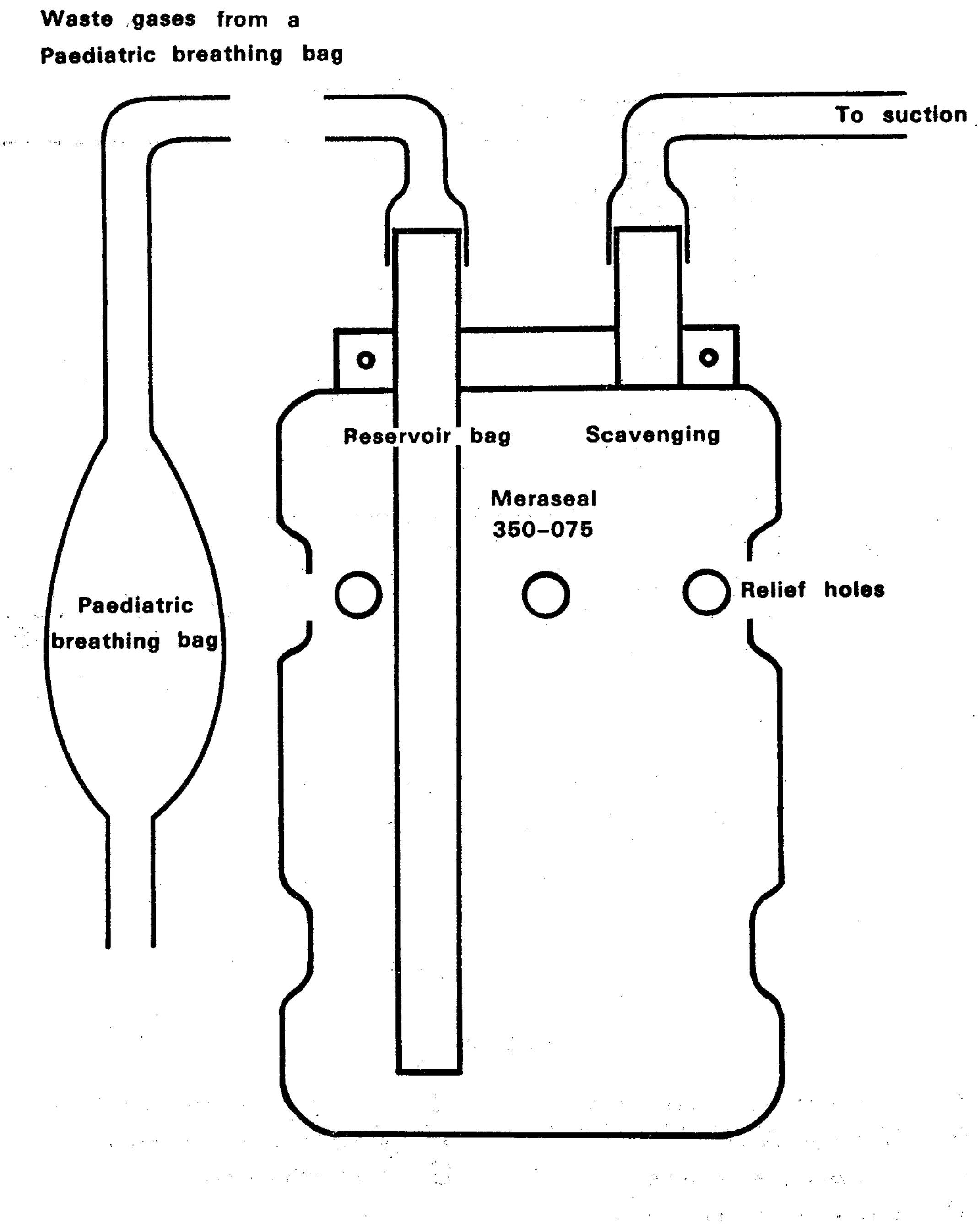


Fig.No. 6

Modification of C.I.G. Medishield Scavenging System MK.I for use with Paediatric T-piece

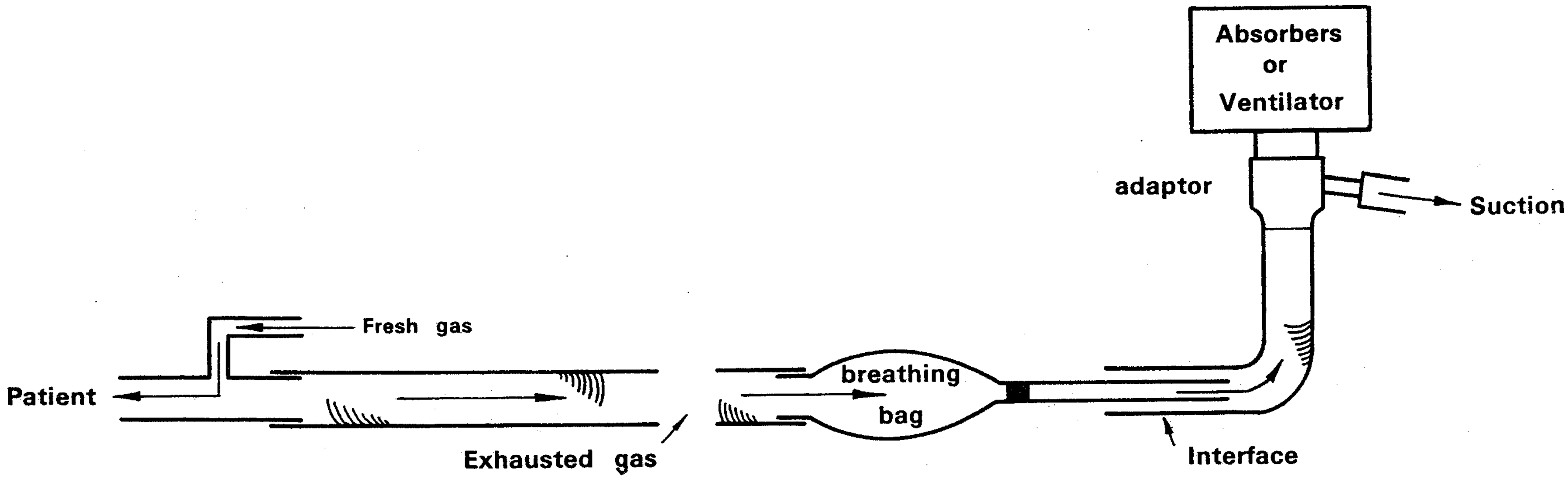


Fig.No. 7

Modification of C.I.G. Medishield Scavenging System MK I for Passive Scavenging.

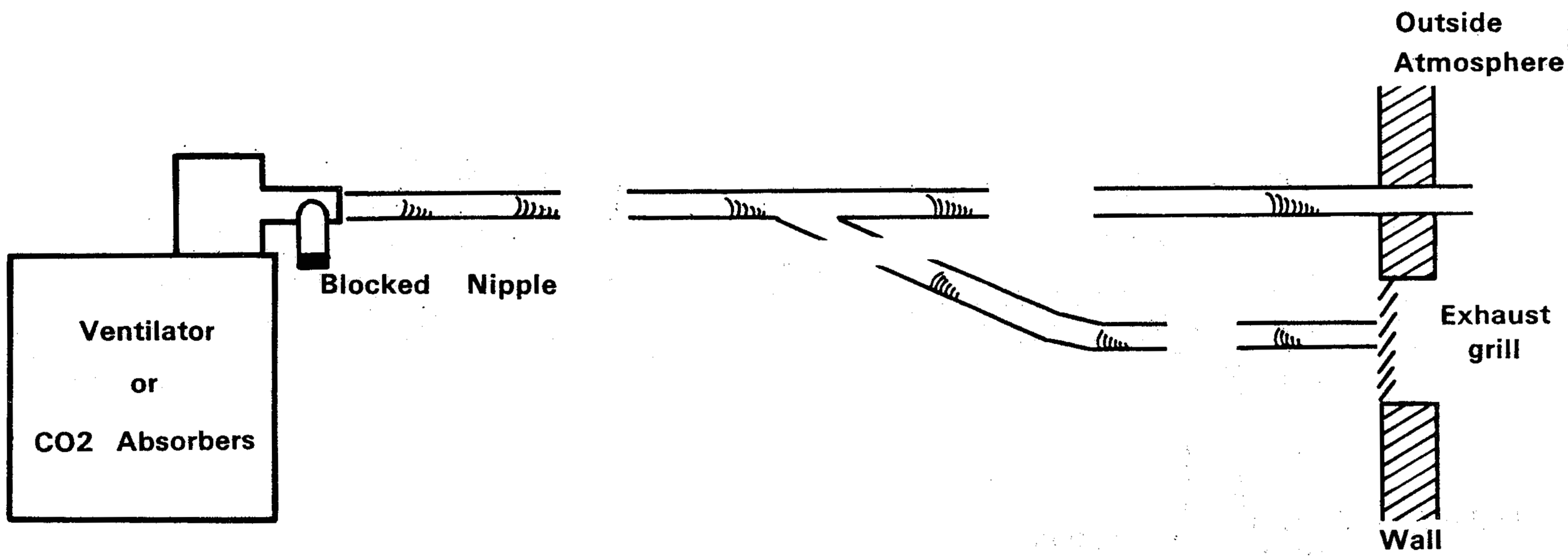


Fig.No. 8

Brown Nitrous Oxide Scavenging Mask

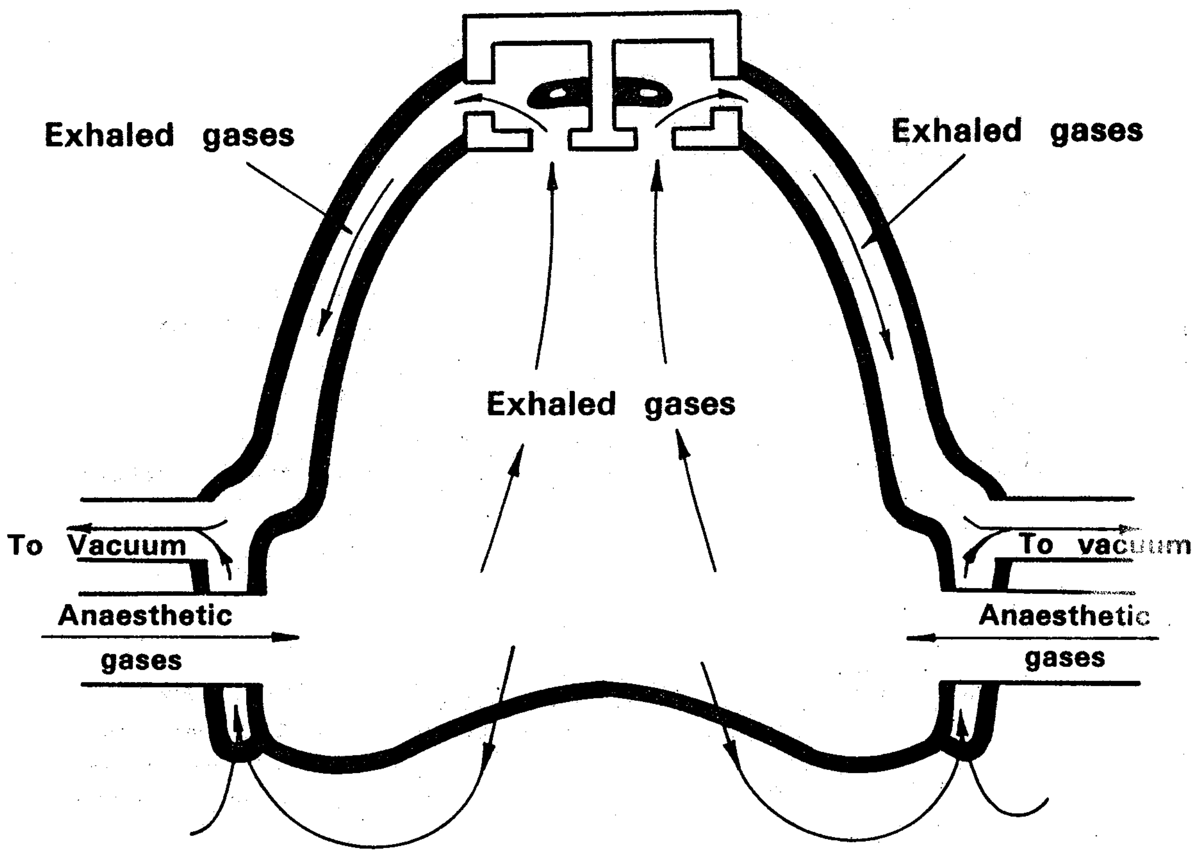


Fig. No. 9

Occupational Health and Radiation Control Branch

The Passive
Quantiflex Anti-Pollution System

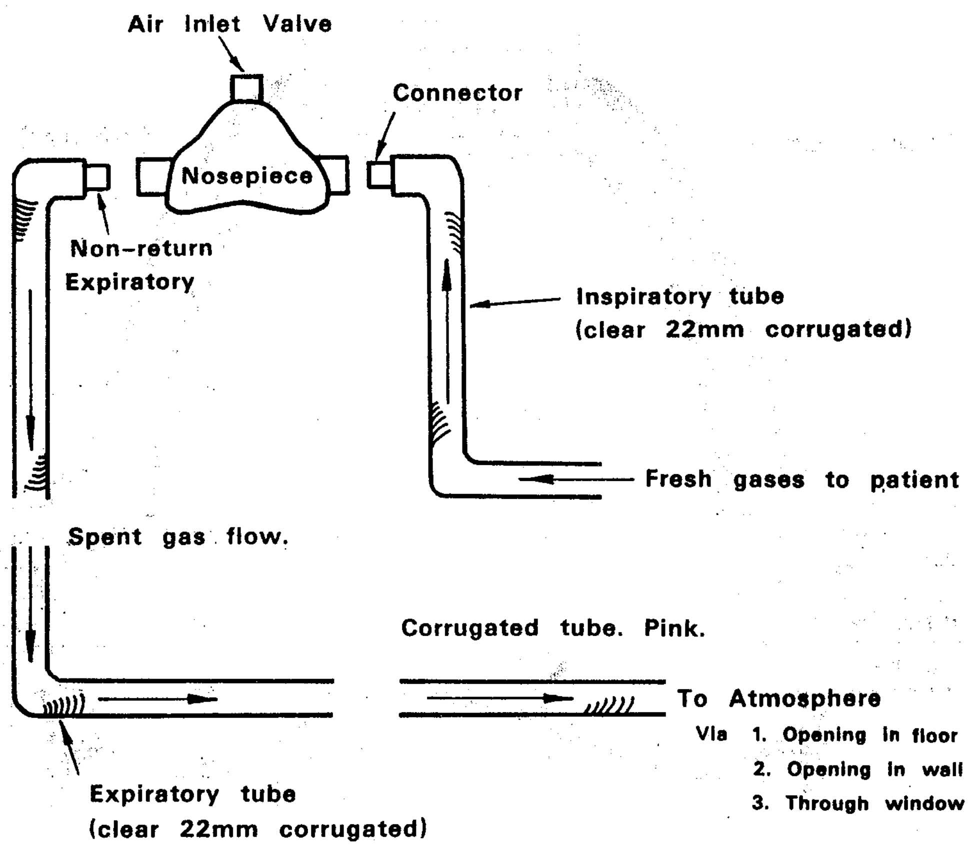


Fig.No10a

The Active Quantiflex Anti-Pollution System

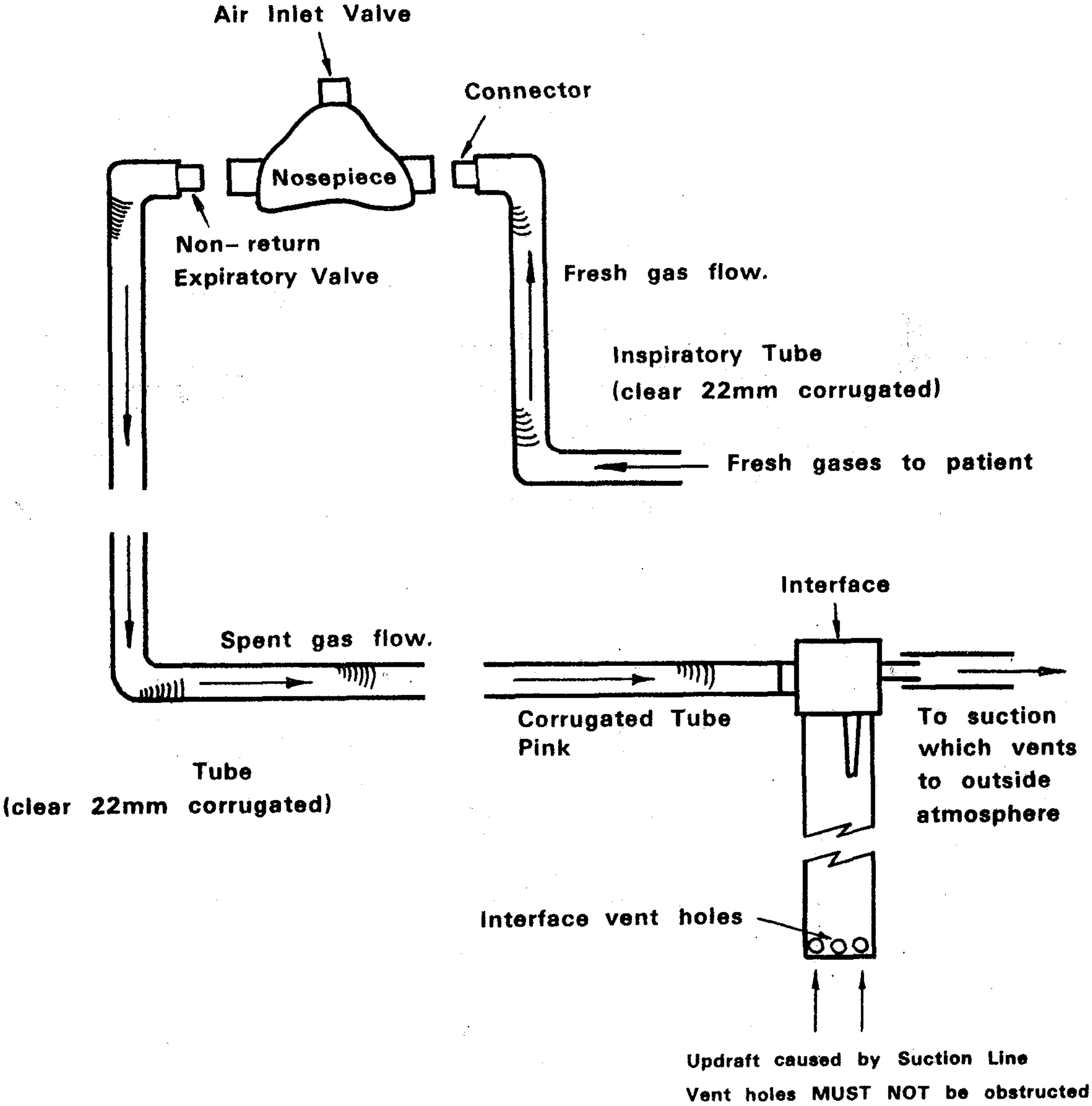


Fig.No10b

Scavenging System used in Veterinary Surgery Type I

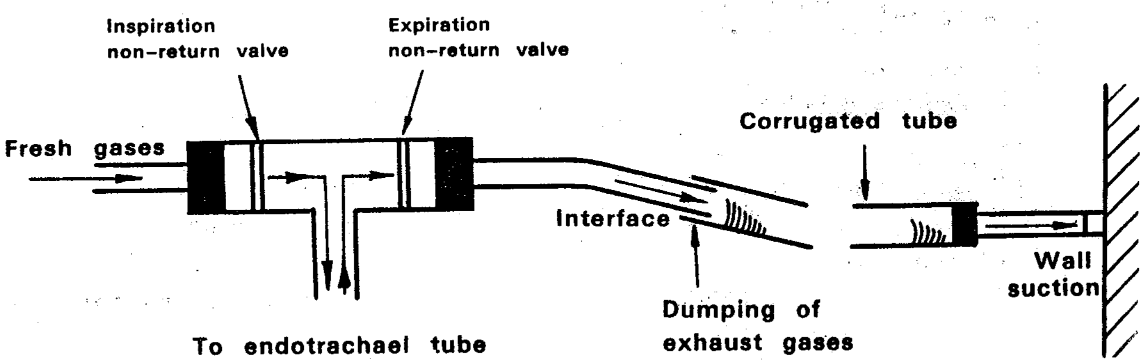


Fig.No.11

Scavenging System used in Veterinary Surgery
Type II

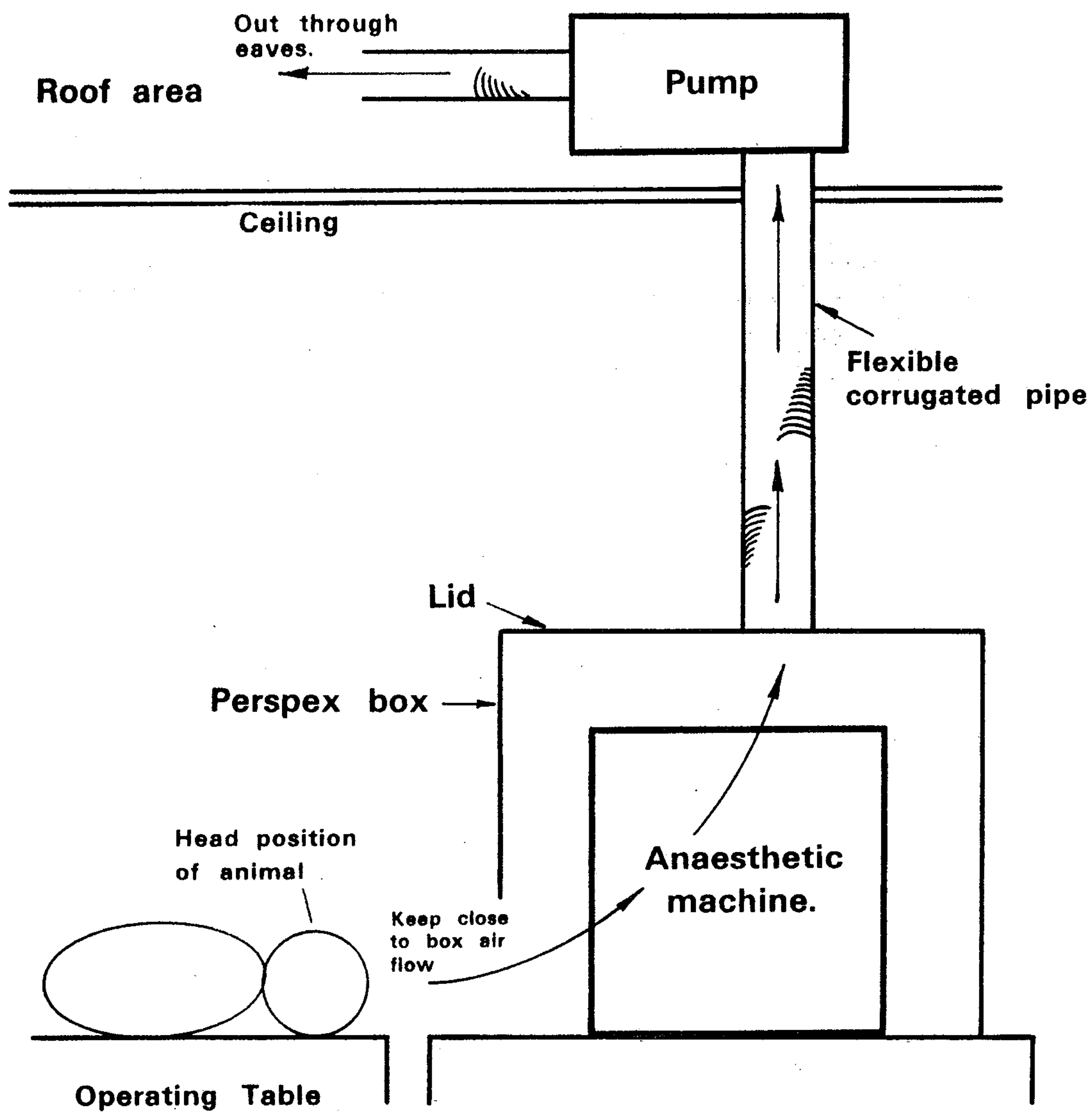


Fig.No.12

Passive Scavenging System used in Veterinary Surgery

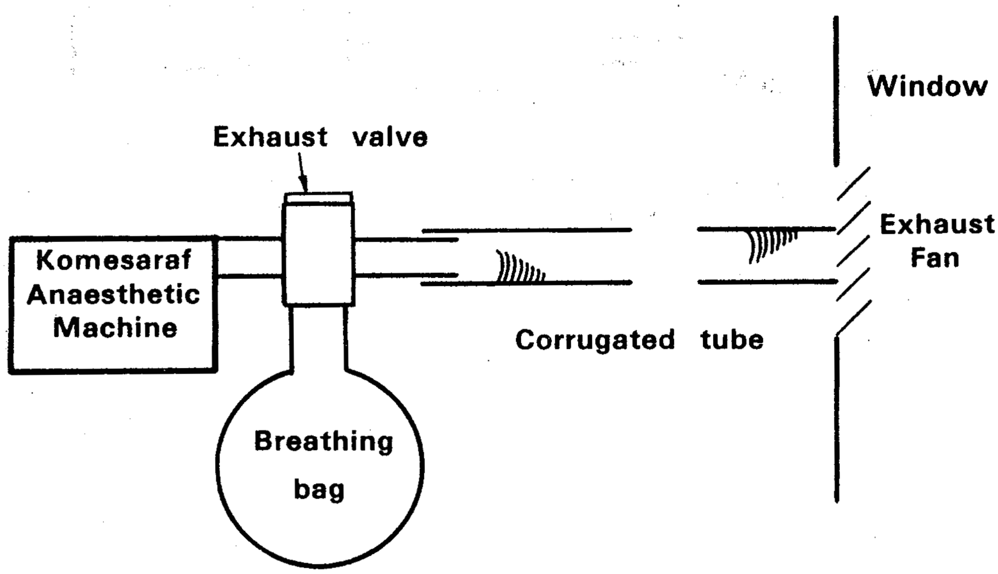


Fig.No.13

Scavenging Mask used in Veterinary Surgery

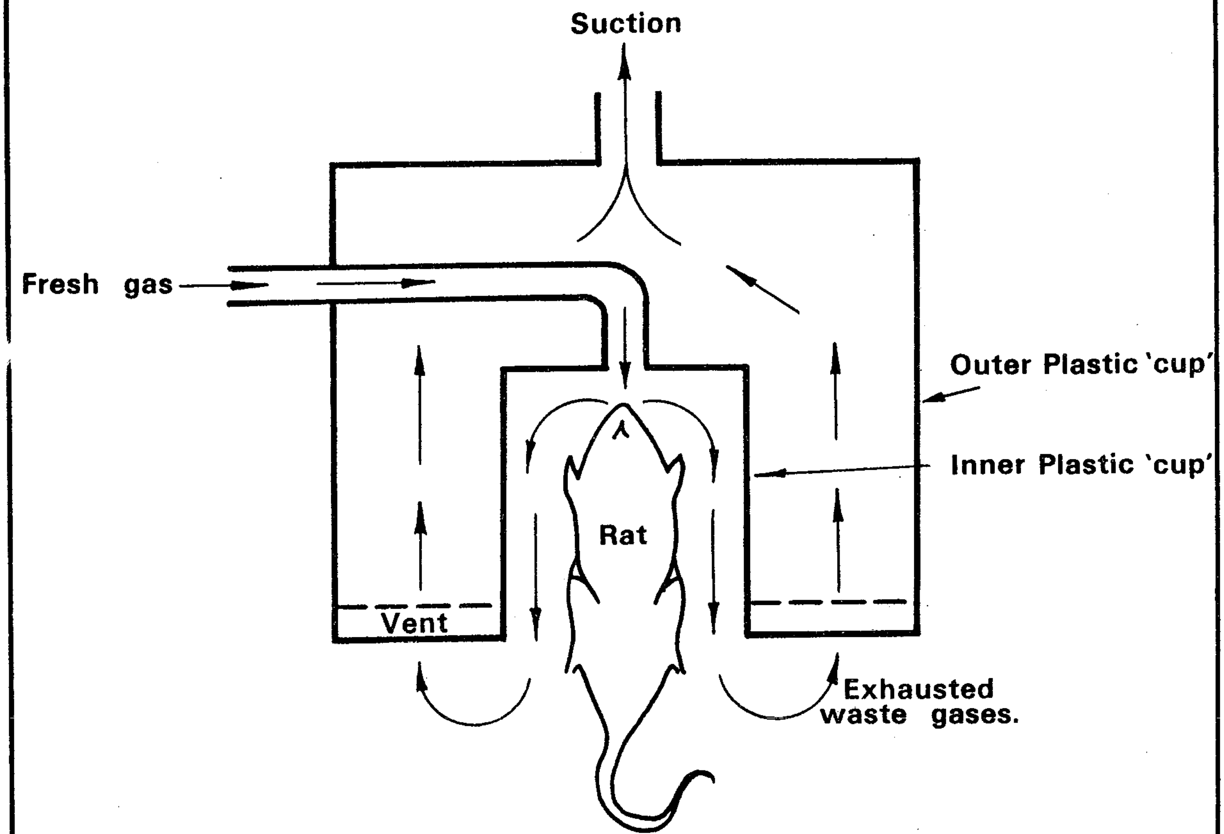


Fig.No.14

APPENDIX D

GLOSSARY OF ABBREVIATIONS USED IN HOSPITAL DATA (TABLE A-1)

COLUMN HEADINGS:

HAL. = Halothane
N_2O = Nitrous oxide
O_2 = Oxygen
l/m - Litres per minute
% = Percentage
ppm = parts per million
WASTE GAS CONC. = Waste Gas Concentration
SAMP. TIME = sampling time
min = minutes
SITE MON. = Site of Monitoring
ANAES PROC. = Anaesthetic Procedures
AIR COND. = Air Conditioning
SCAV. SYST. = Scavenging System

COLUMN 1 ABBREVIATIONS (Used to identify the hospital, location in the hospital, and possibly the type of surgery performed).

H_n = Hospital
T_n = Theatre number
C_n = Case number
R. Rm = Recovery Room
L. Wd. = Labour Ward
M.T. = Major Theatre
GYN = Gynaecology
mT = Minor theatre
OBT = Obstetrics Theatre
I. Rm = Intubation Room
Ma. Wd. = Maternity Ward
Am. H. = Animal House
R.R. = Recovery Room
Gn. T. = General Theatres
CYI = Cystoscopy I
E.T. = Eye theatre
C. Th. = Cardio Thorasic
E.N.T. = Ear, Nose, Throat
T (B) = Theatre B
T (A) = Theatre A
Nu. S. = Neuro Surgery
E.S.S. = Emergency Surgery Suite
O.P.T. = Orthopaedic theatre
O.S.T. = Oral Surgery Theatre
X-R.T. = X-ray Theatres

COLUMN 3 Describes gas meter settings, and identifies gases other than halothane.

intm. = intermittent
U = Units setting on the Vaporizer
MAX = maximum
M.O.F. = Methoxy Fluorane
ETH = Ethrane

COLUMN 5

Describes the location of the sampling probe during the monitoring.

B.Z.A. = breathing zone of Anaesthetist
Env. = Environmental - at breathing height
12P = 12 cm from patient's face
B.Z.N.& P. = Breathing zone of Nurse and patient
B.Z.S. = Breathing zone of Surgeon
B.Z.N. = Breathing zone of Nurse
B.B. = Between 2 Beds - at Breathing height
50 P = 50 cm from patient's face
B.Z.Sr. = Breathing zone of Sister
E.B. = Edge of Bed
20P = 20 cm from Patient's face
60P = 60cm from Patient's face

COLUMN 6

The type of anaesthetic procedure used.

I. = Intubation
A. = Assisted
C.C. = Circle Circuit
M. = Mask
M.S. = Mapleson Circuit
C. = Controlled (using Auto. Ventilator)
P.C. = Paediatric Circuit
B.C. = Bain Circuit
Cl. C. = Closed Circuit

COLUMN 7

The nature of air condition in the operating theatre.

N.R. = Non Recirculating
AC/H = Air changes per hour
Air C. = Air Cooler
Win. A/c = Window Air Conditioner
EXH = Exhaust
Re = Recirculating
Duc. = Ducted
Wall A/c = Wall air Conditioner

COLUMN 8

N.S. = no scavenging
(Refer to separate sheet for description of scav. systems)

SA_1 - CIG - MEDISHIELD SCAVENGING SYSTEM (MK I)
SA_2 - CIG - MEDISHIELD SCAVENGING SYSTEM TYPE II (Modification of Type I by splitting suction into 2 sections)
SA_3 - CIG - MEDISHIELD SCEVENGING SYSTEM (Modification of Type I for use with paediatric T-piece)
SA_4 - CIG - MEDISHIELD SCAVINGING SYSTEM (Modification of type I - for use "passively").
SB - CIG - MEDISHIELD SCAVENGING SYSTEM - MKII - Approved system
SC DRAGER INTERFACE
SD DRAGER UNIVERSAL ANTIPOLLUTION SYSTEM
SE PAEDIATRIC HOLLANT SCAVENGING SYSTEM

GLOSSARY OF ABBREVIATIONS USED IN DENTAL SURGERIES (TABLE A-2)

COLUMN HEADINGS:

N_2O - Nitrous Oxide
O_2 = Oxygen
l/m = Litres per minute
WASTE GAS CONC. = waste gas concentration
ppm = parts per million
SAMP. TIME = sampling time
min. = minutes
SITE OF MON. = Site of Monitoring
R.A. = Relative Analgesia
hrs = hours
SCAV. SYSTEM = Scavenging System

COLUMN 1 (Used to identify the Dental Surgery and experimental conditions used in the testing of the scavenging system).

DS = Dental Surgery
Sn = Surgery
Cn = case number
Vis. = Visit
M. not W. = Mask not Worn
M.W.P. = Mask worn by adult Patient
EXPT. = Experimental
chd. = Children

COLUMN 4 (results of the waste gas concentrations)

Tri = Trilene
HAL = Halothane

COLUMN 5 (Describes the location of the sampling probe during monitoring).

B.Z.D. = Breathing zone of dentist
B.Z.A. = Breathing zone of Anaesthetist
B.Z.D.N. = Between Breathing zone of Dentist and Nurse
B.Z.N. = Breathing zone of Nurse

COLUMN 7 (The nature of Ventilation in the Dental Surgery).

Re = Recirculating
N.U. = Not Used
W.A/c = Wall Air Conditioner
Air C. = Air Cooler
Du. = Ducted
P.C. = Portably cooler
E.F.C. = Exhaust fan on ceiling
Wd. A/c = Window Air conditioner

COLUMN 8

N.S. = No scavenging
(see separate notes for description of the systems).
SL = Brown, Nitrous Oxide Scavenging Mask
SM = Quanti-flex nitrous oxide Antipollution system

GLOSSARY OF ABBREVIATIONS USED IN VETERINARY SURGERIES DATA (TABLE A-3)

COLUMN HEADINGS :

HAL. = Halothane
N_2O = Nitrous oxide
l/m = Litres per minute
% = Percentage
ppm = Parts per million
WASTE GAS CONC. = Waste Gas Concentration
SAMP. TIME = sampling time
min. = minutes
SITE OF MON. = site of Monitoring
ANAES. PROC. = Anaesthetic Procedure
SCAV. SYSTEM = Scavenging System

COLUMN 1 ABBREVIATIONS (Used to identify the veterinary surgery and location in the surgery).

VSn = Veterinary Surgery
Cn = Case number
L.T. = Large Theatre
S.T. = Small Theatre
m.T. = Minor Theatre
M.T. = Major Theatre

COLUMN 2 (Describes the gas meter setting)

U. = number of units setting on Vaporizer

COLUMN 5 (Describes the location of the sampling probe during monitoring)

B.Z.S. = Breathing zone of Veterinary Surgeon
EXH. Gr. = Exhaust Grill
Env. = Environmental (at Breathing height)
B.Z. A. = Breathing zone of Assistant
B.Z.N. = Breathing zone of Nurse

COLUMN 6 (The type of anaesthetic procedure used)

I. = Intubation
C. = Controlled (Spontaneous)
O.C. = Open Circuit
Cl. C. = Closed Circuit
A. = Assisted (using bag)
M. = Mask
T.P. = Jackson Rees T-piece
C.C. = Circle Circuit

COLUMN 7

(The nature of Ventilation in the Veterinary Surgery)

Re. = Recirculating
Ev. C. = Evaporative Cooler
Du. = Ducted
W. A/c = Wall Air Conditioning
E.F. Wd. = Exhaust fan in Window
E.F.W. = Exhaust fan in Wall
E.F. = Exhaust Fan
Wd. A/c = Window Air Conditioner
AC/H = Air charges per hour
Wd. = Window
E.F.C. = Exhause fan on Ceiling

COLUMN 8

N.S. = No Scavenging
(see separate sheet for a description of the scavenging system).
SP = Inhouse made scavenging system Type I
SQ = Inhouse made scavenging system Type II
SR = Passive system
SS = Inhouse made scavinging mask